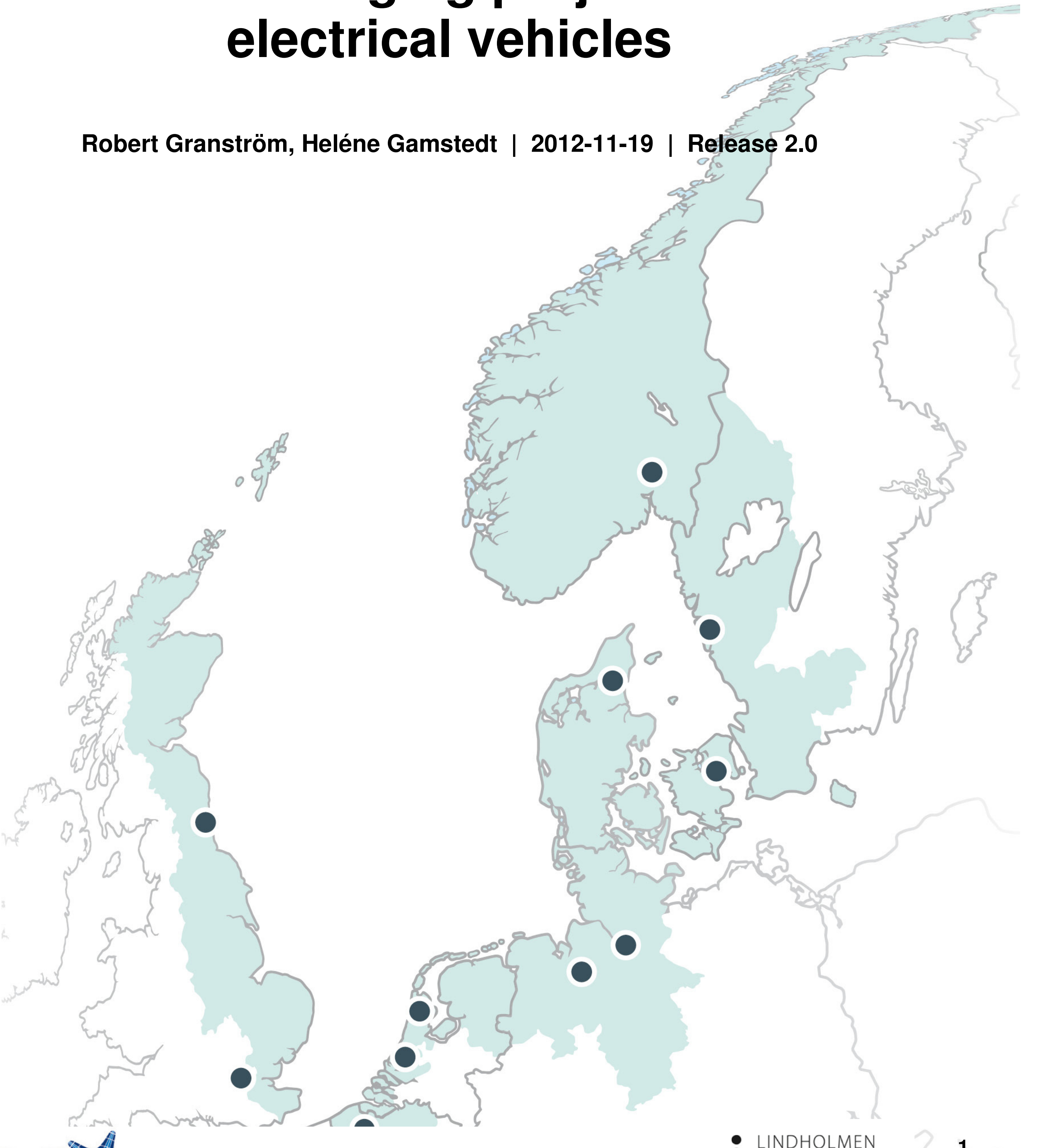
NORTH SEA REGION ELECTRIC MOBILITY NETWORK

e-mobility NSR

Experiences from the Gothenburg fast charging project for electrical vehicles

Robert Granström, Heléne Gamstedt | 2012-11-19 | Release 2.0



The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

European Union

The European Regional Development Fund

LINDHOLMEN SCIENCE PARK

Table of content

Summary

This report gives a brief summary on experiences and outcomes from a test and demo project in Gothenburg with the main objective to establish and evaluate CHAdeMO fast charging for Electrical Vehicles. The project is a Lindholmen Science Park, "LSP", initiative within the "E-mobility NSR project" founded by European Union: Interreg IVB.

