

Saimaa University of Applied Sciences
Faculty of Business Administration Lappeenranta
Degree Programme in International Business

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Electric vehicle charging stations in Finland – now and tomorrow

Thesis 2016

Abstract

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Instructor: Senior Lecturer Timo Saarainen, Saimaa University of Applied Sciences

The purpose of this thesis was to find out the current situation in Finland's electric vehicle charging station infrastructure, and how it is developing. The research was also done to determine how industry insiders view the market and hope it to be developed. One objective was also to determine if Finland should commit to one or a few of the proposed standards for electric vehicle charging.

Data for this thesis were gathered from academic literature, Internet sources, and professional journals. This data was gathered to gain insight into the current situation in the Finnish electric vehicle charging station market and its future development. For the empirical part, data was gathered by semi-structured interviews over telephone from industry insiders working in electric vehicle production or electric vehicle charging station infrastructure development. Both qualitative and quantitative data was gathered.

The result of this thesis was that the current situation in Finland's electric vehicle charging market is in its infancy, and that industry insiders perceive the largest barrier for growth to be a lack of political will. Based on the findings, commitment to one or a few charging standards is not necessary on a national level. Further study is required to determine best methods for overcoming lack of political will.

Keywords: Electric vehicle, charging station, EV, charging infrastructure

Table of contents

1	Introduction	5
1.1	Background.....	5
1.2	Objectives	5
1.3	Limitations.....	5
1.4	Delimitations	6
1.5	Research question and method	6
2	Electric vehicle.....	7
2.1	Electric vehicles in general	7
2.2	Basics of electric vehicle charging	8
2.2.1	Power level.....	8
2.2.2	Electrical current.....	9
2.2.3	Plug	9
2.2.4	Battery size	9
3	Electric vehicle charging infrastructure	9
3.1	Charging methods	9
3.2	Charging stations & competing standards	11
3.2.1	CHAdeMO.....	11
3.2.2	SAE Combined Charging Solution	11
3.2.3	Tesla Supercharger	12
3.3	Using a charging station	12
3.3.1	Business driving forces	13
4	Comparisons of electric vehicle charging markets.....	14
4.1	Electric vehicle charging infrastructure in Finland.....	15
4.1.1	Governmental incentives for electric vehicle purchase in Finland ..	17
4.2	Electric vehicle charging infrastructure in Sweden.....	17
4.2.1	Governmental incentives for electric vehicle purchase in Sweden ..	18
4.3	Electric vehicle charging infrastructure in Norway	19
4.3.1	Governmental incentives for electric vehicle purchase in Norway ..	19
4.4	Comparisons.....	21
5	Factors affecting electric vehicle charging infrastructure	21
5.1	Legislation and policies.....	21
5.2	Government incentives for electric vehicle charging stations.....	22
5.3	Environmentalism	22
5.4	Range anxiety.....	23
5.5	Batteries.....	24
5.5.1	Small-format cells.....	24
5.5.2	Large-format cells.....	24
6	Empirical research	25
6.1	Methodology of this study	25
6.2	Interviews with industry insiders	26
6.2.1	Data collection and data analysis	26
6.2.2	Interview participants.....	26
6.3	Current situation	27
6.3.1	Interviewees opinions of current infrastructure in Finland	27
6.3.2	Interviewees opinions on standards and directives concerning charging station infrastructure.....	28
6.3.3	Interviewees commitment to certain charging methods.....	29
6.3.4	Interviewees opinions on Finland having a competitive edge in electric vehicle charging infrastructure compared with other nations	30

6.4	Risks in the current market	31
6.4.1	Perceived risks in the Finnish charging station market.....	31
6.4.2	Perceived risks in the global charging station market.....	32
6.4.3	Views on adaptability in shifting markets.....	33
6.5	Views of the future	34
6.5.1	Interviewees opinions on development of electric vehicle charging station infrastructure in Finland.....	34
6.5.2	Most important aspects of developing Finland's charging station infrastructure.....	35
7	Summary and discussion.....	36
	Figures	39
	Graphs	40
	Tables	41
	References.....	42

Appendices

Appendix 1	Interview questions
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1 Introduction

1.1 Background

The infrastructure that enables consumers to use electric vehicles is as important as the electric vehicles themselves. The best possible infrastructure development can be found by researching what more developed market areas have done, and by learning from their practices.

The most important aspect about building the best possible infrastructure for electric vehicles is the ability to provide consumers with viable options to replace vehicles producing tailpipe emissions and move from fossil fuels to renewables. By creating the best possible infrastructure for electric vehicles, the public and the private sector can ease the transition into the use of sustainable energy in automotive transportation.

A well-developed electric vehicle charging infrastructure brings down barriers that consumers might have when considering electric vehicles as their primary transport in both urban and rural areas.

1.2 Objectives

The purpose of this study is to examine the current state of Finland's electric vehicle charging infrastructure, and to gain insight into how the market will likely develop. The study will focus on the functions and distribution of charging stations – as they are the most integral part of electric vehicle infrastructure.

