Organizing ERS Projects: Implications for Demonstrations and Deployments

A Comparative Stakeholder Analysis of the Swedish ERS-Projects eRoadArlanda and eHighway E16

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Abstract
The electric road system (ERS) receives increasing attention as a potential solution to cope with the transition to environmentally friendly heavy road transport. Moving from the initial technology development phase to the technology demonstration phase has motivated the creation of demonstration projects. Thus, ERS-project organizations have evolved.

This report makes an inquiry into the organizing of ERS-projects. It is based on a comparative analysis of the two ongoing demonstration projects in Sweden; eRoadArlanda and eHighway E16. The study addresses what implications the current ERS demonstration projects can provide through a stakeholder assessment.

The outcome of the study is 11 implications for the organizing of ERS demonstration and deployment projects. These are divided among the six perspectives: project leadership, electric road vehicle, electric infrastructure, funding, verification, and interest vs power.

Sammanfattning


Studiens resultat är 11 implikationer gällande organisering av ERS-projekt för demonstration eller kommersialisering. Dessa är uppdelade mellan de sex perspektiven: projektledarskap, elvägsfordon, elinfrastruktur, finansiering, verifiering och intresse vs makt.
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Abbreviations
ERS – Electric Road System(s)
ERV – Electric Road Vehicle(s)
EV – Electric Vehicle(s)
RUAB – Rosersberg Utvecklings AB
1. Introduction

Electric road systems (ERS) receive increasing attention as a potential solution to cope with the transition to environmentally friendly heavy road transport. ERS offers charging of vehicles in motion, which enables smaller and lighter batteries in fully EV or hybrid EV, while still reaching the goal of environmentally friendly heavy road transport. However, the ERS technology also implies major investments in new physical infrastructure, which is added to the existing road network.

Thus, ERS-projects constitute large undertakings that involve a new technology, various actors, and several new technical and organizational interfaces. There are, so far, neither a role model, nor an established best practice, for how these types of projects should be organized. There are different alternatives and the effects of the made choices are ambiguous.

Thus, this report makes an inquiry into the organizing of ERS-projects. It is based on a comparative analysis of the two ongoing demonstration projects in Sweden; eRoadArlanda and eHighway E16. It addresses the following research questions:

- What implications can the current ERS demonstration projects provide, regarding:
  - Contribution of and motivation for stakeholder involvement?
  - Stakeholder roles in an ERS?
  - Interest in and influence of a stakeholder on an ERS-project?

The report is structured as follows. Section two provides a short description of the methodology applied. In section 3, the two projects are described and their organization and stakeholder involvement analyzed. Thereafter, in section 4 the two projects are compared. The report concludes with a discussion and implications for future ERS-projects.

2. Methodology

The report is based on a qualitative methodology, primarily interviews with involved actors, but also written documentation, and study visits.

2.1 eRoadArlanda Case Study

The eRoadArlanda case study was conducted from October 2017 until the end of the same year. The studied period of time was one of significant importance for eRoadArlanda. In October, an issue of electric certification, which threatened the future of the project, was solved and thereby enabled the project’s finalization. In December 2017, the road installations were completed. On April 11, 2018, the ERS was inaugurated and the electric road vehicle (ERV) was charged from the electric road for the first time. Thus, the ERS-project became the first in-road conductive ERS technology used in open traffic in the World. Table 1 summarizes interviewees of the eRoadArlanda case study.
### Table 1 - Interviews Conducted at eRoadArlanda

<table>
<thead>
<tr>
<th>Organization</th>
<th>No. of Interviews</th>
<th>Interviewee(s) Role(s) in eRoadArlanda</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCC</td>
<td>2</td>
<td>(1) CEO Rosersberg Utvecklings AB; (2) Construction manager.</td>
</tr>
<tr>
<td>VTI</td>
<td>1</td>
<td>eRoadArlanda project manager.</td>
</tr>
<tr>
<td>ABT Bolagen</td>
<td>1</td>
<td>Vehicle project manager.</td>
</tr>
<tr>
<td>Elways</td>
<td>1</td>
<td>Inventor of ERS technology.</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>1 (2 interviewees)</td>
<td>Competence in electricity distribution.</td>
</tr>
<tr>
<td>KTH</td>
<td>1</td>
<td>ERS technology verification.</td>
</tr>
<tr>
<td>Arlandastad Holding</td>
<td>1 (telephone)</td>
<td>CEO of real estate owner.</td>
</tr>
<tr>
<td>Postnord</td>
<td>1</td>
<td>Environmental specialist of transportation customer.</td>
</tr>
</tbody>
</table>

In total, 9 interviews with 10 interviewees, representing 8 organizations were conducted for the case study. The interviews were semi-structured with part prepared questions and part questions that emerged during the interviews. The prepared questions were the same for all interviews (see appendix A and B). At each interview, the interviewee was provided with the interview guide and could read from it while the interview was conducted. All interviews, except the telephone interview, were recorded with permission of the interviewees. This was done to verify the interview notes, written by the interviewer during the interviews, after each interview.

#### 2.2 eHighway E16 Case Study

The eHighway E16 case study was conducted during January and February 2018. By this time eHighway E16 was in the second year of operation. The finalizing of the project was planned to mid-2018. However, there were ongoing discussions considering a possible continuation of the project. In Table 2 below the organization, number of interviews and interviewee role or interviewees roles are introduced for the eHighway E16 case study.

### Table 2 - Interviews Conducted at eHighway E16

<table>
<thead>
<tr>
<th>Organization</th>
<th>No. of Interviews</th>
<th>Interviewee(s) Role(s) in eHighway E16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region Gävleborg</td>
<td>2</td>
<td>(1) Project manager, consultant; (2) Project manager, strategist at Region Gävleborg.</td>
</tr>
<tr>
<td>Scania</td>
<td>1</td>
<td>Project manager at truck manufacturer.</td>
</tr>
<tr>
<td>Sandviken Energi</td>
<td>1 (2 interviewees)</td>
<td>(1) Project manager at the local energy utility; (2) Engineer involved in installation.</td>
</tr>
<tr>
<td>Ernst Express</td>
<td>1</td>
<td>CEO at transport operator.</td>
</tr>
<tr>
<td>Siemens</td>
<td>1 (3 interviewees)</td>
<td>(1) Head of business unit mobility of the eHighway technology supplier; (2) Employee at business unit mobility; (3) Business developer of e-mobility.</td>
</tr>
</tbody>
</table>

In total, 6 interviews with 9 interviewees, representing 5 organizations were conducted for the eHighway E16 case study. The interviews were semi-structured and conducted in the same way as for eRoadArlanda.
3. The Cases
This part of the report initially tells the story of ERS in Sweden. In a second part, the eRoadArlanda case is introduced and assessed with regards to stakeholders. For the final part, the same is done for eHighway E16.

3.1 ERS in Sweden
The development of ERS in Sweden was triggered in 2009 when the organization Svenska elvägar AB (founded a year earlier and with its basis in Gävle in central Sweden) caught the public eye with a debate article in Svenska Dagbladet named “Elvägar bättre än höghastighetsräl” (Eng. Electric roads better than high-speed railways) (Frank & Nordqvist, 2009). From here on, a number of R&D activities have been executed by public agencies, and universities, usually financed by one, or several, of the three Swedish governmental agencies Vinnova, the Swedish Energy Agency, and the Swedish Transport Administration. Four initial feasibility studies were conducted during the Spring of 2010, followed by the initiation of the two research projects Slide-In Inductive and Slide-In Conductive, in October the same year. The common purpose of these two projects was to evaluate the potentials of alternative ERS technologies and they engaged a large number of stakeholders, with potential interests in a future deployment, e.g. Scania, Volvo, Svenska Elvägar AB, Vattenfall, Bombardier, Alstom, Trafikverket, as well as Chalmers Technical University, Lund University, and KTH Royal Institute of Technology. From here on, the number of ERS projects in Sweden has increased steadily.

In June 2015, the development of ERS entered a new phase when the Swedish Transport Administration, together with Vinnova and the Swedish Energy Agency, launched a call for “pre-commercial procurement” of ERS demonstration projects. A number of consortia applied for funding. In June 2015, it was announced that two applications would gain public funding: eRoadArlanda and eHighway E16.

3.2 eRoadArlanda
eRoadArlanda is a demonstration project in the Swedish Transport Administration’s pre-commercial procurement. In eRoadArlanda, the project budget is 75 MSEK. Financial support is divided between two groups of stakeholders: The Swedish Energy Agency, the Swedish Transport Administration, and Vinnova – 46 MSEK (61% of total project budget), and organizations involved in the project – 29 MSEK (39% of total project budget).

The execution of the project started in June 2015. In December 2017, the road installations were completed and on April 11, 2018, eRoadArlanda was officially inaugurated. The project runs until the end of June 2019.

eRoadArlanda demonstrates Elways' and NCC’s ground-based conductive ERS technology with an electric rail in the road which transmits energy to the vehicle through an active arm under the vehicle. The technology can be applied for both light and heavy vehicles. An 18-ton truck is used in the project and operated in commercial traffic by ABT Bolagen and Postnord (eRoadArlanda, 2017A) & (eRoadArlanda, 2017B).
**eRoadArlanda** is physically located on the public road 893 north of Stockholm, between Cargo City at Stockholm Arlanda Airport and the industrial park and major logistics center of Rosersberg, located 12 km from Cargo City. The demonstration encompasses a two-kilometer distance in the south-bound direction towards Rosersberg.

**Project History: From Elways to eRoadArlanda**
To understand what leads up to the moment when this case study is conducted, October-December 2017, this part of the report introduces the reader to the history of *eRoadArlanda*. In the following text the development from Elways to *eRoadArlanda* is described as portrayed through interviews with those involved.

Elways is a start-up created in 2009 by two individuals with background in ABB, the global power and automation technology company. The business idea underlying the creation of Elways was the electrification of road transport. Initially, small scale prototyping was conducted with minor financial support from the Swedish Energy Agency to create an ERS technology. After a year, discussions with Volvo Trucks were initiated. However, these discussions soon ended due to unresolved juridical issues concerning primarily intellectual property rights.