Complementary national founding was received from Västra Götalands Regionen, "VGR" in 2011-03-01 and thanks to this the project was one of the first LSP-actions to start within the e-mobility project. The project was finalised by the end of November 2012. This is the common report from the project delivered to both VGR and the e-mobility NSR Consortium. The report will also be used as an input to the national development work for new test activities in Sweden called Test Site Sweden, "TSS", also managed by LSP.

One of the key questions for the project was to investigate if fast charging, based on the CHAdeMO-standard, is technically mature as a charging solution. The common picture among the project participants is that, despite the fact that both cars and chargers ready for fast charging is available on the market, there is still one or two steps of development left to be able to say that fast chargers is a mature and easily implemented technology ready to operate on a 24/7 basis. The project participants do also agree on the fact that this project was useful, educative and led to more action and new important project activities.

From an infrastructure provider perspective we learned that more or less everything about fast charging is to be seen as new issues regarding planning, installation and maintenance. As a direct result from those facts and lessons learned in this project in particular LSP made the decision to facilitate and stimulate further fast charging efforts by generation of a fast charging establishment guide as a supplement to this report. The main objective with this effort is to help future providers of fast charging infrastructure to avoid the main obstacles we noticed during this project. This guide will soon be found at http://e-mobility-nsr.eu, and at http://www.lindholmen.se/

From a TSS perspective we believe that a combined test and demo site, with a national approach and coordination, is needed to learn more about the fast charging technology. We need that to be able to make well advised decisions during the "national rollout" of fast chargers. There is still a lot to be tested and validated. We would like to learn more about the long term effects on battery lifetime from fast charging. Other fast charging solutions need to be tested. We also need to sort out the limitations of fast charging in a cold Scandinavian/ Nordic context as well as to test out alternative fast charging solutions/interfaces. But, there is also a need for more hands on key metrics to decide what a good business model looks like and how a suitable price setting for fast charging could be developed.

Regarding business models we initially had much higher ambitions than the results and conclusions we managed to produce in the end. Due to problems with getting both the cars and the chargers delivered and running, the business perspective had to be excluded from our user questionnaires. We made the decision to include at least one theoretical approach on the economics of fast charging to this report, since in the end business perspective will be the most important question even for fast charging. Different business models will be tested after this report is published. Until this is done our discussion

within the project about alternative ways to get a fast charger ROI “return of investment” is to be found as a “platform for reflection” for the reader to start from. Chapter five shows that the best way to get ROI will, not surprisingly, most likely be to invest in a car pool (Courier van business case).

We believe that the main beneficiaries of the project conclusions are grid operators, energy companies, fleet operators and government/city officials. The report structure is therefore designed with an overview of the experiences in three concluding chapters to meet the stakeholder perspective. The chapters are named: User perspective, Infrastructure provider perspective and Economy perspective. We hope that the chosen structure will work for you as a reader even though you may look on these questions from an OEM or R&D perspective.

Heléne Gamstedt and Robert Granström, for LSP Nov 2012

1 Introduction

1.1 Background

During the autumn 2009 Lindholmen Science Park, LSP, and Test Site Sweden initiated a dialogue on how to launch a learning process concerning fast charging as a tool to stimulate green transportation. The main objective was to establish a demo site. In this early market introduction stage of EVs, Electrical Vehicles, fast charging compatible vehicles was a rare phenomenon, at least in Sweden. The scope for the fast charging project was initially also quite wide, spanning from grid installations to different charging solutions and studies on battery lifetime reduction.

During spring 2010 a number of different stakeholders realised a common need to, as a first step in this process, learn how fast charging works from a user and provider perspective. This resulted in a joint project with the focus on:

- A test environment for fast charging of EVs in the Gothenburg area
- Obtaining experience of practical use of fast charging
- Investigate the safety aspects associated with fast charging
- Make an overall assessment of the fast charging maturity based on the above
- Inputs from the work of the Swedish-Norwegian Working Group on electric vehicles infrastructure*

Main Objective

The main objective for the project was set to:

- Provide and install a CHAdeMO quick charger in the Gothenburg area and make it available for testing and demonstration of electric vehicles
- Process two completed test projects

During 2010 LSP also joined the partnering group for the E-mobility NSR project and with this action the fast charging project received a valuable complement of the European and comparative perspective in this sector.

** The Swedish-Norwegian Working Group on Electric vehicles infrastructure is focusing on how to make it easier to travel with electric cars between Norway and Sweden. The term charge infrastructure included charge spots, road signs, parking places etc. Evaluation of technologies such as fast charging was identified as a possible part of the project.*

1.2 Work group

The project partners in this project are presented in Table 1.