1.3 Limitations

The empirical study in this thesis focuses on the perceptions of industry insiders in fields like electric vehicle production and electric vehicle charging station infrastructure development. Due to the nature and scale of the empirical study, the suggestions made regarding incentives and policy changes are limited to the views of the professionals working in the fields mentioned above.

1.4 Delimitations

This study will not be focusing on the functions of the Finnish power grid as a part of the electric vehicle charging infrastructure.

This study will not focus on battery replacement methods and the infrastructure built around switching batteries from old to new ones in electric vehicles.

1.5 Research question and method

The main question this research is aiming to answer is: What is the current situation in Finland's electric vehicle charging infrastructure, especially regarding electric vehicle charging stations, their locations and methods of charging?

The second question to answer is: How do industry insiders view the current market, and how they hope to see it develop?

The third question is to find out if Finland should commit to one, or a few of the proposed standards for electric vehicle charging methods?

The method for acquiring empirical data was telephone interviews of people within the electric vehicle production, or charging station infrastructure industry. This method was chosen due to the author's experience in acquiring data from interviews over telephone, and the ability access data from open questions that would otherwise be inaccessible to the author in the required timeframe. The method of this study is qualitative. The aim of qualitative research is gain understanding of the researched subject. This method allows the describing of specific situations using research tools like interviews and observations. (Saukkonen 2015)

The data acquired from interviewees will be held confidential, and the interviewees or their organisations will not be named. This allows the interviewees to speak frankly and not worry about giving competitors direct information about their practices. (Burke & Miller 2001)

2 Electric vehicle

As the electric vehicle charging infrastructure relies heavily on the existence of an electric vehicle fleet that uses it, this chapter will explain common terminology and basics of electric vehicles. Aspects of charging an electric vehicle will also be explained.

The most commonly known electric vehicles in Europe are Renault Zoe, Nissan Leaf, Tesla Model S, Volkswagen e-Golf and the BMW i3, which made up over 75% of European electric vehicle sales in 2016 to date as Figure 1 shows.

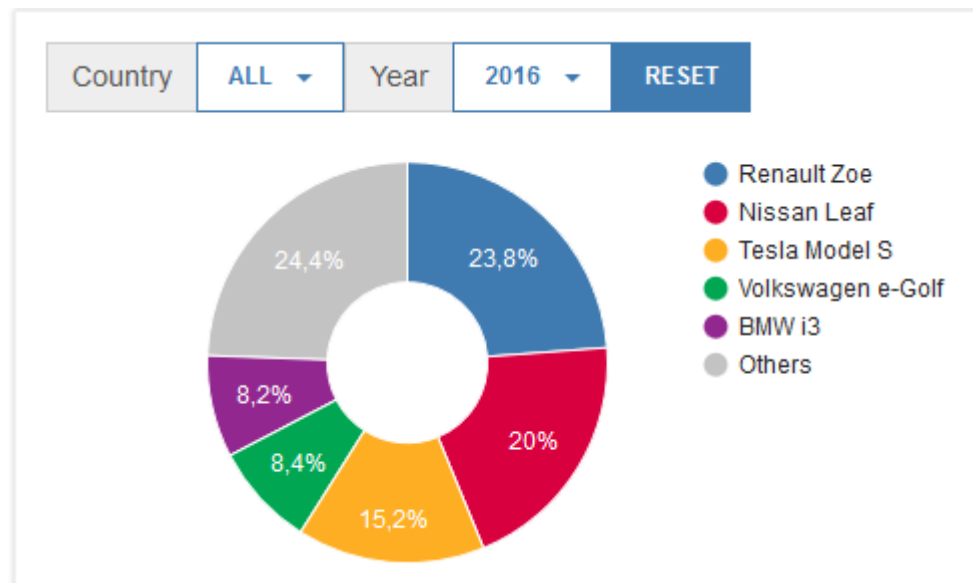


Figure 1. Electric vehicles sold in Europe 2016. (EAFO, 2016)

2.1 Electric vehicles in general

The term electric vehicle comes from the fuel it uses. Unlike traditional personal transportation vehicles, which use an internal combustion engine (ICE) and petroleum as fuel, the electric vehicle's engine is a motor powered by electricity which gets its electricity from an on-board battery.

There are two types of electric vehicles. All electric vehicles or battery electric vehicles (BEV's) - and hybrid electric vehicles or plug-in hybrid electric vehicles (PHEVs). Both of these vehicle types fall under the term plug-in electric vehicle (PEV). BEVs only use electricity as their energy source, whereas PHEVs can

switch to gasoline based ICE engines or other fuel types in case of running out of charge in their battery packs.

According to EAFO, there are currently 526,498 PEV's registered in Europe. (EAFO 2016)

2.2 Basics of electric vehicle charging

There are a few methods of charging an electric vehicle, but by far the most common way is to charge it by a cable that is attached to the vehicles port by a plug. The power level of the station used for charging, the electrical current used, the plug used and the battery that is being filled up define which electric vehicles can be charged, where they can be charged and how long it takes. (Amsterdam Roundtables Foundation 2014.)