Following a move to Stockholm in 2011, discussions continued and connected Elways with a business developer at NCC. A cooperation was initiated and an application for a 200-meter-long test track using the in-road conductive ERS technology was submitted to the Swedish Energy Agency. With NCC as guarantor, the application was accepted by the Swedish Energy Agency in the end of 2011. During the spring of 2012 rails where produced and installed in the road of a closed off test track in Rosersberg. At this time Elways consisted only of one person since the other founder had left the company. However, in 2012 the first employee was hired. Tests were conducted during the end of 2012 and for most of 2013 with mixed results. However, in the end of 2013 a major breakthrough was achieved regarding the functionality of the ERS technology. In 2014 an additional 150 meters of rail were installed with the new, updated ERS technology. Following this, a more extensive and formal cooperation between Elways, NCC and two other companies situated in Rosersberg was initiated through the Rosersberg Utvecklings AB (RUAB) in order to prepare the application for the pre-commercial procurement. As seen in Table 3, four organizations own the company RUAB.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Ownership (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCC (CEO)</td>
<td>30</td>
</tr>
<tr>
<td>Elways</td>
<td>30</td>
</tr>
<tr>
<td>ABT Bolagen</td>
<td>30</td>
</tr>
<tr>
<td>Kilenkryssett</td>
<td>10</td>
</tr>
</tbody>
</table>

*Table 3 - Owner Structure of Rosersberg Utvecklings AB*
In the meantime, with RUAB as the juridical entity working on the application under administration of NCC, the development of the in-road conductive ERS technology was continued. The first-generation test track was replaced by 200 meters of the updated technology. Elways expanded at this point in time by two more employees due to the increasing need for control systems engineering in the project. By the end of 2015, RUAB was one of two accepted projects in the pre-commercial procurement. The project eRoadArlanda and the project consortium with RUAB constituting its core was created. However, accepted in the pre-commercial procurement, Elways was dissatisfied with the current rail used at the test track. A switch of body supplier for the rail, from concrete to plastic, was made. An additional 50-meter test track was installed and the functionality was verified before a decision was made that this was the ERS application to use on the public road.

In parallel, a standard truck from DAF was purchased and converted into an ERV compatible to the in-road conductive ERS technology. ABT Bolagen lead this work with the mission of developing an ERV with the same driving experience as a regular ICE-truck. On commission of ABT Bolagen, e-Traction converted the DAF-manufactured 18-ton truck to an ERV with Elways and Bilprovningen acting as consultants during the conversion. In the spring of 2017, the ERV arrived and was used at the test track from summer and onward. However, not with use of the ERS until April 2018 even though road installations were completed in December 2017.

**Involved Actors**

Officially, there are 22 stakeholders in the eRoadArlanda project consortium (see Figure 1). These represent various kinds of business and interests. However, throughout the case study interviewees have mentioned six additional stakeholders within the project: Svevia; Trafikverket; Vinnova; Energimyndigheten; WSP; and RISE. Hence, a total of 28 stakeholders have been identified. Bellow, each actor is described with focus on contributions to the project and their motivation for participation.

*Figure 1 - The eRoadArlanda Project Consortium (eRoadArlanda, 2017A)*
**Project Leadership**

**ABT Bolagen** is a midsized transportation company with the business idea to provide machine and transport services to construction and property development companies. In *eRoadArlanda*, ABT Bolagen contributes with transportation knowledge and is responsible for the “Vehicle group”; i.e. the group of stakeholders dealing with issues related to the development and verification of the ERV. ABT Bolagen contributes to the project by operating the ERV in service, by performing the transports between Arlanda and Rosersberg on behalf of Postnord, and off service, by housing and charging the ERV. Furthermore, ABT Bolagen also operates the *eRoadArlanda* “on-demand visitor center” at their office premises in the Rosersberg industrial park.

ABT Bolagen’s motive for participation in *eRoadArlanda* is strategical and aligns with its vision of becoming the most environmentally friendly company in the industry. In addition, involvement in the project is considered as a marketing strategy. Financially, the interest in ERS is due to the potential reductions of fuel and maintenance costs in truck operations.

**Elways** is the start-up owning the patents for the in-road conductive ERS technology used in *eRoadArlanda*. As inventor of the technology, Elways is essential for the project. The start-up has contributed to the project through the development of the ERS technology, including the current collector for the ERV, while also receiving the largest funding from the pre-commercial procurement. In addition, Elways contributes to *eRoadArlanda* by disseminating knowledge in relevant technology-oriented forums.

Elways’ motive for participation is to prove that its in-road conductive ERS technology is ready for commercialization. In addition to marketing of the solution, Elways has collected unique competences throughout the development. Thereby, the maturity of the company has increased which in turn has increased the company’s value.

**NCC** is one of the largest construction and property development companies in Scandinavia and is involved in the project through its Infrastructure Division. The size of NCC has contributed to the project with financial and administrative stability. Furthermore, NCC has contributed to the project with its deep competence in road construction and maintenance, both in managing the construction and installation work, as well as in the preparatory actions, e.g. with respect to the rail production. The construction manager has also been responsible for the documentation throughout the production and installation phase. In addition, NCC has assigned the CEO of the company Rosersberg Utvecklings AB (RUAB), which functions as the administrative and juridical body of the project. The CEO holds this function within his ordinary function as business developer at NCC. NCC is also responsible for communication and marketing of *eRoadArlanda* through two employees working part-time in the project.

NCC’s motive for participation in *eRoadArlanda* is to explore how construction and infrastructure development will function in the future. The project also aligns well with NCC’s sustainability strategy, while considered a mean to gain a strategic position for future contracts (when the technology is commercialized). The business potential in the ERS installations are estimated to equal that of traditional infrastructure projects (typically, 20-25% of the total infrastructure investment is usually accrued by the building contractor). Furthermore, operation and maintenance of ERS constitute potentially significant revenue streams in the future independently of ERS application.
VTI, the Swedish National Road and Transport Research Institute, is a state-owned research institute in the transport sector. VTI’s primary contribution is the part-time allocation of its deputy research director as project manager for eRoadArlanda with the main objective of holding together the consortium and moving the project forward. Through the deputy research director, the project has also gained a general understanding of the transport sector, as well as a large professional network of experts within, or related to, this sector. As project manager, VTI also contributes by disseminating knowledge about the project in forums related to the transport sector.

One mission of VTI, as a public authority, is to contribute to the development of an efficient and long-term sustainable transport system. This is the reason behind VTI’s participation in eRoadArlanda.

**Electric Road Vehicle**

**Bilprovningen** is a Swedish, nation-wide, vehicle inspection company, which has functioned as an internal consultant for the ERV to pass the legislated inspections in order to be a legally approved road vehicle. Bilprovningen contributed through participation in the “Vehicle group” until the vehicle inspection was passed.

Bilprovningen’s motive for participation in the project is to act proactively and gain knowledge for future inspection routines on electric vehicles.

**Cosmo Truckcenter** (today renamed Nordic Truckcenter) acts as the agent for DAF’s heavy vehicles in Sweden, Finland and Norway. The main contribution was the delivery of the DAF truck to the project. However, Cosmo Truckcenter was also part of the “Vehicle group” and contributed with automotive competence throughout the rebuilding of the truck from an ICE-vehicle to an ERV.

Cosmo Truckcenter’s is a paid supplier of an ERV to the project.

**DAF** is a Dutch truck manufacturer based in Eindhoven, the Netherlands. DAF’s contribution to eRoadArlanda was through the involvement of its Swedish agent Cosmo Truckcenter (Nordic Truckcenter).

DAF participated primarily as a paid supplier of an ICE-vehicle to Cosmo Truckcenter. Additionally, DAF’s motive for participation is for marketing purposes, since the DAF-logotype is seen whenever the ERV is used in the project.

**e-Traction** designs and implements electric and hybrid drivelines for vehicles. Thus, the main contribution to eRoadArlanda is the rebuilding of the ICE-vehicle to an ERV. In addition, e-Traction has also contributed through participation in the “Vehicle group” with knowledge regarding e.g. the rectifier for the ERV and the ERV charging.

e-Traction’s role in the project was primarily as paid supplier. The paid service was the rebuilding of the ICE-vehicle to an ERV.

**Electric Road**

**Dulevo** is a major Italian manufacturer of industrial cleaning machines, such as street sweepers. The company provides eRoadArlanda with a modified standard machine model for cleaning of the rail for the in-road conductive ERS technology.

Dulevo is a paid supplier who leases a cleaning machine to the project. The involvement in eRoadArlanda aligns well with Dulevo’s intention to increase its shares on the Swedish market.
**Frost Production** is a manufacturing company, operating in Mora, Sweden. The contribution to *eRoadArlanda* is the production of the rails for the in-road conductive ERS technology.

Frost Production is a paid supplier. However, in addition the monetary revenues, the company has also generated significant knowledge of rail production for the in-road conductive ERS technology.

**Sandströms Elfirma** is an electrical installation contractor operating in the region of Sigtuna. In *eRoadArlanda*, its contribution has been electrical installations related to the in-road conductive ERS-technology. The same contribution was made in earlier projects at the test track.

In the project, the company functioned as a paid contractor.

**Svevia** is a state-owned company which constructs and operates infrastructure, e.g. roads, in Sweden and Norway. As contractor to Trafikverket, Svevia operates and maintains the public road on which the in-road conductive ERS technology is installed. Svevia is not a participant in the project.

**Vattenfall** is a major, state owned energy utility, which produces and distributes electrical power and heat, primarily in Sweden, Denmark, Finland, the Netherlands, Germany, and the UK. In *eRoadArlanda*, Vattenfall has contributed in two ways; first by installing and financing the connection between the electric road and the local power distribution grid (owned by Vattenfall); second by contributing with competence on issues related to electrical power distribution.

Vattenfall’s primary motive for participation is the ERS technology’s potential to increase the demand for electrical power, as well as the possible opportunities for building, owning and operating the electric infrastructure related to the ERS, in the future. Furthermore, Vattenfall currently supplies electrical power to the operations of the electric road.

**Verification**

**KTH** Royal Institute of Technology, in Stockholm, is Sweden's largest technical university. KTH functioned as an independent actor, engaged in tests of the ERS and the ERV throughout the project. Third party verifications were conducted also for the preceding projects to *eRoadArlanda*. Another contribution is the direct use of scientific results in *eRoadArlanda*, e.g. master thesis projects commissioned by Elways.

KTH’s motive for involvement in *eRoadArlanda* is related to research funding, knowledge creation, and educational activities.

**Real Estate Owners, Tenants, and Neighbors**

**Arlandastad Holding** is a real estate company active in developing and managing the area surrounding Stockholm Arlanda Airport. Its main contribution to *eRoadArlanda* (and the previous Elways projects) is provision of facilities at reduced rent for project meetings and visitor presentations.

Arlandastad Holding participates in the project in order to market the area, hence attracting visitors and tenants. Arlandastad Holding owns DRIVELAB Stockholm, which is the test area for the automotive industry that was used by *eRoadArlanda*. DRIVELAB also includes the DRIVELAB Hotel, managed by First Hotel Arlanda Airport.