Partner	Focus and contribution
Gatubolaget, Göteborg	Mission is to deliver environmentally friendly vehicles and transport in Gothenburg to create a clean and a leading road safety city. Contribution: Drivers and EVs adapted for fast charging.
HO Enterprise	Company in the area of environmental friendly energy production. Contribution: Drivers and EVs adapted for fast charging
ABB	A global company that is a leader in power and automation technologies, providing solutions that will improve performance while lowering environmental impact. Contribution: Fast charging technology and project manager
Turning Point Cleantech	Gothenburg based company providing fast charging solutions. Contribution: DBT-fast charger and technology know how.
Göteborgs Energi	A west Sweden energy company with the aim to create energy solutions that are sustainable in the long term. Contribution: Project management and Grid connection.
Västra Götalandsregionen, VGR	Regional development organization with three dimensions: economic, social and environmental. Contribution: Cofounder and objective authority for the project.
Lindholmen Science Park AB/ **Test Site Sweden (TSS)**	TSS is a Swedish national cooperation program focused on test and demonstration of new vehicle technology. The stakeholders are Swedish automotive OEMs, academies and authorities. TSS is facilitated by Lindholmen Science Park AB in Göteborg. Contribution: Responsible body for whole Project.

Table 1, Project partners

2 The project process

The project addressed stakeholders in a broad perspective such as scientists, vehicle manufacturers and suppliers, network owners and utility companies, operators of vehicle fleets and government/city officials responsible for traffic and infrastructure issues.

During the project initiation and the partnering process it was decided to install two stations instead of one. A DBT-charger was installed at Ringön, close to Gatubolagets office, and a charger from ABB was installed in Agnesberg. The Agnesberg charger was meant to be used by H-O Enterprise, already owning three CHAdeMO compatible cars. Gatubolaget bought two Micro-Vett cars in order to be able to test the charger at Ringön. With this setup a platform was established for evaluation of two different CHAdeMO-chargers and two different perspectives of use. For the Ringön charger the focus was daily use of two vans (one Courier van and one van customized for carpenter/caretaker service). The main idea at Ringön was to charge during lunch time in order to reduce range anxiety for new EV users. The Agnesberg charger was on the other hand more to be seen as a complement for already "mature" EV users who occasionally would need a fast charge at the company home base. The distance between the chargers was about 10 km and the two chargers were intended to be used both by Gatubolaget and H-O Enterprice as a backup/complement during range problems.

In this way evaluation of two different test projects (our first main objective) was secured for the project. By making the Ringön charger as a permanent installation the other main objective (to install one CHAdeMO-charger) was achieved. The ABB charger was decided to be dismounted in the last phase of the project to keep the project cost down (lower prize for temporary grid installation).

The project was initially intended to be finalized by the end of 2011, but had to been prolonged three times. First of all there weren't any chargers available to be installed before late autumn 2011. By the 11th of November 2011 we finally managed to run an inauguration for both chargers. In order to make it possible to evaluate the user perspective, the project was prolonged until the 30th of July 2012. During the spring 2012 a lot of problems were encountered, especially with one of the chargers. So we asked VGR for permission to prolong the project until the end of September.

In April 2012 Turing Point Cleantech offered a free upgrade of the Ringön charger to a totally new product, but due to problems getting this new charger shipped the final date for the project was postponed to the 30th of November 2012. (More or less one year later than the initial plan)

Viktoria Institute was signed on to evaluate the user perspective, regarding preparation and conducting of interviews as well as analysis and report generation. The delay also had an impact on this work and primarily on the Ringön survey. With a good flexibility from Viktoria Institute the report from the survey was delivered in late October 2012.

During the last phase of the project a dialog about the main lesson learned was initiated and concluded within a workshop on the 19th of November 2012 at LSP. The common picture from that workshop is encapsulated in the summary and the input was presented by three main headlines:

- Learnings from a User perspective
- Learnings from an Infrastructure provider picture
- Fast charging economy

Those headlines are also to be found as chapter 3 to 5 in this report.

2.1 Project focus and reflections

The project was initiated with a focus on/to:

1. Establishment of a test environment for fast charging of EVs in the Gothenburg area.
2. Obtain experience of practical use of fast charging
3. Investigate the safety aspects associated with fast charging
4. Make an overall assessment of the fast charging maturity based on the above
5. Follow the work of the Swedish-Norwegian Working Group on electric vehicles infrastructure.

