

# OVERALL PLAN FOR EV CHARGING INFRASTRUCTURE BETWEEN ST. PETERSBURG AND KOTKA ALONG THE E18 HIGHWAY

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According to the Finnish national programme for the distribution network of alternative power for transport, the goal is to increase the number of electric cars in Finland to 263,000–250,000 passenger cars and 13,000 vans – by 2030. (Liikenne- ja viestintäministeriö 2017) According to Finland's national target, by 2030 there should be 25,000 public recharging points in Finland. The charging infrastructure should cover all municipalities and cities, transport hubs, TEN-T core network ports, railway stations and airports. In the road network, there should also be recharging points on main roads. (Liikenne- ja viestintäministeriö 2017)

This study is part of the Green Energy Regional Markets Development (Green ReMark) project funded by the South-East Finland–Russia CBC 2014–2020 programme and project partners. The project partners are Peter the Great St. Petersburg Polytechnic University, the South-Eastern Finland University of Applied Sciences, Miksei Oy and Neva Energy Ltd. In this study, sites suitable for public charging points for electric cars were identified on the section of the E18 road between Kotka and St. Petersburg. The aim was to provide a comprehensive charging infrastructure and map out business opportunities in connection with the charging places.

## THEORY

The charging infrastructure covers public, semi-public and private charging points. A well-functioning charging infrastructure is a prerequisite for the proliferation of electric vehicles. (Salonen et al. 2015) Among the charging operators on the Finnish side, between Kotka and Vaalimaa, Liikennevirta, Fortum Charge & Drive, Lidl, K-lataus and Tesla operate (Latauskartta.fi). In addition, Motonet Motolataus and Ionity operate elsewhere in Finland. On the Russian side between Vyborg and St. Petersburg, Lenenergo and E-mobility operate mainly (Lenenergo.ru). Tesla is planning to establish one charging station in the Ogonk area. In addition, elsewhere in Russia, Moesk operates mainly in the Moscow region.

The most important regulations concerning charging infrastructure and charging points are EU Directive 2014/92/EU (Distribution Infrastructure Directive) and the Act on the Distribution of Alternative Fuels for Transport 2017/478 (Distribution Infrastructure Act). The Distribution Infrastructure Directive has been implemented by the Distribution Infrastructure Act.

## **CHARGING INFRASTRUCTURE AND BUSINESS OPPORTUNITIES AT CHARGING PLACES**

In Finland, the charging infrastructure has developed rapidly in recent years, but there are still too few fast charging opportunities, especially in Eastern and Northern Finland. Public charging places for electric cars are most often set up on market terms. The charging station should be located in a place where electric motorists can easily stop to charge. When establishing charging points, the standards and recommendations for charging stations and charging points as well as the electrical connections to the charging station must be taken into account. Remote management allows user authentication and billing of the charging. It facilitates the maintenance and servicing of charging stations and speeds up the response to potential problems. (Karppinen 2014)

The proliferation of electric cars has brought a new kind of thinking to motoring. Because charging takes longer than refuelling an internal combustion engine, other services are relevant to the charging experience. To ensure a sufficiently high-quality service, the charging point must be easy to find and it must be possible to pay for the charge according to the energy used. (Teknologiatoimisto 2017, Kupiainen 2013) According to Kupiainen (2013), the most important services in connection with public charging services are dining and shopping services, as well as a safe and comfortable playground for children. As electric cars become more common, the customer base will increase and diversify, which will bring new types of service needs in the future that have not yet arisen. On the other hand, traditional services available from petrol stations such as car washing and cleaning as well as tyre pressure measurement/inflation are desirable services when charging an electric car. Electric car charging stations require maintenance and repair work. This provides business opportunities for companies providing electrical work and increases the need for training services for both the staff of electrical companies and car dealers' own maintenance and repair staff. (Kupiainen 2013)

Pricing and payment practices vary widely. From a customer perspective, pricing should be moderate and, where possible, part of the customer service. From a business perspective, providing a charging option can bring in more customers, but its cost should be able to be covered by debiting for the charging.

## MATERIAL AND METHODS

The charging network was examined on the section of the E18 highway between Kotka and St. Petersburg. For the planning of the charging infrastructure, surveys were conducted with fuel distribution chains and electric motorists operating in Finland. In addition, questions were sent to charging operators operating in Finland. Information on existing charging locations and charging points was collected from the Latauskartha.fi, Lenenergo.ru and Electromobili.ru services. Potential sites suitable for charging places were investigated on-site by driving the route and making observations of the sites. The findings were augmented using Google Maps.

Traffic volumes on the selected road section on the E18 highway vary. The largest traffic volumes, 15,439–32,549 vehicles per day, are located on the section between Kotka and Hamina and in Kotka on Hyväntuulentie. (Väylävirasto 2020) In 2019, a total of 978,945 vehicles crossed the Vaalimaa border. The same numbers travelled from Finland to Russia as from Russia to Finland. (Väylävirasto 2020b)

## RESULTS AND REVIEW OF RESULTS

Petrol stations have little capacity to charge electric cars. There are 31 petrol stations between Kotka and Vaalimaa, only two of which offer a charging option for an electric car. However, a few petrol stations plan to introduce charging points in the next few years. The reason for the low number of charging options for electric cars may be that the charging option is not yet having a significant impact on the number of petrol station customers. Not everyone has enough information on subsidies for setting up charging points for electric cars, which may be part of the reason why petrol stations have not built charging points. On the other hand, public charging points are constantly being built in connection with various public buildings where other services are also available.