**First Hotels** is a franchise hotel chain with business in Sweden, Norway, Denmark, and Spain. First Hotel Arlanda Airport is known as DRIVELAB Hotel and owned by Arlandastad Holding.
**Kilenkrysset** is a construction and real estate company, which has significant business interests in (and owns large parts of) the industry and logistics park of Rosersberg (the closest connection to the railway system for cargo coming from Arlanda). Kilenkrysset has been collaborating with NCC in the region since the early 2000’s. Its primary direct contribution to *eRoadArlanda* is Rosersberg Utvecklings AB (RUAB), which was a small subsidiary to Kilenkrysset before it was handed over to *eRoadArlanda* to use for managing legal and financial issues of the project (Kilenkrysset still keeps 10% of the shares). Another contribution has been through provision of facilities for meetings and presentations early in the project.

Marketing and development of the Arlanda-Rosersberg area is the primary motive behind Kilenkrysset’s participation.

**Sigtuna Kommun**, the municipality of Sigtuna, is the municipality in which *eRoadArlanda* is physically located. The main contribution to *eRoadArlanda* is through backing of the project (and previous projects developing and testing Elways’ in-road conductive ERS technology).

Marketing and regional development are the major motives behind Sigtuna Kommun’s participation.

**Swedavia** (Airports) is a state-owned company owning and managing ten major airports in Sweden, among which Stockholm Arlanda Airport is the largest. The main contribution to *eRoadArlanda* is through backing of the project and, initially, through decision support related to the choice of an appropriate road to electrify.

*eRoadArlanda* is strategically aligned to Swedavia’s vision of developing its airports with the least possible environmental impact. In addition, the project provides positive marketing for Stockholm Arlanda Airport.

**Training Partner** Nordic AB is a service provider to the automotive industry based in Arlandastad (and a tenant to Arlandastad Holding). The organization has not had any significant contributions to the project.

Marketing of the area towards the automotive industry and its involvement in the business of DRIVELAB are the motives for participation.

**Financers**

**Energimyndigheten**, the Swedish Energy Agency, is a state agency that, among other things, facilitates the transition to a more energy efficient society and fulfilment of the climate objectives through financing of research, development and commercialization in the energy field. The main contribution to *eRoadArlanda* is financing of the project, as well as previous projects during the development of Elways’ in-road conductive ERS technology.

Energimyndigheten’s motive for participation is aligned with the purpose of the public agency.

**Trafikverket**, the Swedish Transport Administration, is a Swedish governmental agency responsible for strategies for the transport system, as well as building, operating, and maintaining public roads and railways. The main contributions to *eRoadArlanda* is as the major financer of the project and as client for the project, both through its regional division and its corporate headquarters. In addition, Trafikverket owns the public road, public road 893, in which the in-road conductive ERS technology is installed.

Trafikverket’s motive is to gain knowledge of, and evaluate, the in-road conductive ERS from a strategic viewpoint for the transport system.
Vinnova is the national innovation agency of Sweden, which contributes to sustainable growth through bettered conditions for innovation. The main contribution to eRoadArlanda is financing of the project. Vinnova’s motive for participation is aligned with the agency’s mission.

Transport Customer

Postnord is a major logistics company, which was formed by a merger between the Swedish and the Danish postal services. Its contribution in eRoadArlanda is primarily as customer of transport services. However, Postnord also contributes with one driver for the operations of the ERV.

Stockholm Arlanda Airport is a major transportation hub for Postnord, which consequently has one of its largest logistic terminals situated in Rosersberg, the industrial park closest to the airport. As logistics company, Postnord has a strategic interest in the development of fossil free road transportation. Since Postnord do not pursue own development projects towards this goal, it engages instead in external projects such as eRoadArlanda in order to learn and acquire experiences.

Consultancies and Others

Gävle Containerterminal, now Yilport Gävle, is the largest container terminal on the Swedish east coast. The organization has not contributed to eRoadArlanda and their motivation for participation in eRoadArlanda is unknown.

RISE, The Swedish Research Institute, is a state-owned research and innovation partner working in international collaboration programs with academia, industry, and the public sector.

The organization is not a formal stakeholder in eRoadArlanda, but a paid supplier who provided a third party verification service of the project safety for Trafikverket.

WSP is a multinational Canadian engineering consulting corporation. The company has 4,000 employees in Sweden. Its main contribution to the project was originally selling the service of a part-time project manager for the consortium. However, when the project manager moved and became employed by VTI, these services ended. The organization is not a participant in the consortium, but a paid supplier of consultancy services to the project.

Table 4 - Stakeholder Contribution to and Motivation for Participation in eRoadArlanda

<table>
<thead>
<tr>
<th>Organization</th>
<th>Contribution to eRoadArlanda</th>
<th>Motivation for participation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Project management for the development of an ERV;</td>
<td>(1) Aligned with sustainability strategy;</td>
</tr>
<tr>
<td></td>
<td>(2) Operation of the ERV;</td>
<td>(2) Marketing;</td>
</tr>
<tr>
<td></td>
<td>(3) On-demand visitor center;</td>
<td>(3) Potential cost reduction for business through ERS.</td>
</tr>
<tr>
<td></td>
<td>(4) Competence in transport.</td>
<td></td>
</tr>
<tr>
<td>ABT Bolagen</td>
<td>(1) Invented and developed the in-road conductive ERS technology;</td>
<td>(1) ERS technology verification;</td>
</tr>
<tr>
<td></td>
<td>(2) Invented and developed the current collector for the ERV;</td>
<td>(2) Marketing of ERS solution;</td>
</tr>
<tr>
<td></td>
<td>(3) Knowledge dissemination;</td>
<td>(3) Knowledge collection;</td>
</tr>
<tr>
<td></td>
<td>(4) ERS technology competence.</td>
<td>(4) Increase company value.</td>
</tr>
<tr>
<td>Elways</td>
<td>(1) Invented and developed the in-road conductive ERS technology;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2) Invented and developed the current collector for the ERV;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) Knowledge dissemination;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) ERS technology competence.</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>Contribution to <em>eRoadArlanda</em></td>
<td>Motivation for participation</td>
</tr>
<tr>
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<td>-----------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Project Leadership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCC</td>
<td>(1) Guarantor for <em>eRoadArlanda</em>; (2) Installation work; (3) Responsible for legal and financial activities through administration of RUAB; (4) Knowledge dissemination; (5) Responsible for communication and marketing; (6) Various competences, e.g. juridical issues, and safe installation work by the road.</td>
<td>(1) Knowledge collection; (2) Positioning; (3) Business opportunity; (4) Aligned with sustainability strategy.</td>
</tr>
<tr>
<td>VTI</td>
<td>(1) Project manager for <em>eRoadArlanda</em>; (2) Transport sector competence; (3) Large network within or related to transport sector.</td>
<td>(1) Aligned with the purpose of the public authority.</td>
</tr>
<tr>
<td><strong>Electric Road Vehicle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilprovningen</td>
<td>(1) Competence on how to pass the vehicle inspection.</td>
<td>(1) Proactively collect knowledge for future vehicle inspection routines.</td>
</tr>
<tr>
<td>Cosmo Truckcenter</td>
<td>(1) Sale of DAF manufactured truck; (2) Competence related to the truck.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>DAF</td>
<td><em>No contribution, see Cosmo Truckcenter.</em></td>
<td>(1) Paid supplier; (2) Marketing.</td>
</tr>
<tr>
<td>e-Traction</td>
<td>(1) Rebuilding of ICE-vehicle to EV; (2) Competence in EV.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td><strong>Electric Road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dulevo</td>
<td>(1) Cleaning machine manufacturer.</td>
<td>(1) Paid supplier; (2) Strategic alignment.</td>
</tr>
<tr>
<td>Frost Production</td>
<td>(1) Rail manufacturer.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>Sandströms Elfirma</td>
<td>(1) Electrical installation.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>Svevia</td>
<td><em>No direct contribution; operation and maintenance of the public road 893.</em></td>
<td><em>Not involved in eRoadArlanda.</em></td>
</tr>
<tr>
<td>Vattenfall</td>
<td>(1) Competence in electricity distribution; (2) Local grid owner; (3) Financing of alterations to the local grid due to <em>eRoadArlanda</em>.</td>
<td>(1) Business opportunities.</td>
</tr>
<tr>
<td>Organization</td>
<td>Contribution to eRoadArlanda</td>
<td>Motivation for participation</td>
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<td>----------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
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<tr>
<td><strong>Verification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTH</td>
<td>(1) Third party verification; (2) Scientific studies for eRoadArlanda.</td>
<td>(1) Funding; (2) Knowledge creation; (3) Educational activities.</td>
</tr>
<tr>
<td><strong>Real Estate Owners, Tenants, and Neighbors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arlandastad Holding</td>
<td>(1) Test facility at reduced price; (2) On-demand visitor center.</td>
<td>(1) Marketing of the area; (2) Business opportunities.</td>
</tr>
<tr>
<td>First Hotels</td>
<td><em>No contribution, see Arlandastad Holding.</em></td>
<td><em>See Arlandastad Holding.</em></td>
</tr>
<tr>
<td>Kilenkrysset</td>
<td>(1) Rosersberg Utvecklings AB; (2) On-demand visitor center.</td>
<td>(1) Marketing of the area; (2) Aligned with sustainability strategy.</td>
</tr>
<tr>
<td>Sigtuna Kommun</td>
<td>(1) Support.</td>
<td>(1) Marketing of the area.</td>
</tr>
<tr>
<td>Swedavia</td>
<td>(1) Support.</td>
<td>(1) Marketing of the area; (2) In line with sustainability strategy.</td>
</tr>
<tr>
<td>Training Partner</td>
<td><em>No contribution.</em></td>
<td>(1) Marketing of the area.</td>
</tr>
<tr>
<td><strong>Finance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energimyndigheten</td>
<td>(1) Financer.</td>
<td>(1) Aligned with work towards more energy efficient solutions, and fulfilment of climate objectives.</td>
</tr>
<tr>
<td>Trafikverket</td>
<td>(1) Financer; (2) Client; (3) Owner of public road 893.</td>
<td>(1) Evaluation of in-road conductive ERS from a strategic viewpoint for the Swedish transport system.</td>
</tr>
<tr>
<td>Vinnova</td>
<td>(1) Financer.</td>
<td>(1) Aligned with vision to strengthen Swedish research and innovation.</td>
</tr>
<tr>
<td><strong>Transport Customer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postnord</td>
<td>(1) Transport service buyer; (2) Operation of ERV.</td>
<td>(1) In line with sustainability strategy; (2) Knowledge collection; (3) Marketing.</td>
</tr>
<tr>
<td><strong>Consultancies and Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gävle Containerterminal</td>
<td><em>No contribution.</em></td>
<td><em>N/A</em></td>
</tr>
<tr>
<td>RISE</td>
<td>(1) Verification of project safety for Trafikverket.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>WSP</td>
<td>(1) Consultancy services.</td>
<td>(1) Paid supplier.</td>
</tr>
</tbody>
</table>
Core or Peripheral to the Project

The many actors involved of eRoadArlanda are categorized with respect to their levels of involvement in the project as “core”, “direct” and “indirect” project stakeholders, as in the model shown in Figure 2 (adapted from Freeman, 1984). The idea is that the closer to the center of the model, the more actively involved is the actor in the ongoing project. Stakeholders with contributions which are necessary to eRoadArlanda are classified as direct. E.g. the project is dependent on having a heavy vehicle for testing, thus a heavy vehicle manufacturer is necessary. For eRoadArlanda, DAF happened to be the heavy vehicle manufacturer, though without any active part in the project, except its logotype visible whenever the ERV is demonstrated. Further, stakeholders with, either a passive involvement in the project, such as “spectator”, or an “on-demand involvement” are classified as indirect stakeholders. E.g. Bilprovningen aided the project in the development and testing of the ERV through advice related to regulation and legislations, until the vehicle was approved. In addition, the dotted line in the circle of direct stakeholders marks the distinction between a contribution specifically to eRoadArlanda, and a contribution to the development of the ERS-technology in general or related to the current road system. Furthermore, the direct stakeholders are also grouped related to the content of their respective contribution: To the electric road vehicle, to the electric road, to the financing, and to the verification.