From a project management perspective we did (needed) to put a huge effort and a lot of time in the establishment issue. This was necessary and delayed the work with issues number 2, 3 and 4. The work within the Swedish-Norwegian Working Group was especially useful during the phase of business model summing. Regarding the maturity of the fast charger technology the picture is quite clear. This industry is still learning and it's not only in Sweden that the reliability could be better.

3 User perspective

Due to the small number of users and cars the user evaluation was decided to be made as a qualitative, but not quantitative, study. The goal of the study made by Viktoria Institute was to investigate the effects on drivers´ attitudes and experiences of EVs when having access to fast chargers.

The study made by Viktoria Institute is, in a separate section below, supplemented with some hands-on comments from different users.

3.1 The case of Fast Charging study by Viktoria Institute

The study includes interviews in two questionnaire occasions (before and after). The main strategy was to capture any changes in attitudes and behavior after a period of using the fast chargers. Due to problems with chargers that didn't work, or only were compatible with certain cars, some of the expected extra added values with having two chargers working in the same area (like a "last mile rescue"), couldn't be investigated.

Initial conclusions

Fast charging is a good concept to increase flexibility and ability to use the vehicle more often. Fast charging would play a significant role in the daily use of EVs, but it's important to identify the correct user group for fast charging. In this study in particular, an added value for car pools were identified and a need to increase the daily use of EVs was pointed out as a driving force.

For those that *did not* experience an added value of having access to a fast charger, the following factors are possible explanations and causes:

- They do not represent the correct user group.
- They have had access to EVs for a long time and they already match their daily routine according to the range of the EV.
- They do not have a need to drive long distances.
- They do not have a natural placement of the fast charger for it to play a significant role in their driving.
- The amount of extra energy the fast charger provides does not play a significant role in their daily driving.
- They do not even know about the existence of the fast charger.

3.2 Other findings

One major drawback with fast charging is that the battery won't be filled up to more than 80 %. The reason for that is a need to avoid reduced battery lifetime due to thermal damage to the battery cells during a fast charge. You have to choose a shorter range or, if you need a fully charged battery, plug in the car a second time with "normal" charge (10 Ampere connection). This routine prolongs the complete charging time with about 80-90 minutes.

In cooperation with HRM a parallel technical study on the Agnesberg charger was made. In this study measurements were performed on battery temperature and the charging power.
The study indicates that

- A battery temperature less than + 10 °C will only be charged with 20% effect.
- A battery temperature in the range from + 10 to +20 °C will be charged with 40% of full effect.

And from practical use of the fast charger we know that an expected time of 20 minutes of fast charging can easily be prolonged with 20-25 extra minutes. Note that this simple study is made on only one type of car (Citroen C-Zero). Further investigation is needed to give a true picture.

Some other "hands-on feedback-comments" from the users are:

1. "In front charging" is okey at home, but a public fast charger should be designed in the same way as a normal gas station with the car in parallel to the filling station.
2. The CHAdeMO plug is "fiddly" to use and during charging in darkness an embedded LED in the plug would be useful, thus helping the user to see exactly where to connect.
3. The power cable feels "like a pipe" in cold temperatures and quite often there is problems with restoring the plug after charging, and strong winds adds to that picture.
4. There is problems to see the display in bright sunlight and also in cold weather
5. About 20-25 minutes of fast charging can be considered a long time to wait. Some users would like to have a "Charge-done-SMS".

4 Infrastructure providers perspective

The learning's from an infrastructure provider´s perspective should be more or less about how to meet the customer needs and how to establish and maintain a working/operating fast charger. Already from the start we realised that that we needed to add a safety analysis to this picture. To match that picture this chapter of the report is separated into three parts:

- Important customer issues
- Installation and maintenance issues
- Safety analysis

4.1 Important customer issues during establishment of a fast charger

From the user study made by Viktoria Institute we learnt that some of the main aspects that determine the use of the fast charger include some issues to be concerned by the provider. The ones with extra importance are:

- Location and timing (do you need to find a charger before you reach your final destination?)
- What will it take in time and what will it add to my driving distance and range?
- Does it feel safe to wait for 20 minutes at the charging site?
- Is it a charger for private/commercial use and is it easy to operate/book?
- Do people know that the charger exists?

In particular the *location* of the chargers was highlighted as a question of great importance. As shown in chapter 5 the choice of location is very much depending on the user/business case if you add a RoI (Return of Investment) perspective to the picture.