Inductive charging is also discussed as a method for charging electric vehicles. Inductive charging does not require a cable to be connected to a charging station and the vehicle, but uses an electromagnetic field to transfer energy between the charging station and the vehicle. However, this method of charging is not yet in wide commercial use due to the high costs of current technological solutions. (Eckhardt 2014.)

2.2.1 Power level

The power level of a charging source is always expressed in kW. The power level is defined by the voltage and current of the power supply. The power level determines how long it takes to charge the battery of an electric vehicle.

There is a very large range in the power levels that chargers supply to electric vehicles. Charging stations range from a 3.3kW output, to up to 145kW output. (Lambert 2016). Charging an electric vehicle at home is usually done with a low power level such as the common 3.3kW-3.7kW range, and consumers who wish to use higher power levels usually have to upgrade their connection to the local power grid. (Amsterdam Roundtables Foundation 2014.)

2.2.2 Electrical current

Electricity from the power grid is provided in alternating current (AC) and as batteries can only store direct current (DC), the electricity from the power grid has to be converted into DC. Most charging stations have a converter integrated into the charging station that converts the AC to DC, however most electric vehicles have an on-board AC-to-DC converter that allows the vehicle to charge directly from an AC source. (Amsterdam Roundtables Foundation 2014.)

2.2.3 Plug

Currently, many different types of plugs and sockets are used to connect electric vehicles to charging stations. For slower charging, a type 2 “Mennekes” is standard in Europe, after a 2013 decision by the European Commission. (LeSage, 2013.) The “Schuko” plugs are also used in Finland, as they can be used with the heating poles that can be found in most Finnish parking spaces. For type 3, or “fast charging” there are three major competing standards which will be examined by the author in chapter 3.1 of this thesis.

2.2.4 Battery size

Electric vehicles have different power level thresholds and current types that they can accommodate. These factors are determined by the battery size of the vehicle in question. Smaller batteries are limited to a maximum of 3.7kW, while larger batteries can take up to 22kW of AC or 120kW of DC. (Amsterdam Roundtables Foundation 2014.)

3 Electric vehicle charging infrastructure

3.1 Charging methods

There are currently several different methods for charging electric vehicles in the market. The author will focus on charging stations in this study, as they are the most essential part of electric vehicle charging infrastructure.

Charging stations deliver the energy to the vehicle's battery. This is usually done in the form of high voltage alternating current (AC) or high voltage direct current

(DC). Manufacturers currently have several different designs for these cables and ways to connect the car and the charging station.

Charging methods are often classed by power levels.

- Level 1 refers to single phase alternating current (AC) using grounded plugs, as used in most domestic appliances that require power. In European countries this often refers to 10 or 16 Amps at 220-240 Volts delivering a power level starting at 3,3 kW of power. This is also known as “slow charging”. (Sähköinen liikenne 2014.)
- Level 2 delivers up to 20 kW of power from either single or three phase AC sources of 208-240 Volts at up to 80 Amps. Level 2 charging is the recommended choice as the charging method at the consumers’ homes where the vehicle is charged most often. This method takes up to 6 hours to charge a vehicles battery. (Sähköinen liikenne 2014.)
- Level 3 refers to DC charging, or “fast charging.” To achieve very short charging times, level 3 chargers supply very high power levels up to 140kW. (Electropaedia, n.d.) This method usually charges the car’s battery up to 80% in approximately 30 minutes. (Sähköinen liikenne 2014.)

The most commonly discussed terms for charging are:

- Home- or work charging – which is often a low-to-mid level current charging method (Level 1 – Level 2). This method of charging can use lower power levels as the vehicle is usually parked for longer periods, and a high speed of charging is not mandatory. This method of charging is also used as a customer retention and attraction tool in shopping areas. (Herron 2016.) Level 1 charging uses a Mennekes type 2 plug, or a Schuko plug.
- On-the-go charging (Level 2 – Level 3). This method is usually used in places like service stations, where electric vehicles are parked for shorter periods. These chargers are usually DC fast chargers. The charger types are most commonly CHAdeMO or CCS chargers.
- Supercharging (Level 3). Superchargers are Tesla Motors’ proprietary technology and can only be used by Tesla Motors vehicles. Superchargers are currently the fastest method of charging an electric vehicles battery.

3.2 Charging stations & competing standards

3.2.1 CHAdeMO

CHAdeMo – an abbreviation of “Charge de Move” which means “move using charge” is currently the standard charging method for the following vehicle manufacturers:

- Citroën
- Honda
- Kia
- Mazda
- Mitsubishi
- Nissan
- Peugeot
- Subaru
- Toyota

CHAdeMO has currently installed 13295 fast chargers globally, of which 6958 are in Japan, 3866 in Europe, 1956 in the USA, and 515 in other locations (CHAdeMO 2016). The CHAdeMO can also be used with the Tesla Motors vehicles with a Tesla CHAdeMO adapter accessory (Tesla Motors 2016).