![Figure 2 - Stakeholder Map of eRoadArlanda](image)

Consequently, four stakeholders belong to the core, 15 stakeholders are direct, and 9 stakeholders are indirect to the project. This collective type of project coordination and the large number of actors involved in the project are two characteristic features of eRoadArlanda. Furthermore, except for the financers and landowner, the inner circles of the project are totally dominated by organizations providing various types of technical competences to development of the in-road conductive ERS application of eRoadArlanda.
Technical Tasks in the Project

In a second stage, stakeholders are categorized based on the technical division of labor in the project, i.e. which tasks the various stakeholders perform in relation to the applied ERS technology, see Table 5. On the vertical axis are the various subsystems and components of the ERS listed, while the horizontal axis distinguishes between the following three tasks with respect to each subsystem/component: to provide it to the project, to control the long-time ownership of the subsystem/component, and to operate the subsystem/component during the demonstration project. All subsystems and components are financed through the project budget, except the road.

Table 5 - Technical Division of Labor in eRoadArlanda

<table>
<thead>
<tr>
<th>Provider</th>
<th>Owner</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution grid</td>
<td>Trafikverket</td>
<td>Trafikverket</td>
</tr>
<tr>
<td>Way side</td>
<td>Vattenfall</td>
<td>Vattenfall</td>
</tr>
<tr>
<td>Contact technology</td>
<td>Elways; NCC; Sandströms</td>
<td>eRoadArlanda</td>
</tr>
<tr>
<td><strong>Vehicle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powertrain</td>
<td>DAF; Cosmo</td>
<td>eRoadArlanda</td>
</tr>
<tr>
<td>Battery</td>
<td>e-Traction</td>
<td>eRoadArlanda</td>
</tr>
<tr>
<td>Current collector</td>
<td>Elways</td>
<td>eRoadArlanda</td>
</tr>
<tr>
<td><strong>EV components</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ERV components</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SYSTEM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payment solution</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Data</td>
<td>eRoadArlanda</td>
<td>eRoadArlanda; Trafikverket</td>
</tr>
</tbody>
</table>
As seen in Table 5, Vattenfall controls all activities related to the power distribution grid. In addition, there are only two other owners involved in the project; Trafikverket, which owns the road, and the eroadarlanda project consortium, which owns the way side installations, i.e. the electric infrastructure closest to the road, and all subsystems included in the ERV. Elways has provided the current collector to the ERV and the electric infrastructure close to the road. NCC has provided the construction management and provisioning of the electric infrastructure closest to the road. Further, e-Traction rebuilt the DAF-manufactured truck sold by Cosmo Truckcenter. Sandströms was involved in the electrical installations of the electric infrastructure closest to the road, except for the Frost-manufactured rail. ABT Bolagen operates the ERV, assisted by Postnord.

There is no specific payment system for eroadarlanda, primarily because there is only one transport customer (Postnord) charged by ABT Bolagen for the transport services, which are executed even when the ERV is not in use. ABT Bolagen reimburses Vattenfall for the electricity used.

Data in the project is collected by Elways and KTH in cooperation and is provided by the eroadarlanda project consortium. Due to the pre-commercial procurement’s set-up all data collected is owned by the eroadarlanda project consortium and Trafikverket.

Project Interest Vs Power

While the previous analyses have illustrated the stakeholder interests in the project, each stakeholders’ power to influence the project is an equally important factor to consider. Following Mendelow (1991), each project stakeholder is categorized according to the simple interest/power matrix, shown in Figure 3.

![Figure 3 - Interest Vs Power of eRoadArlanda Stakeholders](image)
Following this model, the stakeholders are categorized in four quadrants: High level of interest/high level of power, low level of interest/low level of power, low level of interest/high level of power, and high level of interest/low level of power:

- Five stakeholders (see Figure 3) are categorized as high level of interest/high level of power. Trafikverket, in their role as financer and client, VTI, in the role of project manager, alongside the three most prominent members of the eRoadArlanda project consortium: Elways, NCC, and ABT Bolagen.
- Nine stakeholders are categorized as low level of interest/high level of power. These are: The real estate owners and neighbors – Sigtuna Kommun, Swedavia, Kilenkrysset, Arlandastad Holding, and Airport city Stockholm, Svevia – operator of the road where the ERS is installed; Bilprovningen – approver of the ERV, and Vattenfall – owner and operator of the power distribution grid in the area. Each of these stakeholders control a material, or immaterial, resource that is crucial for the project.
- Three stakeholders are categorized as high level of interest/low level of power. The financers Vinnova and Energimyndigheten have strong interest in the project outcomes. However, their power to influence is indirect and allocated to Trafikverket. The involved KTH researchers do also have a strong interest in the project but limited direct power to influence.
- 11 stakeholders are categorized as low level of interest/low level of power. These are primarily acting as suppliers or consultants to the project or are companies with business interests in the vicinities of the eRoadArlanda demonstration track.

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1 It should be noted that both the interest and power of stakeholders are dynamic and can change over time. In addition, stakeholders are often actors with many interacting connections to each other, which means that they also influence each other.
3.3 eHighway E16

eHighway E16 is a demonstration project in the Swedish Transport Administration’s pre-commercial procurement. The project budget for eHighway E16 is 125 MSEK. Financial support is divided between two groups of stakeholders: The Swedish Energy Agency, the Swedish Transport Administration, and Vinnova – 77 MSEK (62% of total project budget), and organizations involved in the project – 48 MSEK (38% of total project budget).

eHighway E16 is located on the public road E16 outside the town of Sandviken, in central Sweden. Between the interchanges of Hillsta (Kungsgården) and Sandviken Västra, there is a two-kilometer motorway, which is electrified in one lane in the east-bound direction towards Gävle. The project eHighway E16 demonstrates an overhead-line conductive ERS technology which transmits energy to the trucks through a pantograph on the roof of the truck (Region Gävleborg, 2017). This solution is provided by Siemens and called eHighway. Two 60-ton trucks are used in the project. They are manufactured by Scania and operated in commercial traffic by Ernsts Express.

The project started in June 2015. In May 2016, the installation on the E16-highway was completed and on June 22, 2016, officially inaugurated. The project is planned to run until the end of June 2018.

Project History: From Siemens to eHighway E16

The German company Siemens has produced pantographs and electrical equipment for more than 100 years. In 2009, Siemens started to extend this business by creating a test track in Germany for its overhead-line ERS-application; eHighway. The functionality of the eHighway solution was confirmed and commercialization deemed possible. After Siemens had identified possible synergies between the eHighway solution and Scania’s new hybrid powertrain, Scania was contacted in 2011 and during the following year, an ERS-ready Scania truck was introduced to the Siemens’ eHighway test track in Germany. By the summer of 2013, a pantograph had been developed for the Scania truck.

In 2013, Region Gävleborg (the county council of the Gävle region) received a question from Siemens and Scania if it would be interested in facilitating an ERS demonstration within the region. Together with a consultant, two strategists at Region Gävleborg, engaged in regional development, assessed the interest on ERS within the local industry. The response was positive: in theory, an ERS was looked upon as a commercially viable solution within the area. Consequently, an application was sent to the pre-commercial procurement.

After a number of iterations, in June 2015, eHighway E16 was chosen as one of two ERS demonstration projects. With Region Gävleborg as the project leader, the construction of the ERS outside Sandviken started immediately. In May 2016, the eHighway E16 installation was completed and in June 22, 2016, also officially inaugurated. Two ERV, Scania trucks with pantographs from Siemens are currently using the system for their commercial transports, with weekly tests, undertaken every fourth week. One of the ERV is the truck used during the initial tests in Germany. The other ERV is based on Scania’s so called New Technology Generation. The two ERV are planned to run on eHighway E16 until the end of June 2018.
Involved Actors

There are 36 official project members in eHighway E16, see Figure 4. However, throughout the case study, interviewees have mentioned one additional stakeholder within the project: Sweco.

Figure 4 - Project Members in eHighway E16 (Region Gävleborg, 2017)

Project Leadership

Region Gävleborg, the county council of Gävleborg, is a public organization responsible for healthcare, public transport and regional development of the Gävleborg county. In eHighway E16, Region Gävleborg is main responsible in the role as project coordinator and planner. As a public organization, Region Gävleborg functions as a neutral, central node in the project with main focus on project execution and moving the project ahead. This is done primarily through a dual leadership of two project managers working closely with the local stakeholders, as well as with Trafikverket. Furthermore, Region Gävleborg contributes with knowledge dissemination, partly through the two project managers, who represent the project in various forums, and partly through an eHighway E16 visitor center, located at Sandbacka industrial park in Sandviken. In total four employees at Region Gävleborg work part-time in the project.

Region Gävleborg’s main motive for participation in eHighway E16 is to enhance regional development of the county. ERS enables low-cost and carbon dioxide emission free transport for the industry in the region. ERS knowledge might also be an export commodity for the businesses in the region. In addition, eHighway E16 drives interest to the region from both visitors and researchers.
**Electric Road Vehicle**

**Ernsts Express** is a regional haulage company which positions itself as “the green haulage company”. The company employs 150 and operates around 100 trucks fueled by biodiesel. In *eHighway E16*, the company operates the two ERV and ensures that trailers are connected to the trucks during operation. The two trucks are operated five full days every fourth week. In addition, the trucks are operated when visitors arrive at *eHighway E16* (at the time of interview, February 15, 2018, *eHighway E16* had hosted 1 200 visitors).