4.2 Installation and maintenence

From this study and experiences from Norway and other partners within the e-mobility network we know that it's easy to underestimate the task to establish a site for fast charging. First of all the choice of locations is not only something to be considered from a user perspective. When trying to find the right location one need to take the distance to the grid into the perspective. It's not that easy to find sufficient power at a decent price. A spot looking good from a customer perspective could easily be twice as expensive because of e.g. unforeseen problems while connecting to the grid due to long distance to the power and if there may be buildings, roads or other obstacles in the way.

During the installation process more issues than the locations are to be considered. First of all, in contrast to a normal gas station, there is a lack of available standard/custom guidelines for how a charging site should be designed.
The provider needs to think and make plans for issues like: how to anchor a foundation, what kind of authorization is needed and if the product is following Swedish regulations?

At the end of 2012, when the market introductions of fast chargers are going from demo sites to commercial use, we suggest that you should be aware of the following issues:

- The product might not be harmonized according to Swedish regulations and/or best practice (See 4.3 Safety analyses).

- Expensive maintenance and education (to be made by certified bodies).
- Specifications are not explained in any IEE paper.
- The plug is fragile and expensive.
- Slow maintenance turn-around-time.
- Software updates resulting in backward compatible problems with certain cars.
- Protect the charging station from damage caused by cars or working machines.
- The whole process from planning to installation will take a lot of time and cause extra project cost.

4.3 Safety analyses

Already from the project start we decided to hire Intertek Semko to perform safety analyses on our charging stations. The driving force behind this was to eliminate all potential technical, human and environmental risks that could be considered while installing and using the fast charging stations.

Intertek Semko´s safety analyses showed that there are still some issues that should be considered even though the charger is CE-marked. The three studies performed by Intertek Semko are summarised below in three headlines:

Insufficient marking and labeling regarding:

- Rated output etc.
- Conformity with CE etc.
- Main switch.
- Fuses

Operational/access problems

- Accessibility on fuses/switches
- Bad screw connections
- During reassembling:
    - Risk of cable-mixing
    - Risk of cable-damage (sharp edges)
- Components open for unintended touch during maintenance
- Unclear separation of high and low voltage

Other issues

- Some components on the circuit board appear dark (over heated?)
- Cooling fans not protected from snow/rain
- Air inlet can be jammed by snow
- Charger is designed for -10 °C (but the standard says -25 °C)

The conclusion from the safety analyses indicates that the first two chargers were more or less on a prototype level, with non CE-labeling for instance. The improvement by the newly installed charger is a proof of an ongoing progress in design and production. We strongly recommend the forthcoming provider of a fast charging to ask for a safety analysis before purchasing a new charger. Note that none of the chargers we tested had faults that would prohibit normal use. The issues noted only shows that regarding maintenance there is still work to do by the manufacturer.

5 Fast charging economy

One project aim was to test out different business models for fast charging. However this goal turned out to be more or less impossible to fulfil within the timeframe of the project due to problems with getting the chargers in place, starting them up and finally using them/keeping them running. With no business-model-testing we decided to make calculations on four different user cases. This is to be seen as a second best solution to point out a next step to learn more about fast charging economy. The main idea behind this was to prepare for the final workshop and to initiate a dialogue about ideas for future demo-projects where we can learn more about business models. But the decision to add this part to the report is also to be seen as an initiative to initiate an open dialogue about fast charging economy.

We have chosen to present four different business models:

1. The local energy company providing pay per minute fast charging
2. Parking lot provider with the charged power for free
3. Charging company providing a city infrastructure with flat rate access to fast charging
4. Car pool/ Courier vans. Where the need of more mileage per day is the main driving force.

Note that everything in this chapter is theoretical and based on information gained from the project partners and from the web. We are looking forward to a dialogue with you as a reader to investigate this further.

Initial cost

The cost for the Ringön installation ended up with a total of about 700 kSEK. Due to the fact that a "first try" in a new business normally ends up with a high price we aggregated a platform for the calculations based on information from both Göteborg Energi and some other projects. The cost was divided into three basic items: charger, grid connection and environment setup.

From fast charger suppliers we know that the cost will stay around 100-200 kSEK. The connection to the grid adds 50-200 kSEK and the big difference in cost here is mainly depending on the distance from the grid to the decided/desired location for the charger. The final work to establish a decent surrounding will easily add 100 to 400 kSEK depending on the grade of functionality and style (base slab, weather shield, signs and displays, pavement/ground cover, light, solar cells etc). A cost effective installation could end up below 250 kSEK, but you can easily spend more money on those issues and exceed a price way above the 700 kSEK spent in this project. To have a picture to start with the total price for the investment examples was finally decided to be 500 kSEK, which was agreed on at the evaluation workshop in Nov 19, 2012.