CHAdeMO charging stations are DC charging stations, which means that the AC electricity from the grid is converted into DC within the charging station before being transferred to an electric vehicle that is being charged.

3.2.2 SAE Combined Charging Solution

SAE Combined Charging Solution, also known as the SAE Combo or CCS. The CCS uses a J1772 plug with 2 additional DC fast charging ports below it. (Field 2016.) This standard is being used by the following vehicle manufacturers:

- Audi
- BMW
- Daimler
- Ford

- General Motors
- Porsche
- Volkswagen

The CCS functions both as an AC and DC charger, as shown in figure 2.



Figure 2. CCS Charging functions (Charin 2016)

According to EAFO (2016), there are currently 48 CCS charging positions in Finland, and 2775 in Europe.

3.2.3 Tesla Supercharger

The Tesla Supercharger is a charging method created by Tesla Motors and is currently the fastest method of charging an electric vehicle. The Tesla Supercharger is a DC charging station, that can only be used by Tesla Motors' vehicles. (Field 2016.) According to EAFO, there are currently 20 Tesla Supercharger positions in Finland, and 1479 in Europe (EAFO 2016).

3.3 Using a charging station

Charging stations vary in composition of available charging methods. Figure 3 below shows a Fortum Charge & Drive charging station. The charging station is equipped with both CHAdeMO and CCS standard chargers, and as most charging stations is a level 3 "fast charger".



Figure 3. Charging station. (ABC, n.d.)

To use a charging station, the consumer must first verify that the charging method of the station is compatible with the charging method of the vehicle. After this, consumers use the charging stations preferred method of identifying themselves which is usually done by a mobile app, RFID-card or keychain, or by text message. After this the consumer plugs the charging stations plug into the power socket on the vehicle. Fast charging generally charges most cars to 80% charge in 30 minutes, which relates to roughly a 100 km range. (Sähköinen Liikenne 2014.)

3.3.1 Business driving forces

The major operators in the field of electric vehicle charging stations in Finland are Fortum Charge & Drive, and the network of charging locations developed and managed by Virtapiste, also known as Liikennevirta Oy.

Fortum Charge & Drive operates in Finland, Norway and Sweden with their own network of charging stations, and a turnkey charging solutions being sold to infrastructure investors (Fortum 2015).

Virtapiste or Liikennevirta Oy operates in Europe as seen in Figure 4 below, as both an infrastructure developer and network manager for companies like Helen.

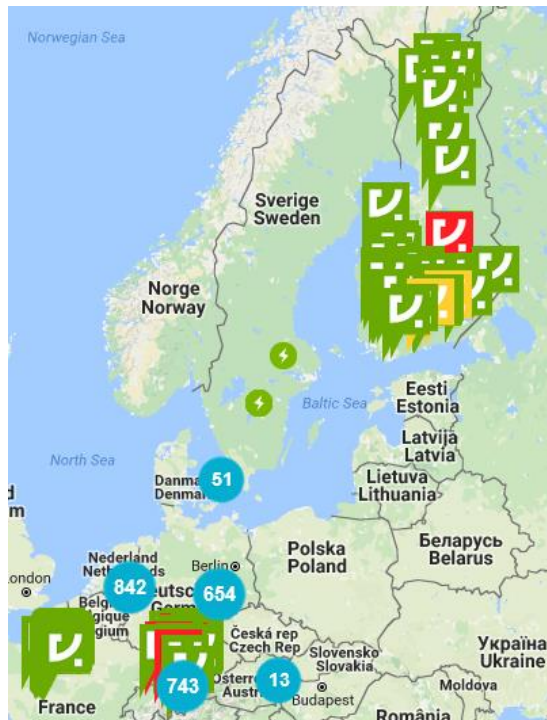


Figure 4. Virta charging stations in Europe. (Virta 2016)

Virtapiste handles Helen's and many other companies' payment systems for electric vehicle charging, as well as customer service and an app which has the locations of all Liikennevirta charging stations. (Helen 2016.)

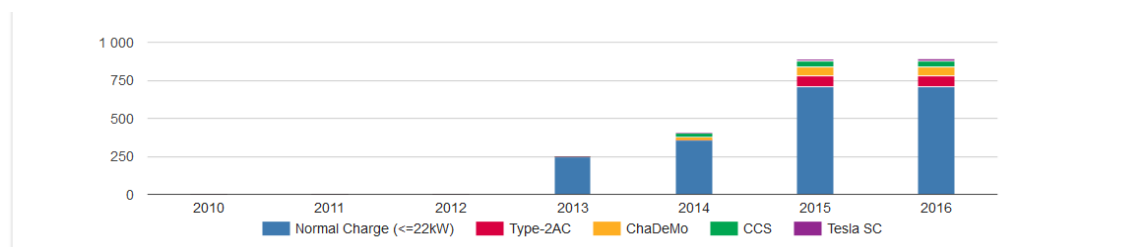
4 Comparisons of electric vehicle charging markets

In this chapter the author will research the differences between the Finnish, Swedish and Norwegian electric vehicle charging infrastructures. These nations were chosen to be compared due to their similar societal structures, living standards, climate conditions and the level of difference in their electric vehicle charging station infrastructure.