Ernsts Express’ motive for participation is the strategic alignment to the company’s policy of being in the forefront towards fossil-free heavy transport. This strategy is pushed by the owners of Ernsts Express who also advocate that the company should be actively engaged in projects towards this purpose. Furthermore, the largest customers of Ernsts Express are heavy industries which are highly concerned with sustainability and obliged to present sustainability reports to the government. Therefore, these customers are inclined to pay a higher price for sustainable, than for non-sustainable, transports.

**Scania** is a multinational automotive company, a subsidiary in the Volkswagen group, with a primary focus on heavy transports, i.e. trucks and buses. In *eHighway E16*, Scania is responsible for the provisioning of the two trucks as well as the operation of the pantographs mounted on top of the trucks in cooperation with Siemens. Scania collects data from the trucks which, after data processing, is shared with Region Gävleborg and made open to the public. In addition, Scania contributes financially to *eHighway E16* through subsidization of the two trucks.

Scania’s motive for participation is to evaluate and build knowledge of how the company's hybrid trucks function in an ERS in open traffic. Thus, it is important for Scania that it is a haulage company that operates the trucks in commercial operations and provides feedback from a business-as-usual perspective.

**Electric Road**

**Peab** is a Nordic construction company, which employs around 15,000 people. Peab is responsible for necessary construction work in order to install the overhead-line ERS. In addition, it also manages the operations and maintenance of the E16, where the eHighway solution is installed.

**Sandviken Energi** is a local energy utility group with the mission to “… contribute to a long-term development of Sandviken’s infrastructure, from an environmental and economic perspective.” The company has 150 employees. In *eHighway E16*, Sandviken Energi’s main contribution has been electrical installations and provisioning of electric power from the local power distribution grid. In addition, the company supports the project in issues related to its competence in electricity distribution and electrical safety.

Sandviken Energi’s motive for participation in the project is to evaluate what influence an ERS has on the management of the power system, as well as to gain experiences of how an ERS affects its business. In addition, it is important for Sandviken Energi to do effective infrastructure investments, why it emphasizes the possibilities to adapt the local distribution grid to both ERS and an EV charging infrastructure, simultaneously. Furthermore, as a utility with a local monopoly, the positive marketing generated by the project is beneficial.
**Siemens** is a major multinational corporation, active in infrastructure, energy technology, production, and healthcare. Siemens has more than 4,000 employees in Sweden. In *eHighway E16*, Siemens is responsible for the provisioning of its eHighway-application (conductive overhead-line ERS technology). The eHighway solution includes all infrastructure, from the power distribution grid to the overhead-line in addition to the pantographs mounted on top of the two Scania trucks. This involves a number of Siemens employees, both from the Sweden and Germany. Furthermore, Siemens collects data from both the truck and the operating station located at *eHighway E16*, which after processing is shared with Region Gävleborg and open to the public. Furthermore, Siemens contributes financially to *eHighway E16* through subsidization of the eHighway application.

Siemens’ motive for participation is aligned with sustainability as a strategic focus for all parts of the organization, which is pushed from corporate level in the company. Furthermore, demonstrating the eHighway application offers a possibility for Siemens to extend its business to the potentially emerging market segment of ERS. The *eHighway E16* enables further development of the eHighway concept through demonstrations and tests in open traffic on a public road.

**Finance**

**Energimyndigheten**, the Swedish Energy Agency, contributes as financer of the project. The project’s alignment with the agency’s mission is the primary motive for participation.

**Trafikverket**, the Swedish Transport Administration, contributes mainly to *eHighway E16* as the major financer of the project and as client for the project, both through its regional division and its corporate headquarters. In addition, Trafikverket owns the public road E16 where the overhead-line conductive ERS technology is installed.

Trafikverket’s motive is to gain knowledge of, and evaluate, the overhead-line conductive ERS from a strategic viewpoint for the transport system.

**Vinnova**, Sweden’s national innovation agency, contributes as financer of the project. The project’s alignment to Vinnova’s mission to strengthen Sweden as a country of research and innovation, is the primary motive for participation.

**Verification**

**Blue light services**, emergency and rescue services, is in *eHighway E16* the collective name for a group of organizations: Gästrike Räddningstjänst – fire brigade, Polisen – the Police Authority, and SOS Alarm – the emergency management company which operates the emergency number 112 in Sweden and dispatches appropriate services in case of emergency. These organizations share the same main contributions to and motives for participation in the project. The contributions are safety approval of the project and knowledge on how accidents should be handled, which has been shared at several workshops. Accordingly, the motives for participation are to gain knowledge on ERS and to evaluate how to handle accidents in an ERS.

**Elsäkerhetsverket**, the National Electrical Safety Board, is a public authority responsible for electrical safety in Sweden. Elsäkerhetsverket contributes to *eHighway E16* through revisions and authorization of the electrical installations. The motive for participation in *eHighway E16* is to ensure electrical safety.
Real Estate Owners, Tenants, and Neighbors

Gävle Energi is an energy utility group, owned by Gävle Kommun, which operates in the Gävleborg region. It contributes to eHighway E16 with knowledge related to their key competences; power and energy. The motive for participation is similar to that of Sandviken Energi.

Gävle Hamn, the Port of Gävle, is the biggest container terminal on the east coast of Sweden. Gävle Kommun owns the harbor, which is operated by Yilport. Gävle Hamn contributes to eHighway E16 by support of the project and with knowledge on subjects related to the port. The main motivation for participation in eHighway E16 is aligned with Region Gävleborg’s motivation.

Länsstyrelsen Gävleborg, The County Administrative Board of Gävleborg, constitutes the link between the region and the Swedish state government.

MellanSveriges LogistikNav is a cooperation between Mellansvenska Handelskammaren, the regional chamber of commerce, and eight municipalities in the proximity of eHighway E16. The purpose is to create regional development related to transports and logistics. In eHighway E16, MellanSveriges LogistikNav contributes in the discussions related to future development of the logistics in the area (e.g. a new logistics center, and the installations of hydrogen gas fueling opportunities.) eHighway E16 aligns well with the organization’s purpose.

Sandbacka Park is an industrial park in Sandviken focusing on companies involved in technology and IT. Sandbacka Park contributes to eHighway E16 with a visitor center. The motivation for participation in eHighway E16 is as a paid supplier of a visitor center. Further, motivation is likely also marketing of the science park and the positive effects visitors to the ERS-project have on the creative environment in Sandbacka Park.

Sandnet is a local broadband supplier in Sandviken, owned by Sandviken Energi (Sandnet). The motive for participation is therefore the same as for Sandviken Energi.

Sandvikens Kommun, the municipality of Sandviken, includes the location where eHighway E16 is situated.

Transport Customers

Transport buyers is in eHighway E16 the collective name for a group of organizations: Boliden, Outokumpu, Ovako, Sandvik, SSAB, and Stora Enso. These industrial companies all have significant production plants and other business activities in the vicinities of eHighway E16 and share the same main contributions to and motivations for participation in eHighway E16.

The transport buyers are heavy industries, which generate significant volumes of goods that are transported on the E16, primarily to the harbor of Gävle. As heavy industries, they have a common concern when it comes to sustainability and a common interest in presenting themselves as sustainable industries.

Electrification is considered as a possible mean to gain more sustainable road transport and at the same time, reduce the cost of road transports compared to other fuels. In addition, the rail freight transport system is heavily congested in the region and therefore alternative sustainable freight solutions need to be pushed.
Boliden is a mining and metal company producing high quality metals. The organization owns mines and smelters in Sweden, Finland, Norway, and Ireland. Boliden employs approximately 5,500 people. The mine Boliden Garpenberg is situated in close proximity to eHighway E16.

Outokumpu is an advanced multinational materials company focusing on stainless steel with 10,000 employees worldwide. Outokumpu runs four production units and one research center in the town of Avesta, in close proximity to eHighway E16.

Ovako is a Finnish producer of steel based on recycled scrap and employs approximately 3,000 people. Ovako has three plants in the in close proximity to eHighway E16, in Hofors, Hällefors, and Smedjebacken.

Sandvik is a multinational materials and manufacturing company, employing 43,000 people globally. Sandvik has its headquarters and main production plants in Sandviken, in close proximity to eHighway E16.

SSAB is a global steel company with main production in Sweden, Finland and the US. The company employs 15,000 people. SSAB is present in close proximity to eHighway E16 with a production site located in Borlänge.

Stora Enso is a major pulp and paper company with approximately 26,000 employees in over 30 countries. Stora Enso is present in close proximity to eHighway E16 through two pulp and paper mills: One in Fors, and one in Kvarnsveden, Borlänge.

Consultancies and Others

Consultancies is in eHighway E16 the collective name for a group of organizations: Tyréns, WSP, and Sweco. These organizations share the same main contribution to and motivation for participation in eHighway E16. The contribution in eHighway E16 is by execution of a needed service in the project. The motivation for participation is as paid supplier of the service.

Sweco is an architecture and engineering consultancy, with operation in 70 countries globally. The organization employs 14,500 people in Northern Europe.

Tyréns is a community development consultancy with operations in Sweden, Denmark, the UK, and Estonia. The organization employs 2,200 people working with sustainable solutions in the two fields urban development and infrastructure.

WSP is a privately owned Canadian engineering consulting firm working internationally. The company has 4,000 employees in Sweden.

Midroc is an Ethiopian multinational corporation active in construction, installations and real estate development, with 3,600 employees in Sweden. Midroc’s contribution to eHighway E16 was related to installation of the switchgear equipment in the initial phase of the project. Midroc’s is a paid supplier.

Ramudden is a supplier of products and services related to construction and maintenance work on, and close to, roads. Ramudden contributes to eHighway E16 through the operations of a truck mounted attenuator-vehicle (TMA-vehicle). Ramudden is as a paid supplier of a service.

Research institutes is in eHighway E16 the collective name for a group of organizations: Stockholm School of Economics, University of Gävle, KTH Royal Institute of Technology, RISE, and VTI. These organizations share the same main contribution to and motives for participation. The contribution is third party verification and the motives for participation are funding, knowledge creation, and educational activities.
**Transportstyrelsen**, The Swedish Transport Agency, works towards accessible, high quality, safe, and sustainable air, road, rail, and sea transports.