Electric cars are often charged at home during the night. Home slow charging is ideal when arriving during the day or overnight. For long journeys, it is important to be able to charge the car quickly, and charging points should be plentiful enough. Charging points should preferably be accessed without queuing and should be successful in less than an hour. Slower charging powers are best for charging hybrids. Public charging places should have charging points for both slower charging and fast charging.

The most popular services at the charging points are restaurant and café services and a grocery store. Other shops, outdoor sports or nature trails and petrol station services, as well as accommodation services, are needed at least every now and then. Service needs vary greatly. All kinds of services and recreational opportunities lasting 0.5 to 2 hours are desirable. Primarily, however, the charging place is selected based on the fast charging option.

The following points were made regarding the charging places:

- The power of the quick charging points should be at least 50–100 kW. That, too, may soon be too little, and even greater powers were presented.
- Quick charging stations must be sufficiently plentiful along the way, for example every 50 to 100 kilometres.
- Charging places should be clearly marked and they should be maintained and reliable.
- Snow-ploughing to charging points in winter should be taken care of so that it is possible to drive there.
- Access to the charging station with a boat trailer or trailer should be ensured.

Electric car charging stations are expected to be reliable, convenient, flexible and reasonably priced. On long trips, families need entertainment for children in addition to food and coffee. Frustrating queuing should be eliminated by increasing the number of charging points. Power-based pricing combined with time-based pricing would work best for many. It pays for the charge on the amount of power charged, but if the car is parked for a longer time at the charging point, the charge becomes time-based.

Two out of five charging operators responded to the questionnaire. Kesko's charging network includes more than 75 charging stations and 400 charging points. Pricing is per minute and the same for all chargers. An unregistered charger will also be charged a start-up fee of one euro. Kesko's K-lataus is actively exploring the possibilities of increasing charging points across Finland and would promote electric motoring by supporting the construction of charging points.

Liikennevirta (Virta) has about 2,000 charging points in Finland and about 15,000 worldwide. In addition, the roaming connection enables the use of 100,000 charging stations for Virta's customers. It has more than 300 charging network owners as customers who invest in charging points around the world. The price base for the charging depends on the owner of the charging network. Virta would promote electric cars in Finland in many different ways. Supporting the purchase of electric cars would bring electric cars to the used car market faster. Subsidies for the construction of the charging network and charging points are necessary in order to make the fast charging network cover the whole of Finland in particular. The price of electricity should be regulated so that charging an electric car would be more economically viable for the user than refuelling an internal combustion engine car. Fiscal means can be used to favour the purchase and long-term rental of all-electric cars. Virta see tax breaks for all-electric company cars as one of the most significant means. Other ways to promote electric cars include everyday facilities such as cheaper parking pricing for electric cars.

Virta has a few two-way charging points to balance the electricity grid, and more are under construction. As part of the service, the owner of an electric car can in the future utilise the

car battery as an energy store at home and contribute to balancing the electricity market. According to Virta, the chargers that enable bidirectional charging can only be found in test use presently.

## ESTABLISHING A CHARGING STATION IN CONNECTION WITH A BUSINESS LOCATION

Public charging points are often set up in connection with existing services and functions. An example in this review was the retail store in Hamina. The store is located in the immediate vicinity of the E18 highway and there is also a lunch restaurant on the store property. The store is open 8 hours a day, every day. The charging station should be equipped with transaction charging points, in which case it will best serve customers who visit the store and possibly use the services of a lunch restaurant. For customers in a hurry, fast charging is also required.

If four 22 kW charging points and two 50 kW charging points are installed at the charging place, the total cost of the investment will be approximately € 46,900–60,800. The price includes charging equipment, excavation work, cabling (up to 10 metres) and electricity for additional capacity booking fees. The price is greatly influenced by, among other things, what kind of services are required to be connected to the charging stations. The power fee and the service and maintenance costs total fixed costs of approximately € 13,400 per year. Variable costs – approximately € 13,000 – arises from the amount of energy used for charging. The costs are shown in Table 1.