It is important to indicate that as this chapter addresses the amounts of electric vehicles and possible charging locations the author has to make a distinction between charging stations and charging positions. Charging stations may have several charging positions available, and several electric vehicles can be charged simultaneously at a charging station.

4.1 Electric vehicle charging infrastructure in Finland

According to the European Alternative Fuels Observatory (EAFO 2016) there are currently 906 charging positions in Finland as shown below by graph 1.



Graph 1. Electric vehicle charging positions in Finland in 2016 (EAFO 2016)

These charging positions consist of 706 type 2 positions, 70 type-2AC positions, 62 CHAdeMO positions, 48 CCS position and 20 Tesla Supercharger positions as seen in Graph 1.

This network of 906 positions is serving an electric vehicle fleet of 736 BEV's and 1855 PHEV's to a combined amount of 2591 PEV's as seen in Table 1 below.

Fuel Source	BEV					PHEV		PEV	
Vehicle Category	L	L6+L7	M1	N1 (Light	M2 +	M1	M2 +	M1	M2 +
Country	(Motorbikes)	(Quadricycles)	(Passenger cars)	Commercial Vehicles)	M3 (Buses)	(Passenger cars)	(Buses)	(Passenger cars)	M3 (Buses)
EU 28	2.550	19.270	188.226	40.579	571	219.272	191	407.498	762
Austria		581	7.740	1.167	138	2.864		10.604	138
Belgium	816	952	5.349	547	3	9.505	120	14.854	123
Denmark		416	8.154	520	3	854		9.008	3
France	246	4.800	61.167	25.376	29	14.701	1	75.868	30
Germany		4.833	38.247	4.417	40	27.899		66.146	40
Italy		2.811	4.878	1.031		2.554		7.432	
Netherlands	327	976	11.986	1.579	99	84.730		96.716	99
Spain	588	2.382	5.648	1.706	37	2.757	50	8.405	87
Sweden		370	7.050	1.252		18.318	17	25.368	17
United Kingdom		607	29.837	2.135	76	49.564	3	79.401	79
Bulgaria	159	16	20		51	31		51	51
Croatia	184	74	180	52	2	62		436	2
Cyprus			9	3		44		53	
Czech Republic			790	70	14	299		1.089	14
Estonia			1.130	28	24	55		1.185	24
Finland	166		736	128	2	1.855		2.591	2
Greece								163	

Table 1. Vehicle fleet 2016. (EAFO 2016)

The dispersion of charging stations can be seen in Figure 5 below. The current electric vehicle charging station infrastructure is focused mainly around three large cities in Finland – Helsinki, Turku and Tampere. Eastern and northern areas in Finland lack charging station infrastructure.