**Table 6 - Stakeholder Contribution to and Motivation for Participation in eHighway E16**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Contribution to eHighway E16</th>
<th>Motivation for participation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Leadership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region Gävleborg</td>
<td>(1) Head responsible – project coordinator and constructor; (2) Knowledge dissemination; (3) Operation of visitor center.</td>
<td>(1) Regional development; (2) Environmentally friendly low-cost heavy transport in the region; (3) ERS knowledge as export commodity for businesses in the region; (4) Marketing of the region.</td>
</tr>
<tr>
<td><strong>Electric Road Vehicle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ernsts Express</td>
<td>(1) Operation of the two heavy ERV in commercial traffic and for visitors.</td>
<td>(1) Strategic alignment; (2) Business opportunity.</td>
</tr>
<tr>
<td>Scania</td>
<td>(1) Provider and owner of the two heavy ERV; (2) Operation of the pantograph; (3) Knowledge dissemination; (4) Data collection and processing; (5) Financer.</td>
<td>(1) Evaluate hybrid trucks functionality in ERS demonstration with operation by external party;</td>
</tr>
<tr>
<td><strong>Electric Road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peab</td>
<td>(1) Competence in road operation and maintenance.</td>
<td>N/A</td>
</tr>
<tr>
<td>Sandviken Energi</td>
<td>(1) Provider, owner, and operator of local electricity distribution grid; (2) Electricity supplier; (3) Competence in electricity distribution and electrical safety.</td>
<td>(1) Evaluate influence of an ERS on the power quality; (2) Knowledge collection; (3) Business opportunities; (4) Marketing.</td>
</tr>
<tr>
<td>Siemens</td>
<td>(1) Provider, owner, and operator of the eHighway solution; (2) Knowledge dissemination; (3) Data collection and processing; (4) Financer.</td>
<td>(1) Aligned with sustainability strategy; (2) Business opportunities; (3) Further development and verification of the eHighway solution.</td>
</tr>
<tr>
<td>Organization</td>
<td>Contribution to eHighway E16</td>
<td>Motivation for participation</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Finance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energimyndigheten</td>
<td>(1) Financer.</td>
<td>(1) Aligned with work towards more energy efficient solutions, and fulfilment of climate objectives.</td>
</tr>
<tr>
<td>Trafikverket</td>
<td>(1) Financer; (2) Client; (3) Owner of the public road E16.</td>
<td>(1) Evaluation of overhead-line conductive ERS from a strategic viewpoint for the Swedish transport system.</td>
</tr>
<tr>
<td>Vinnova</td>
<td>(1) Financer.</td>
<td>(1) Aligned with vision to strengthen Swedish research and innovation.</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue light services (Gästrike Räddningstjänst, Polisen, and SOS Alarm)</td>
<td>(1) Competence in accident handling; (2) Safety approvals.</td>
<td>(1) Collect knowledge on what ERS is and how to handle accidents in an ERS.</td>
</tr>
<tr>
<td>Elsäkerhetsverket</td>
<td>(1) Revision and authorization of electrical installations.</td>
<td>(1) Ensure electrical safety.</td>
</tr>
<tr>
<td><strong>Real Estate Owners, Tenants, and Neighbors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gävle Energi</td>
<td>(1) Competence in power and energy.</td>
<td>N/A</td>
</tr>
<tr>
<td>Gävle Hamn</td>
<td>(1) Supporter; (2) Competence related to ownership and operation of the Port of Gävle.</td>
<td>See Region Gävleborg.</td>
</tr>
<tr>
<td>Länsstyrelsen Gävleborg</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>MellanSveriges LogistikNav</td>
<td>(1) Competence in transport and logistics development in the region.</td>
<td>(1) Aligned with organization’s purpose.</td>
</tr>
<tr>
<td>Sandbacka Park</td>
<td>(1) Visitor center.</td>
<td>(1) Marketing; (2) Business opportunities.</td>
</tr>
<tr>
<td>Sandnet</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Sandvikens Kommun</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Transport Customers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport buyers (Boliden, Outokumpu, Ovako, Sandvik, SSAB, and Stora Enso)</td>
<td>(1) Financers; (2) Supporters.</td>
<td>(1) Aligned with sustainability strategies and obligations; (2) Marketing; (3) Business opportunities; (4) Risk avoidance.</td>
</tr>
<tr>
<td>Organization</td>
<td>Contribution to <em>eHighway E16</em></td>
<td>Motivation for participation</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Consultancies and Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultancies (Tyréns, WSP, and Sweco)</td>
<td>(1) Consultancy services.</td>
<td>(1) Paid suppliers.</td>
</tr>
<tr>
<td>Midroc</td>
<td>(1) Supplier of electrical equipment for the switchgear.</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>Ramudden</td>
<td>(1) Operator of truck mounted attenuator-vehicle (TMA-vehicle).</td>
<td>(1) Paid supplier.</td>
</tr>
<tr>
<td>Research institutes (Handelshögskolan, Högskolan i Gävle, KTH Royal Institute of Technology, RISE, and VTI)</td>
<td>(1) Third party verification.</td>
<td>(1) Funding; (2) Knowledge creation; (3) Educational activities.</td>
</tr>
<tr>
<td>Transportstyrelsen</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Core or Peripheral to the Project

The stakeholders of eHighway E16 are analyzed with the same models that were applied to eRoad Arlanda, see section 3.2. First, they are categorized with respect to their levels of involvement in the project as “core”, “direct” and “indirect” project stakeholders (see Figure 5). Stakeholders with contributions which are necessary to eHighway E16 have been classified as direct. E.g. the project is dependent on having a well operated and maintained road and for eHighway E16 PEAB happened to be the road operator though only holding a small role in the project related to its competence in road operations and maintenance. Further, stakeholders with, either a passive involvement in the project, such as “spectator”, or an “on-demand involvement” have been classified as indirect stakeholders. E.g. the engineering consultancies Tyrēns, WSP, and Sweco that provided services for the project.

The dotted line in the circle of direct stakeholders marks the distinction between a contribution specifically to the project, and a contribution to the development of the ERS-technology in general or related to the current road system. Furthermore, the direct stakeholders are also grouped related to the content of their respective contribution: to the electric road vehicle, to the electric road, to the financing, and to the verification.

As seen in Figure 5, one stakeholder belongs to the core, 18 stakeholders are direct, and 18 stakeholders are indirect to the project. The project is characterized by the involvement of a very large number of actors. However, the project core is monolithic, with a well-defined center constituted by Region Gävleborg.

Figure 5 - Stakeholder Map of eHighway E16
**Technical Tasks in the Project**

Table 7 shows a categorization of the project stakeholders, based on the technical division of labor in the project, i.e. which tasks the various stakeholders perform in relation to the applied ERS-technology. On the vertical axis are the various subsystems and components of the ERS listed, while the horizontal axis distinguishes between the following three tasks with respect to each subsystem/component: To provide it to the project, to control the long-time ownership of the subsystem/component, and to operate the subsystem/component during the demonstration project. All components and subsystems are financed through the project budget, except the road.

*Table 7 - Technical Division of Labor in eHighway E16*

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Provider</th>
<th>Owner</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Road</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution grid</td>
<td>Trafikverket</td>
<td>Trafikverket</td>
<td>PEAB</td>
</tr>
<tr>
<td></td>
<td>Sandviken Energi</td>
<td>Sandviken Energi</td>
<td>Sandviken Energi</td>
</tr>
<tr>
<td>Way side</td>
<td>Siemens</td>
<td>Siemens</td>
<td>Siemens</td>
</tr>
<tr>
<td>Contact technology</td>
<td>Siemens</td>
<td>Siemens</td>
<td>Siemens</td>
</tr>
<tr>
<td><strong>Vehicle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Road Vehicle EV components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powertrain</td>
<td>Scania</td>
<td>Scania</td>
<td>Ernsts Express</td>
</tr>
<tr>
<td>Battery</td>
<td>Scania</td>
<td>Scania</td>
<td>Ernsts Express</td>
</tr>
<tr>
<td><strong>ERV components</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current collector</td>
<td>Siemens; Scania</td>
<td>Siemens; Scania</td>
<td>Ernsts Express</td>
</tr>
<tr>
<td><strong>SYSTEM</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payment solution</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Data</td>
<td>Siemens; Scania</td>
<td>Siemens; Scania; Trafikverket</td>
<td>Siemens; Scania</td>
</tr>
</tbody>
</table>
As seen in Table 7, Sandviken Energi controls all activities related to the power distribution grid, including ownership. Furthermore, Siemens does the same for the electric infrastructure closest to the road. In addition, Siemens is part-owner and provider of the current collector. The same applies to Scania which also provides and owns the two ERV. Trafikverket provides and owns the road and uses PEAB for road operations. Lastly, Ernsts Express is in control of operation of the ERV.

There is no specific payment system for eHighway E16. Data in the project is collected by Siemens and Scania in cooperation, and is provided by the same two organizations. Due to the pre-commercial procurement’s set-up, all data collected is owned by Scania, Siemens, and Trafikverket.

Project Interest Vs Power
Each project stakeholder is categorized according to the simple interest/power matrix, shown in Figure 6 (compare section 3.2).

![Figure 6 - Interest Vs Power of eHighway E16 Stakeholders](image-url)
Following this model, the stakeholders are categorized in four quadrants: High level of interest/high level of power, low level of interest/low level of power, low level of interest/high level of power, and high level of interest/low level of power:\(^2\)

- Five stakeholders (see Figure 6) are categorized as high level of interest/high level of power. Trafikverket, in their role as financer and client of the project, Region Gävleborg, in the role of project coordinator, alongside the three other most prominent members of eHighway E16 consortium; Ernsts Express, Scania, and Siemens.
- Eleven (out of 37) stakeholders are categorized as low level of interest/high level of power. These are: The power utility – Sandviken Energi, the visitor center – Sandbacka Park, the building contractor – Peab, the regional authorities – Sandvikens Kommun and Länsstyrelsen i Gävleborg, and the transport buyers – Boliden, Outokumpu, Ovako, Sandvik, SSAB, and Stora Enso.
- 14 organizations are categorized as high level of interest/low level of power. This group consists of a mixture of organizations such as: The financers – Vinnova and Energimyndigheten, the local actors – Gävle Hamn and Gävle Energi, and the public services – Elsäkerhetsverket and blue light services.
- Seven stakeholders low level of interest/low level of power. Except for the national authority Transportstyrelsen, these are primarily contractors and consultants to the project.

\(^2\) It should be noted that both the interest and power of stakeholders are dynamic and can change over time. In addition, stakeholders are often actors with many interacting connections to each other, which means that they also influence each other.
4. Cross-Case Analysis

In the following section, the *eHighway E16* case and the *eRoadArlanda* case are compared. The purpose is to identify implications for the organizing of future ERS demonstration, or deployment projects.

4.1 Project Leadership

VTI, the Swedish National Road and Transport Research Institute, is the project manager of *eRoadArlanda*. As an independent research institute in the transport sector, knowledge of the sector and a large network within and related to the sector has been the contribution. On a national level, VTI works towards an efficient and long-term sustainable transport system. This motivates the organization’s involvement of one project manager in *eRoadArlanda*.