**TABLE 1.** Investment costs, fixed costs and variable costs of charging stations (4x22 kW and 2x50 kW charging points)

<b>Investment costs</b>	Purchase	€ 33,500–€ 39,400
	Installation work	€ 7,000 –€ 15,000
	Additional electricity capacity	€ 6,368
<b>Fixed costs</b>	PJ power charge	€ 10,445 per year
	Service and maintenance	€ 3,000 per year
<b>Variable costs</b>	Electricity *)	€ 13,099 per year

\*) includes: electrical energy, electricity transmission, electricity tax

The PJ power charge arises from an additional power of 188 kW (4 x 22 kW + 2 x 50 kW) and is 4.63 € / kW / month (Kymenlaakson Sähkö). The reservation fee for additional electricity capacity is based on the same reservation fee for the additional capacity of 188 kW. The service and maintenance costs are estimated at around € 1,000 per charging station. The following assumptions have been used for variable costs: charging is possible during store opening hours (8 hours / day 360 days a year), the utilisation rate is 30 % and the price of electricity is 10 cents / kWh. The calculations do not take into account possible subsidies for the construction of charging stations.

The calculation assumes an interest rate of 5 % and a useful life of 10 years, after which the

residual value of the investment is € 0. Table 2 shows the annual cost of the investment. The investment costs have been converted into annual fixed costs. The annual fixed costs per year vary between € 19,420 and € 21,200. The variable costs are approximately € 13,100 per year.

**TABLE 2.** Annual costs of charging stations (minimum and maximum)

<b>Fixed costs per year</b>	<b>€ 19,420.95</b>	<b>€ 21,193.20</b>
purchase	€ 4,271.25	€ 5,023.50
installation work	€ 892.50	€ 1,912.50
additional electricity capacity	€ 811.92	€ 811.92
PJ power charge *)	€ 10,445.28	€ 10,445.28
service and maintenance	€ 3,000.00	€ 3,000.00
<b>Variable costs per year **)</b>	<b>€ 13,099.35</b>	<b>€ 13,099.35</b>
<b>Total costs per year</b>	<b>€ 32,520.30</b>	<b>€ 34,292.55</b>

\*) 4.63 € / kW (reserved additional electricity capacity) / month

\*\*) electrical energy, electricity transmission and electricity tax total 0.10 € / kWh, 30 % utilisation rate

The costs are indicative. For example, the cost of the additional capacity and the electricity may be lower than in the calculations, because the need for additional capacity depends on the adequacy of the company's current capacity and the cost of the electricity depends on the utilisation rate of the charging points.

In order for the construction of charging stations to be profitable, the revenues should cover the costs of investment and operating costs. There are various calculation programs for profitability calculation on the Internet. Some of them are free of charge and openly available to users, such as the Investment Profitability Calculator prepared by Mika Mujunen ([www-address: https://mikamujunen.com/investoinninkannattavuuslaskuri/](https://mikamujunen.com/investoinninkannattavuuslaskuri/)) and Cursor Oy's YT14 Investment Profitability Calculator ([www address: https://yritystulkki.fi/fi/alue/cursor/toimiva-yrittaja/tiedostot/](https://yritystulkki.fi/fi/alue/cursor/toimiva-yrittaja/tiedostot/)).

## SUMMARY AND PROPOSALS

Electric cars are becoming more widespread both in Finland and elsewhere in the world. The main obstacles to the spread of electric cars are the high price of all-electric cars, the inadequate charging infrastructure and shortcomings in battery technology. The charging infrastructure is mainly developed in a market-oriented manner. The experiences and opinions of electric motorists must be carefully taken into account when planning the charging infrastructure. The distance between EV charging stations should not be more than 50 kilometres.

The out-of-home charging location is primarily selected based on the fast charging option. The choice is also influenced by the price of the charge and other services and the smoothness of the charge. Electric car charging stations are expected to be reliable, convenient, flexible and reasonably priced. Every motorist has their own needs. On long trips, families need entertainment for children in addition to food and coffee. Frustrating queuing should be eliminated by increasing the number of charging points.

Pricing and payment for a charging transaction will vary depending on the charging operator. The same operator may have different payment bases and use different combinations. Payment should be effortless and clear. Common charging criteria should be set for public charging points and payment should be harmonised so that the customer does not have to download different applications to a mobile device or obtain RFID tags. Comparing the cost of charging is also made easier when comparable information on charging costs is available.

As a result of the review, 12 locations were selected for the E18 highway section between Kotka and St. Petersburg, three of which are located on the Finnish side and nine on the Russian side. The new charging points will ensure that fast charging is possible at intervals of up to 50 kilometres and that electric car charging points will be available at important traffic junctions. The two traffic junction sites are located in an important intersection area. They may not have other services available, but from the point of view of the charging infrastructure, the creation of charging points for them is justified. In terms of location, they are optimal park-and-ride car park spaces.

The acquisition of electric cars and the construction of the charging infrastructure are quite well supported by the EU and the Finnish state, which contributes to the promotion of electric cars. Public subsidies are worthwhile at this stage, as development is advancing at a rapid pace and the technologies are still relatively new. On the other hand, public subsidies may distort competition between different driving forces. A well-to-wheel approach should therefore be introduced to support alternative propulsion, taking into account the life-cycle impacts of motoring.

Electric cars are being acquired at an accelerating rate. Charging options have also increased. While setting up a charging station involves a lot of risk and uncertainty, providing a charging option to customers can bring more customers to the business. At the very least, it can prevent businesses from losing customers to competitors. A functioning charging network also requires a functioning electrical network and smart charging.

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