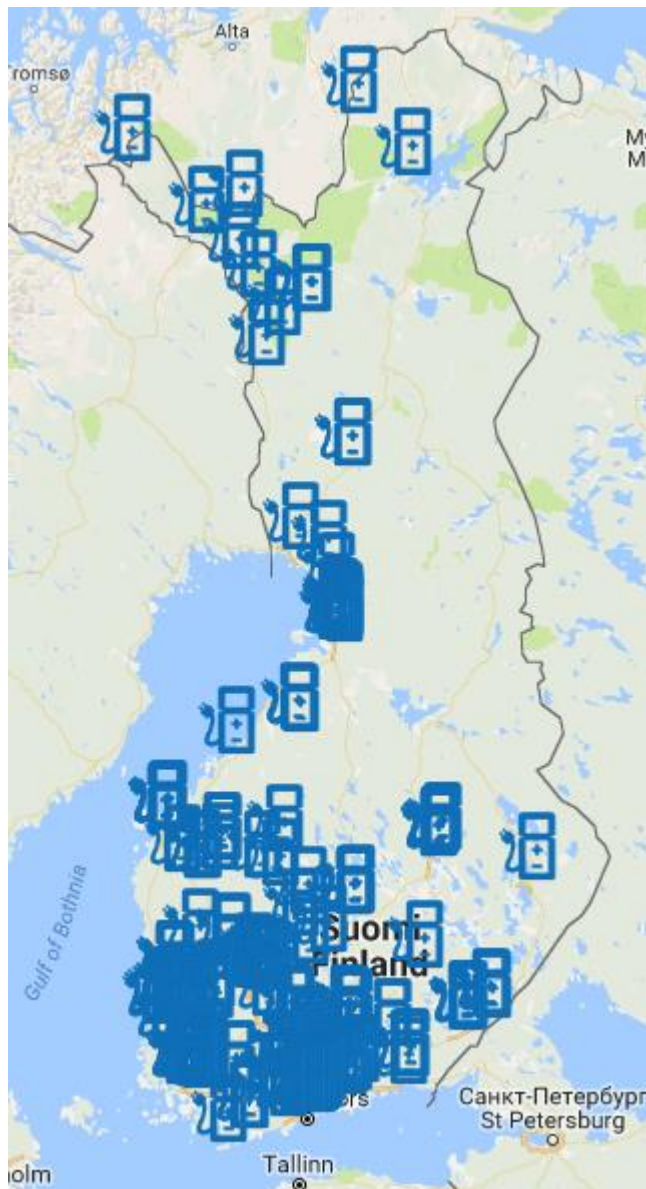


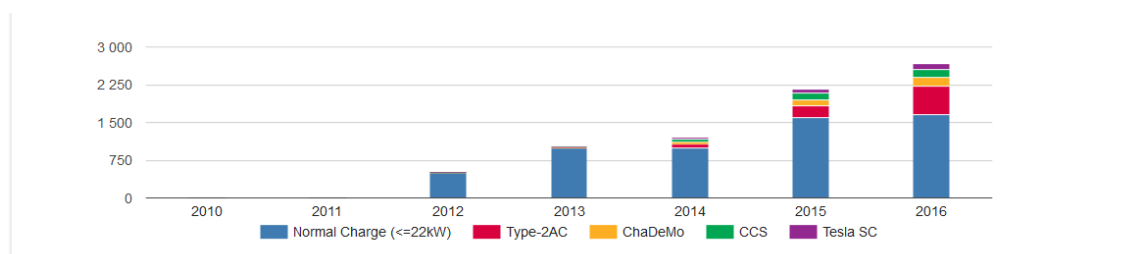
Figure 5. Charging stations in Finland. (Sähköinen Liikenne 2016)

4.1.1 Governmental incentives for electric vehicle purchase in Finland

Finland does not currently have any incentives concerning electric vehicles. On the contrary, electric vehicles are subject to a propulsion tax which all non-gasoline vehicles are subject to in Finland as the taxation on ICE vehicles is partially based on how much greenhouse gas it produces. As electric vehicles do not produce tailpipe emissions, the propulsion tax is used to compensate. (Trafí 2016.)

4.2 Electric vehicle charging infrastructure in Sweden

According to the European Alternative Fuels Observatory (EAFO 2016) there are currently 2714 charging positions in Sweden as shown in Graph 2.



Graph 2. Electric vehicle charging positions in Sweden in 2016. (EAFO 2016)

These charging positions consist of 1654 type 2 positions, 561 type-2AC positions, 173 CHAdeMO positions, 192 CCS position and 134 Tesla Supercharger positions as seen in Graph 2.

This network of 2714 positions is serving an electric vehicle fleet of 7050 BEV's and 18318 PHEV's to a combined amount of 25368 PEV's as seen in Table 1.

The dispersion of electric vehicle charging stations in Sweden can be seen in Figure 6. Infrastructure for electric vehicle charging stations is lacking in the northern areas, however other areas of Sweden are quite well covered by the current electric vehicle charging station infrastructure.