Region Gävleborg, is the project coordinator of *eHighway E16*. The county council is responsible for the regional development of Gävleborg, which motivates the involvement in *eHighway E16*. The organization is described as a technology neutral actor working towards the higher purpose of regional development in various areas independently of the means to reach stated goals. In this context, Region Gävleborg works closely to local and national actors.

An implication derived from the project leadership of *eHighway E16* compared to *eRoadArlanda* is the project coordinator as a link between local and national actors. This connection has enabled total control of the coordination of *eHighway E16* for Region Gävleborg, which has made the project efficient. In comparison, VTI’s lacking local connection has required the involvement of other *eRoadArlanda* stakeholders in this work (primarily Elways, NCC, and ABT Bolagen). Further, project leadership has been distributed based on competencies in *eRoadArlanda*. I.e. the project leadership has been distributed among a larger number of actors than in *eHighway E16*. Thus, the project leadership of *eRoadArlanda* has not been as streamlined. However, the distribution of the project leadership makes the project less vulnerable to the risk of one actor leaving the project with all knowledge of how to move the project forward.

Region Gävleborg, is as mentioned the project coordinator of *eHighway E16*. In addition, the county council is project contractor. In this role the organization works with subcontracting of services to other actors in *eHighway E16*. Thereby, Region Gävleborg controls the financial streams in the project.

In *eRoadArlanda*, VTI as mentioned is the project manager. However, Elways, NCC, and ABT Bolagen together with Kilenkryssel own the central financial entity in the project, Rosersberg Utvecklings AB (RUAB). RUAB is administered by a business developer at NCC. Hence, in *eRoadArlanda* the project manager role is separated from the contractor role.

Another implication derived from the project leadership of *eHighway E16* compared to *eRoadArlanda* is the centralized role of the contractor, which has made full control over the financial streams possible. In *eRoadArlanda* this knowledge is distributed among actors. However, primarily in NCC’s control.

To summarize this initial part on project leadership, *eHighway E16* is considered to have a highly centralized project leadership in contradiction to the distributed project leadership of *eRoadArlanda*. In hindsight, the implication seems to be high efficiency of an ERS project vs minimized vulnerability for the ERS project towards the risk of losing the actor who pushes the project forward.
4.2 Electric Road Vehicle

In *eRoadArlanda*, development of the fully ERV has been driven by requirements stated by the operator ABT Bolagen with assistance of Elways, the current collector provider. A DAF-manufactured truck was delivered to the project by the Swedish retailer Cosmo Truckcenter, rebuilt by E-Traction, and approved by Bilprovningen. Apparently, the provision of an ERV was demand-driven in the project and no actor is possible to point out as an ERV manufacturer.

For *eHighway E16*, development of the hybrid ERV has been ongoing for several years in cooperation between the truck manufacturer Scania and the ERS technology provider Siemens. During the *eHighway E16* project, the ERS technology has been developed for and applied to Scania’s mass produced “New technology generation” hybrid EV. During operation of the ERV, feedback is received from Ernsts Express. In *eHighway E16*, it is clear that the ERV were pushed by the technology-providers in the project.

An implication from the differences regarding the ERV in *eRoadArlanda* compared to *eHighway E16* is the development of the ERV. In *eRoadArlanda*, the specification of the ERV is aligned directly with those of the operator ABT Bolagen. E.g. only a fully electric truck is accepted by ABT Bolagen due to the fact that this suits the specific transport service of parcels for Postnord on a limited 10-kilometer-road stretch. In comparison, the ERV in *eHighway E16* are pushed by the technology-providers which collect feedback from the operator Ernsts Express. This implies the use of hybrid ERV, since this suits a wider customer-base for Scania and thus enables mass-production.

The current collector, i.e. pantograph, operated by Ernsts Express in *eHighway E16* is throughout the pre-projects and the current project developed in cooperation between Siemens and Scania. Siemens has provided the main technology. Scania has made necessary alterations to the ERV (e.g. lowering of the cabin and software updates) to reach a state where the technology is just mounted on top of the ERV and able to use immediately.

In *eRoadArlanda* the current collector is developed by Elways throughout previous projects and in the current project adapted to the specific ERV. The current collector is under operation of ABT Bolagen.

The different approaches to development of the current collector has different implications. Siemens and Scania have in *eHighway E16* reached a state where they are both exchangeable for the other with regard to the current collector. I.e. Scania’s ERV is mature enough to accept another current collector with similar specifications and Siemens’ current collector is mature enough to accept another ERV with similar specifications. However, it is likely that some adaption is needed. In *eRoadArlanda* this adaption is considered essential, independent of which ERV is to be used. This aligns with the customer-driven specification of the ERV in *eRoadArlanda*, which allows specification also with regard to the current collector.

To summarize this part on the ERV, push meets pull in the development of the ERV for the two projects. In *eHighway E16* development is pushed by the technology providers for both ERV and current collector to independently become ready for a mass-market. For *eRoadArlanda* development of the ERV was demand-driven and aligned with the requirements stated by the operator.
4.3 Electric Road
Sandviken Energi is responsible for energy provision and has full control over the distribution grid in eHighway E16. There is an interface between Sandviken Energi and Siemens where the electric infrastructure is seen as way side and not as the distribution grid. From this interface Siemens is in total control of the electric infrastructure related to the ERS. Further, Trafikverket is the provider and owner of the road and has contracted PEAB for operation of the road. This implies that Siemens also has interfaces towards both Trafikverket and PEAB.

Vattenfall is in eRoadArlanda responsible for energy provisions and has full control over the distribution grid, i.e. the same role as Sandviken Energi in eHighway E16. There is an interface between Vattenfall and other actors where the electric infrastructure is seen as way side and not as the distribution grid. From this interface Elways, NCC, Sandströms Elfirma, and Frost Production share provision and operation of the electric infrastructure related to the ERS. In addition, the eRoadArlanda project consortium owns this infrastructure. Furthermore, Trafikverket is the provider and owner of the road and has contracted Svevia for its operations. This implies additional interfaces towards both Trafikverket and PEAB for the actors in eRoadArlanda.

Implications derived from the electric infrastructure are twofold. Firstly, the role of the electric utilities is a similarity of the two projects. Also, this is the normal role for an electric utility, i.e. business-as-usual. Secondly, the number of interfaces increases with the number of actors involved in the electric infrastructure close to the road and with the number of actors involved in the road. This implies increased complexity in eRoadArlanda compared to eHighway E16, where Siemens is in total control of the electric infrastructure closest to the road.

One further implication based on the second implication above is the attractiveness of total horizontal and vertical integration regarding the electric infrastructure. However, electric utilities want control over the distribution grid which hinders upward integration for the provider, owner and operator of the electric infrastructure close to the road. The same reasoning applies to the road provision and ownership of roads in open traffic, for which Trafikverket wants to stay in control. However not interested in reduced control, both the electric utilities and Trafikverket could be interested in increased control through ownership of all electric infrastructure as is today the reality for EV charging stations. Further, a less drastic vertical integration is that of road operation and maintenance and operation and maintenance of the electric infrastructure on the road.

4.4 Finance
The project budget for eHighway E16 is 125 MSEK. Financial support is divided between two groups of stakeholders: The Swedish Energy Agency, the Swedish Transport Administration, and Vinnova – 77 MSEK (62% of total project budget), and organizations involved in the project – 48 MSEK (38% of total project budget). In addition, Region Gävleborg has been granted financing for the visitor center by the European Regional Development Fund.

In eRoadArlanda, the project budget is 75 MSEK. Financial support is divided between two groups of stakeholders: The Swedish Energy Agency, the Swedish Transport Administration, and Vinnova – 46 MSEK (61% of total project budget), and organizations involved in the project – 29 MSEK (39% of total project budget).
The project budget for *eHighway E16* is 50 MSEK higher than the 75 MSEK project budget of *eRoadArlanda*. Further, the visitor center in *eHighway E16* has been financed. In *eRoadArlanda*, the members of the consortium have provided on-demand visitor centers without any additional funding. The financial pressure has been higher for *eRoadArlanda* and financing in-kind has been higher than is stated in the project budget.

The implication from the project budgets of the projects are twofold. Firstly, a big difference in size of the project budgets exists. However, the purpose to demonstrate a two-kilometer ERS applies to both projects. This implies that there exists a difficulty for previously non-demonstrated ERS projects to prior to the demonstration project estimate costs. Since the overhead-line conductive ERS technology used in *eHighway E16* was at a higher technology readiness level when the application to the pre-commercial procurement was made, the estimates were likely more accurate than for *eRoadArlanda* (TRL 6 vs TRL 4 (Sundelin, Gustavsson, & Tongur, 2016)). Secondly, financial pressure in the project does not motivate money spent on the visitor service and thereby marketing opportunities. With small margins, *eRoadArlanda* has worked towards demonstration of the technology rather than the use of the ERS technology in society. Thus, they have had the need to prioritize among inquiries to visit the project and worked with on-demand visitor centers. This effects the marketing and demonstration of the technology both in a national and international context. In contradiction, the *eHighway E16* visitor center with permanently employed personnel enables handling of the interest that an ERS demonstration attracts.

In both *eRoadArlanda* and *eHighway E16*, the transport services are paid directly by the transport customer to transport operators. Thus, the transport services are performed independently of whether the ERS is in use or not. However, preferably the ERS should be used. This aligns with the emphasis of both projects on the importance of transport service customers with high demands on sustainable transport. This implies that the transport service customers have an important role to play in a transition to sustainable transport solutions.

This part on financing is summarized in three steps. Firstly, it is more difficult for an ERS technology at a lower technology readiness level to estimate costs of a demonstration in open traffic than for an ERS technology at a higher technology readiness level. Secondly, financial pressure on an ERS demonstration project harms the visitor service and thereby harms both national and international marketing of the ERS technology. Lastly, transport service customers can with high demands on sustainable transport become increasingly important players in the transition to sustainable transport solutions.

### 4.5 Verification

In *eRoadArlanda*, verification of the ground-based conductive ERS technology was done through active engagement of KTH Royal Institute of Technology. The organization has been involved continuously throughout the technology development and active in testing. Third party safety verification of the project was done by RISE for Trafikverket.

For *eHighway E16*, verification by research institutes has been kept further from the core development. However, with one researcher from Stockholm School of Economics following the project. For safety verification, the blue light services and Elsäkerhetsverket were involved.