Maintenance

Cost for maintenance is not easy to estimate. We know that the prize for the CHAdeMO plug is close to 10 kSEK today. We also know that there is a need for regular visits from maintenance personnel and above that we need to add the cost for keeping the site free from trash, leaves, snow etc. Our estimation is that this ends up with at least 20 kSEK a year.

Some conclusions about those four examples of cost calculations are presented below.

5.1 Pay per minute

This example is intended to show a first ruff picture on a price per kWh for fast charging. The calculation is based on the assumption that the provider of a charger is an energy company with a concession to sell electricity and by that a low power-connection-price and the ability to get good trading fees on transferred energy.

Our assumptions

- 500 kSEK investment
- 10 years depreciation time
- 5 % interest rate
- 0.50 SEK/kWh (+ 0.29 SEK in taxes)
- 4700 kSEK/year net subscription fee

From this calculations we see that five charging occasions a day gives a price per kWh at approximately 5 SEK and if the average number of customers is one a day, the prize is as high as is 20 SEK, which is about 20 times more than what you pay for the energy back home. On the other hand we believe 5 SEK/ kWh to be OK if you really need to use the charger to get home. With a price per kWh on 5 SEK and a lot of EV customers (a customer frequency about 20 a day) you will get 3 SEK in extra profit for every kWh. 20 customers a day (2 every hour) from 12.00 to 22.00 is probably a maximum for a one charger site. This gives, on a yearly basis, some 300 kSEK in extra annual profit.

A table/graph showing price vs. charging occasions is presented below.

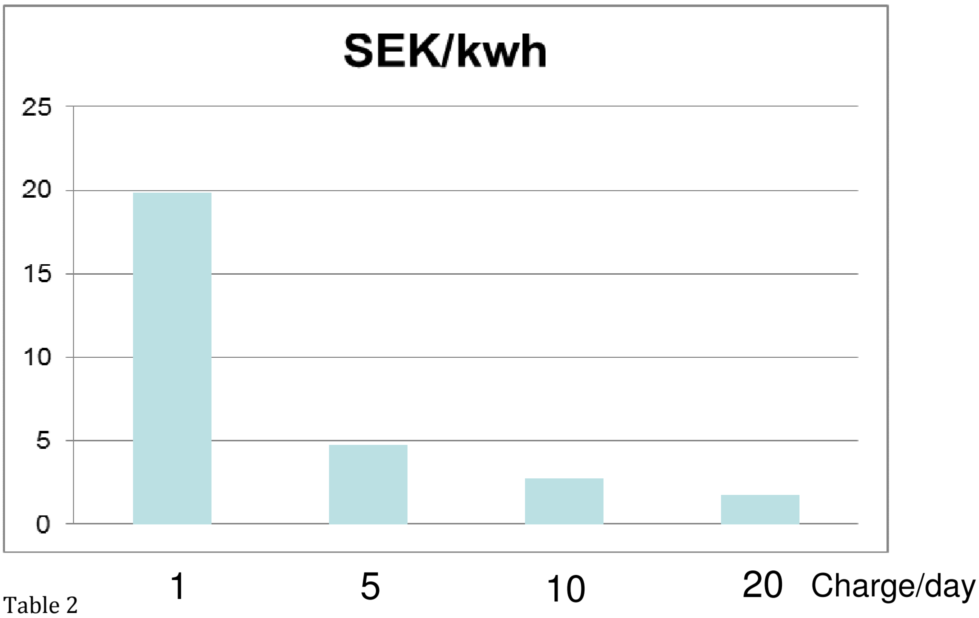


Table 2

From the SWE-NOR-cooperation we know that in Norway it is possible for a charge spot provider to charge for the electricity ***without*** mark up. In Sweden such an arrangement would require changes in the law. The Energy Markets Inspectorate in Sweden has proposed an exception from the network license requirement for electric grids that are reserved for recharging electric vehicles. This means that it would be possible for (non concession) actors, other than the grid operator/energy companies, to sell electricity to electric vehicles. The proposal is under treatment within the cabinet office. While waiting for this process another way to get paid for charging services is to include the cost of electricity in the parking fee. Below, see some examples with that approach.

5.2 Parking lot provider

Given the graph above an alternative way to calculate the need of daily charging activities was selected, based on an already established price model for a fast charge in Norway (Norsk Hydro). In this case the customer pays 45 NOK (53 SEK) for 15 minutes of charging with no extra fee for the transferred energy. Here the assumption is that the provider of the charger is a non energy company with no concession and therefore a higher prize for the power.