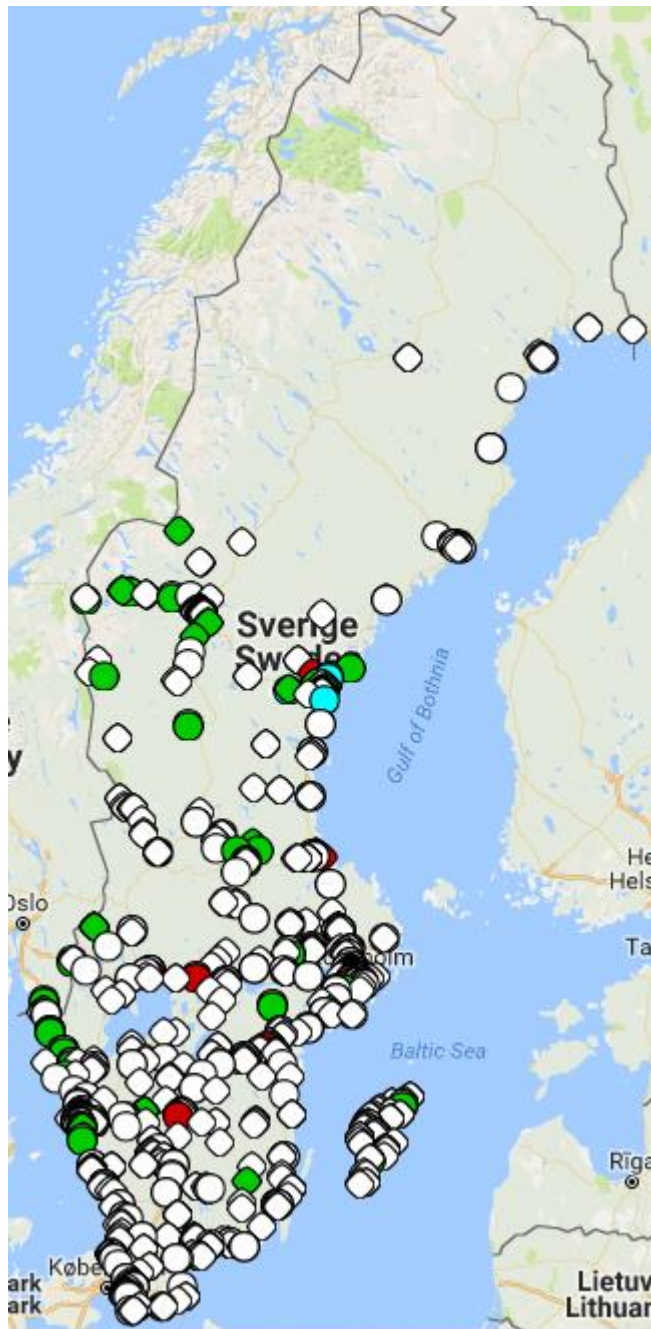


Figure 6. Charging stations in Sweden. (eGOtrip 2016)

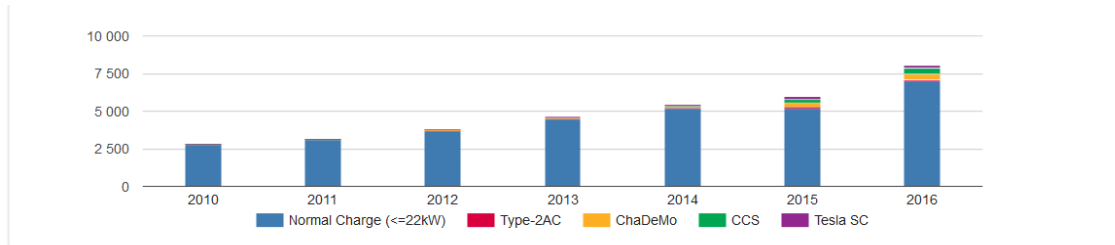
4.2.1 Governmental incentives for electric vehicle purchase in Sweden

Sweden, much like Finland does not have large incentive programs in place for electric vehicle purchase. According to Harryson (Harryson & Kazlova & Ulmefors 2015) these incentives are:

- exemption from yearly circulation tax for five years
- rebate for “super green cars” in the amount of 40,000 SEK per vehicle.

4.3 Electric vehicle charging infrastructure in Norway

According to the European Alternative Fuels Observatory (EAFO 2016) there are currently 8064 charging positions in Norway as shown in Graph 3.



Graph 3. Electric vehicle charging positions in Norway in 2016. (EAFO, 2016)

These charging positions consist of 6984 type 2 positions, 66 type-2AC positions, 412 CHAdeMO positions, 372 CCS position and 210 Tesla Supercharger positions as seen in Graph 3.

This network of 8064 positions is serving an electric vehicle fleet of 94808 BEV's and 30259 PHEV's to a combined amount of 125067 PEV's (Norsk Elbilforening 2016)

4.3.1 Governmental incentives for electric vehicle purchase in Norway

Norway is a global leader in electric vehicle market share, as nearly 30% of the vehicle fleet consists of PEV's (EAFO 2016). Norway also has some of the largest incentives for the purchase of electric vehicles (Harryson & et. al. 2015) These incentives include:

- exemption from purchasing tax and 25% percent VAT charge
- vastly reduces yearly circulation tax fee for electric vehicles
- 50% discount on company car tax for employees
- free access to Norway's toll roads
- exemption from ferryboat fees
- exemption from municipal parking charges
- exemption from bridge fees
- exemption from fees at designated charging stations
- access to bus lanes

- exemption from congestion charging

The dispersion of electric vehicle charging stations can be seen below in Figure 7. Electric vehicle charging infrastructure in Norway is very well dispersed as even the northern areas of Norway have an adequate amount of charging stations.