One finding from the two projects is the difference in focus. *eRoadArlanda* has focused primarily on the involvement of researchers in third-party verification of the ground-based conductive ERS technology, whereas *eHighway E16* has focused primarily on the involvement of actors to verify the project safety.
Possibly, this has to do with the technology readiness level of the different technologies. I.e. the more developed an ERS technology is, the more focus lies on verification of the demonstration project and less on the verification of the technology. Another likely explanation is the difference between the technology providers, Siemens being a financially strong global organization and Elways being a small start-up. This implies that the financial strength and knowledge within the organization at Siemens enables the technology verification to be kept internally, whereas Elways is in need of external support.

4.6 Interest Vs Power

As discussed in section 3, both projects have a similar number of stakeholders with high interest and high level of power, and almost the same number of stakeholders with low interest in the project (eRoadArlanda 20 out of 28, eHighway E16, 18 out of 37). However, the number of stakeholders with high interest but low power differs. While eRoadArlanda has three stakeholders in this category, eHighway E16 has 14 stakeholders. A general conclusion from these numbers is that eHighway E16 has a significantly more centralized organization and raises more interest from the local society than eRoadArlanda. Independently of power of the stakeholders, several of the stakeholders in both projects participate to be present when a business opportunity appears and for marketing purposes. I.e. in order to be associated with the projects close to them when something important happens, such as an inauguration of the ERS demonstration project.

Region Gävleborg, in the role of project coordinator is the most prominent member in eHighway E16 and also has a high interest in the local area. Compared to similar actors with high interest in the local area in both eHighway E16 (Sandvikens Kommun, Länsstyrelsen Gävleborg, Sandbacka Park, Gävle Hamn, and MellanSveriges LogistikNav), and eRoadArlanda (Sigtuna Kommun, Swedavia, Kilenkrysset, Arlandastad Holding, and Airport City Stockholm), there exists no evident correlation between local interest and interest in the ERS demonstration project. However, if Region Gävleborg is viewed as the representative of all actors with high interest in the local area in eHighway E16 the organization should be compared to a similar actor in eRoadArlanda, i.e. Sigtuna Kommun. In this context, the local area representative is much more actively involved in eHighway E16 than in eRoadArlanda. Although not moving the project forward, Sigtuna Kommun could neither be considered to use their influence to hold the project back. I.e. the organization acts in a passive role compared to the active role of Region Gävleborg. An implication of this for eRoadArlanda is limited local embeddedness through the project manager role, which Sigtuna Kommun could have contributed with in the same manner as Region Gävleborg in eHighway E16.

In summary, the implications are twofold. Firstly, participation in the ERS project is motivated as a business opportunity and marketing strategy for several organizations. Secondly, local embeddedness can be achieved through the project management role with involvement of a local or regional public authority. Aligned with this, the interest from the local society is significantly higher in eHighway E16 than in eRoadArlanda.
5. Summary and Conclusion

Project leadership – eHighway E16 is considered to have a highly centralized project leadership in contradiction to the distributed project leadership of eRoadArlanda. This implies high efficiency of the ERS project vs minimized vulnerability of the ERS project towards the risk of losing the actor who moves the project forward.

Electric road vehicle – Push meets pull in the development of the ERV for the two projects. In eHighway E16 development is pushed by the technology providers for both ERV and current collector to independently become ready for mass-markets. For eRoadArlanda development of the ERV is demand-driven and aligned with the requirements stated by the operator. This implies two different perspectives for the development of ERV in an ERS project.

Electric infrastructure - Implications derived from the electric infrastructure are twofold. Firstly, the role of the electric utilities is similar in the two projects. This is the traditional position of an electric utility and deployment of ERS constitutes primarily an extension of business-as-usual for the electric utilities. Secondly, the number of interfaces increase with the number of actors involved in installing the electric infrastructure close to the road and with the number of actors involved in the road operation. Thus, it is attractive to have few contractors for these activities.

Finance – it is more difficult for an ERS technology at a lower technology readiness level to estimate costs of a demonstration in open traffic than for an ERS technology at a higher technology readiness level. The financial pressure on an ERS demonstration project does not motivate money spent on the visitor service, since the demonstration of the technology is deemed more important. This harms both national and international marketing of the ERS technology. Lastly, transport service customers will with higher demands on sustainable transport be increasingly important players in the transition to sustainable transport solutions.

Verification – the two projects’ focus differ. eRoadArlanda focuses primarily on the involvement of researchers in third party verifications of the ground-based conductive ERS technology, whereas eHighway E16 focuses primarily on the involvement of actors in verification of the project in relation to other societal functions. The more developed an ERS application is, the more attention is allocated verifications of the demonstrations per se, and less on verifications of the application’s technology. In addition, Siemens being a financially strong global technology provider is able to keep the technical verification internally, while Elways as a small start-up need external help, i.e. to execute the technical verification within the demonstration project.

Interest vs power – Implications from the stakeholder assessment with regards to interest vs power are twofold. Firstly, participation in an ERS project is motivated as a business opportunity and marketing strategy for several organizations. Secondly, limited local embeddedness in the project management role is countered by involvement in the project leadership by a local or regional public authority. Aligned with this, the interest from the local society is significantly higher in eHighway E16 than in eRoadArlanda.
<table>
<thead>
<tr>
<th>Topic</th>
<th>eRoadArlanda</th>
<th>eHighway E16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Leadership</strong></td>
<td><strong>Distributed</strong>&lt;br&gt;Low vulnerability, but a less efficient project</td>
<td><strong>Centralized</strong>&lt;br&gt;Efficient project, but dependent on one actor</td>
</tr>
<tr>
<td><strong>Electric Road Vehicle</strong></td>
<td><strong>Technology pull</strong>&lt;br&gt;Tailor-made for the specific user needs</td>
<td><strong>Technology push</strong>&lt;br&gt;Standardized ready for mass-production, independent of current collector</td>
</tr>
<tr>
<td><strong>Current Collector</strong></td>
<td><strong>Technology pull</strong>&lt;br&gt;Tailor-made for the specific user needs</td>
<td><strong>Technology push</strong>&lt;br&gt;Standardized ready for mass-production, independent of current collector</td>
</tr>
<tr>
<td><strong>Power Utility</strong></td>
<td><strong>Business-asusual</strong>&lt;br&gt;Power supply and adaptions of the distribution grid</td>
<td><strong>Business-asusual</strong>&lt;br&gt;Power supply and adaptions of the distribution grid</td>
</tr>
<tr>
<td><strong>Electric Infrastructure</strong></td>
<td><strong>Several actors</strong>&lt;br&gt;High number of interfaces and high complexity</td>
<td><strong>One actor with total control</strong>&lt;br&gt;Low number of interfaces, low complexity</td>
</tr>
<tr>
<td><strong>Close to the Road</strong></td>
<td><strong>Low technology readiness level</strong>&lt;br&gt;Difficult to estimate costs</td>
<td><strong>High technology readiness level</strong>&lt;br&gt;Simple to estimate costs</td>
</tr>
<tr>
<td><strong>Project Budgeting</strong></td>
<td><strong>High financial pressure on the project and considered outside of project scope</strong>&lt;br&gt;On-demand visitor services</td>
<td><strong>No financial pressure on the project and considered as within the project scope</strong>&lt;br&gt;Well-developed visitor services</td>
</tr>
<tr>
<td><strong>Visitor Service</strong></td>
<td><strong>Business-asusual</strong>&lt;br&gt;Increasingly important with higher demands on sustainable transport</td>
<td><strong>Business-asusual</strong>&lt;br&gt;Increasingly important with higher demands on sustainable transport</td>
</tr>
<tr>
<td><strong>Transport Customers</strong></td>
<td><strong>Research focus</strong>&lt;br&gt;Verification of the technology</td>
<td><strong>Project safety focus</strong>&lt;br&gt;Verification of the technology’s effects on society</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td><strong>Several actors with low interest</strong>&lt;br&gt;Business opportunity and marketing strategy – be there when it happens</td>
<td><strong>Several actors with low interest</strong>&lt;br&gt;Business opportunity and marketing strategy – be there when it happens</td>
</tr>
<tr>
<td><strong>Involvement</strong></td>
<td><strong>Low</strong>&lt;br&gt;Inactive regional public representative and low local interest</td>
<td><strong>High</strong>&lt;br&gt;Active regional public representative and high local interest</td>
</tr>
<tr>
<td><strong>Local Embeddedness</strong></td>
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Acknowledgements

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The authors,

Daniel Berlin & Mats Engwall
References


Appendix

In appendix A you will find the original version of the questionnaire, in Swedish. In Appendix B, a translated version from Swedish to English is found.

Appendix A – Original Questionnaire

Intervju med [namn]
[Intervjudagens datum]

Generellt syfte för ERSET arbetspaket 4
Genomföra en kvalitativ studie som identifierar olika konfigurationer och hur de påverkar affärsmodeller. Görs genom en jämförelse av eRoadArlanda och Elväg Region Gävleborg.

Specifikt syfte med intervjun
Undersöka nuläget och planer framåt för projektet. Stämma av vilka intressenter som är med, vad de har för roll, vilket bidrag de kommit med och vilka intressen aktören har.

Frågor

- Förståelse
  - Beskriv nuläget.
  - [Organisationens namn]
    - Tidslinje?
    - Bidrag och belöning?
- Intressenter i projektet
  - Vilka är de huvudsakliga intressenterna i projektet?
    - Roll.
    - Bidrag.
    - Belöning.
    - Intresse.
- Kommersielt ERS
  - Är det något du tror på?
  - Vilka fordon kommer använda ERS?
  - När?
  - Intressenter
    - Bidrag?
    - Belöning?
  - Hur?
    - Process.
    - Finansiering.
- Övrigt
  - Vilka bör jag prata med framöver?
  - Vad har jag missat?

Bulla

- Intressenter, core, direct, indirect.
- Provider, Owner Operator model.
Appendix B – English Translation of Questionnaire

Interview with [name]

[Date of interview]

General purpose of ERSET work package 4
To perform a qualitative study, which identifies different configurations and their influence on business models. This is done through a comparison of eRoadArlanda and Elvåg Region Gävleborg.

Specific purpose of the interview
To investigate the current state of and future plans for the project. Which stakeholders participate, what their roles are, what contribution they have made and what motives they have.

Questions

- Understanding
  - Describe the current state.
  - [Name of organization]
    - Time line?
    - Contribution and motivation?

- Stakeholders in the project
  - Which are the main stakeholders in the project?
    - Role.
    - Contribution.
    - Motivation.
    - Interests.

- Commercial ERS
  - Is this something you believe in?
  - What vehicles will use ERS?
  - When?
    - Stakeholders
      - Contribution?
      - Motivation?
  - How?
    - Process.
    - Financing.

- Other
  - Who more should I talk to?
  - What have I missed?

Discuss

- Stakeholders; core, direct, indirect.
- Provider, Owner Operator model.