Our assumptions:

- 500 kSEK investment
- 10 years depreciation time
- 20 % simplified annual ROI-calculation (return of investment in approx. five years)
- 20000 SEK in annual maintenance (included "brooming", snow-removal. etc.)
- 0.75 SEK/ kWh (+ 0.43 SEK in transmission + tax)
- 36000 kSEK/year net subscription fee (non energy company /concession)

This calculation shows that you will need about 15 customers every day if you expect an annual interest of 20 %.

When reducing the ROI-figure to 10 % the need of customers is about 11 a day and with 5% ROI 9 customers is required.

The number of customers with the need to charge is highly dependent on the number of EVs on the roads. Added to that the number of customers willing/ready to take a chance and skip the fast charging will increase with increasing price per kWh. In this example the cost for the power is 400-500% higher than when charging back home. And you need to note that when you only have 15 minutes for charging and the battery might be colder than the optimum charging temperature the price per kWh could easily be as high 10 SEK.

5.3 Infrastructure provider

From the calculations above and given the fact that the introduction of EVs in Sweden is taking longer time than expected we can easily say that knowledge about the number of customers and their charging behaviour is essential to reduce the business risk. A solution to solve the chicken and egg problem, where no chargers will be installed before we have a critical mass of cars and no cars will be sold if you can't find any charger, is to provide access to a fast charging infrastructure for a fixed monthly fee.

To get a ruff picture on this type of access to a provided infrastructure we made a first assumption on a fixed annual price 1200 SEK, with the power included and six charging stations in a lager Swedish city like Gothenburg. The input to these calculations is:

- 240 kSEK investment/ charger (a lower price/charger due to the scale of the investment)
- 10 years depreciation time
- 30 % simplified annual ROI-calculation (to compensate for the high risk)
- 60000 SEK for maintenance (reduced compared to one single station)
- 0.75 SEK/ kWh (+ 0.43 SEK in transmission+ tax)
- 36000 kSEK/year net subscription fee (non energy company /concession)

From the calculation we can see that the need of customers is about 1000 in this example (with a 30 % ROI/year). If the provider will manage to get only 500 customers the first year there is still a possibility to get about 5 % in ROI for the first year.
It's still hard to say if this is the right way to establish a public fast charging. In Oslo, there is a good opportunity to attract enough customers since the EVs are quite popular already and the number of cars is way above the 1000 cars we are talking about in this example. But the business model still needs some work. One issue is that you probably need to have some restrictions on how much energy the customers will get for free by the monthly fee. With 1000 customers charging 15 kWh once every month the ROI will decrease from 30 % to 13 %. If the 1000 customers are charging once every week (means 20 customers a day) the profit from the infrastructure investment is close to zero.

5.4 Car pool/ Courier vans.

From the three examples above our conclusion is that a governmental and regional grant to reduce the high risk in the fast charging infrastructure business is essential. It will probably take a while before a city as Gothenburg will have more than 500 EVs compatible with the fast charging standard. From Norway we know that Transnova is giving grants on up to 200.000 NOK (240 kSEK) for the first fast charger and 100.000 NOK for the following chargers to stimulate the fast charger investments. But Norway has also decided to stimulate traditional EVs instead of Plug-in hybrids. Our picture is that the decision process in Sweden will take time. In order to learn more about the technique, the use and the economy we need to find as profitable solutions as possible before we take our next step in fast charging testing.

Our final example is based on a Car pool/Courier van case. Our assumption here is a company established in an old industry property with a 125 Amp connection to the grid and with a charger designed for indoor charging. The car fleet is four cars from the start and the annual mileage is estimated to 40000 km/ car. The input to these calculations is:

- 100 kSEK investment/ charger
- 10 years depreciation time
- 5% simplified ROI-calculation
- 10000 SEK for maintenance (reduced by charging indoor and few users)
- 0.75 SEK/ kWh (+ 0.43 SEK in transmission and tax)
- 36000 kSEK/year net subscription fee (non energy company /concession)

The calculations indicate 61000 kSEK in annual cost. The cost per km with four cars and fast charging 3 times a day is about 3.5 SEK/km, which is about three times higher than the normal “during the night charging”. (This calculation is based on three fast charging occasions per car due to the fact that a normal charging during the night is recommended to help the battery to recover and to save battery lifetime).
With a daily use of 200-300 km instead of 80-120 km and an assumption that we save 3 SEK compared to the fuel cost for a diesel car a brake-even for the investment will be given in only 2 years. But this calculation is based on the assumption that the company already owns the EVs and would like to add more EV-mileage without having an ICE-car operating on the high mileage routes.
Given the fact that the simple powertrain in an EV is, with only one moving part, supposed to be very cost effective in a maintenance point of view but, on the other hand, probably would suffer from high battery maintenance costs from intensive fast charging, we would like to support a demo project based on these examples to follow up the total cost of ownership for EVs in a Courier Van case.

6 Conclusions

To sum up a pioneer project like this isn’t easy. First of all a lot of the obstacles and delays are associated with the fact that it’s new technology and some of the products used in this project should be seen as something from the prototype stadium. We can also see that the technology is moving forward in a high pace. The product that we started our testing with is already yesterday’s stuff. The new charger at Ringön is a clear step forward, but even better products will soon come for sure. So, what can be considered as an objective picture and a good advice regarding fast charging then?

First of all, if you are going to install a fast charger we strongly advise you to read our fast charging guide and don't expect your project to be "Plug and play". Our picture is that there is still one or two steps left before we can say that fast chargers is a mature and easily implemented technology ready to operate on a 24/7 basis. The main reason for that might not be related to the quality of the charger itself, but instead due to maintenance issues and/or the non-finished process for the car-to-charger- communication. On the other hand the project partners agreed on the fact that in some cases the fast charger is **the** solution for the increased use of EVs. **So, in short: we really need to learn more!**

Further conclusions from the project are given below in a short and encapsulated headline form, for the reader to use while forming their own opinion of the pros and cons with fast charging. The main idea to write this down is to give the reader a picture on our internal dialogue within the project.

Fast chargers and green highways:

- Citroen declares a range up to 150 km on a full battery with the C-Zero
- At -13 ºC, with heater on the range is less than 70 km if you drive at 80 km/h
- Fast charging adds a loss of 10 km more in range due to the 80% limitation
- A "Green route" between city centers requires a charger every 50 km
- Stockholm – Gothenburg in wintertime will add 3 hours for charging (for 5 hours of driving)
- Note that the picture probably will be similar with the air conditioner on in July or August

Alternatives/complements to fast charging:

- "During the night charging"
- Hybrid cars
- Hybrid heaters
- Fuel cells as a range extender
- Inductive charging as a coming solution
- Range extenders to rent (trailers, roof-boxes)
- E-bikes and scooters in the city (decrease the number of cars to charge)
- Three wheelers and MCs for semi urban use
- Tow the car 50% of the "last mile" and drive home after that

Is there a standard?

(A ruff picture on different "opinions" in this area and according to the ongoing standardization dialogue in media and WWW):

- **CHAdeMO:** -"Use CANBUS communication to know what's going on with the battery. We don't like the Franken-plug. And why reinvent the wheel?"
- **Combo:** -"CHAdeMO communications protocol is so "yesterday" (outdated). We're using power line communications (PLC) so we can link up to the web. We don't like two charging doors on the car".
- **Tesla:** -"Our cars use the same small sleek connector for Level 2 and DC Fast Charging. It's smaller, simpler and faster than both of your approaches. We like to perform BMU on a higher level than you do".

- **Chinese EV Makers:** -"Hello? How come we didn't get an invitation to this meeting? Did you see our charging plug and outlet? In case you forgot, we're the biggest auto market in the world, and soon will be the biggest EV market in the world".

The fast charging summary in four bullets:

- Immature technology (as well as the providers and the users)
- Needs a lot of customers (or it becomes a very expensive solution)
- Is still needed and will prevent range anxiety
- Can easily double the range of a delivery car

About future project steps:

- Further test- and demo-project is essential
- Find delivery/courier and perhaps taxi fleet applications
- Tests with other standards and "semi-fast-charging"

About E-Mobility NSR

The Interreg North Sea Region project North Sea Electric Mobility Network (E-Mobility NSR) will help to create favorable conditions to promote the common development of e-mobility in the North Sea Region. Transnational support structures in the shape of a network and virtual routes are envisaged as part of the project, striving towards improving accessibility and the wider use of e-mobility in the North Sea Region countries.

www.e-mobility-nsr.eu

Contact Author(ing team):

Institution
Lindholmen Science Park AB

Name
Robert Granström

Phone
+46 70 648 00 42

Email
robert.granstrom@testsitesweden.com

Contact Lead Partner:

Hamburg University of Applied Sciences
Research and Transfer Centre "Applications of Life Sciences"
Prof. Walter Leal
Lohbruegger Kirchstrasse 65
21033 Hamburg
Germany

Phone: +49-40-42875-6313

Email: e-mobility@ls.haw-hamburg.de