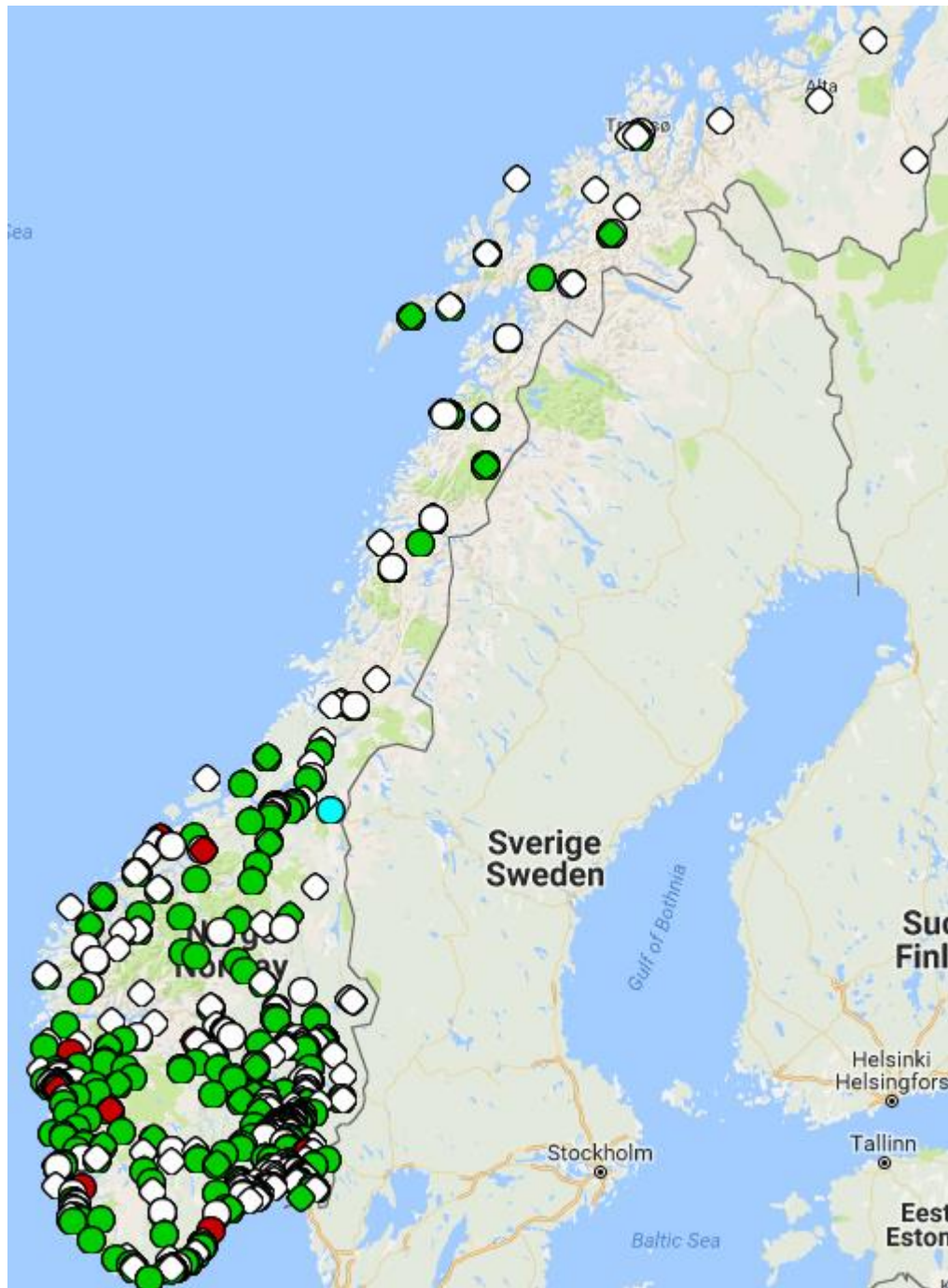


Figure 7. Charging stations in Norway. (eGOtrip 2016)

4.4 Comparisons

As evident in the data in the chapters above, Finland has the fewest electric vehicles and charging stations of the three countries being compared. Sweden is in the middle with a two incentives regarding electric vehicle purchases, and Norway with a large amount of incentives has the largest fleet of electric vehicles and the largest charging infrastructure. According to Harryson (Harryson & et. al 2015) it is clear that the incentive program in place in Norway has had a significant effect on the technology adoption of electric vehicles.

As Finland has no incentives regarding the total cost of ownership (TCO) of electric vehicles, this is also evident in the charging station infrastructure. In the case of Norway, the reduction of TCO was a considerable tool in stimulating electric vehicle uptake levels. According to Harryson, countries with low levels of incentive offerings such as Sweden or Finland, it would be best to use the incentive offerings of Norway as a blueprint to rapidly improve EV uptake. Harryson also states that *“one needs to consider the effects of offering large incentives on tax revenues.”* (Harryson & et. al. 2015.)

5 Factors affecting electric vehicle charging infrastructure

5.1 Legislation and policies

There are several laws and regulations an electric vehicle charging station must comply with as the high power levels used in the charging process are a potential hazard for safety. Most requirements for electric vehicle charging stations can be found in the IEC 61851 standard. In Finland, the standard for usable sockets and plugs are defined under SFS 6000-8-831 standard. (Karppinen 2014.)

According to Karppinen, the general requirements for electric vehicle charging stations are:

- charging station complies with EFC/SFS-standards
- charging station is CE-approved

- charging station fulfils Sesko electric vehicle charging recommendations
- plug & Socket must be of at least IP44 compliant if the charging is being performed outdoors
- charging station must have protection against excess current surges in case of malfunctions.

The current legislation regarding building permits for electric vehicle charging stations in Finland varies by municipality, however in most municipalities a charging station does not require any building permits unless it includes:

- construction of new fixed structures such as walls or shelters around the charging station in which case said structures require permits for their construction
- restructuring or increasing the size of a parking area, in which case a permit for a change in the ground plan must be applied for

Regarding safety distances, the distances must be examined case-by-case. Many electric vehicle charging stations are near service stations and the safety distances are determined by the safety distances of the fuel tanks and fuel pumps of the service station. (Karppinen 2014.)

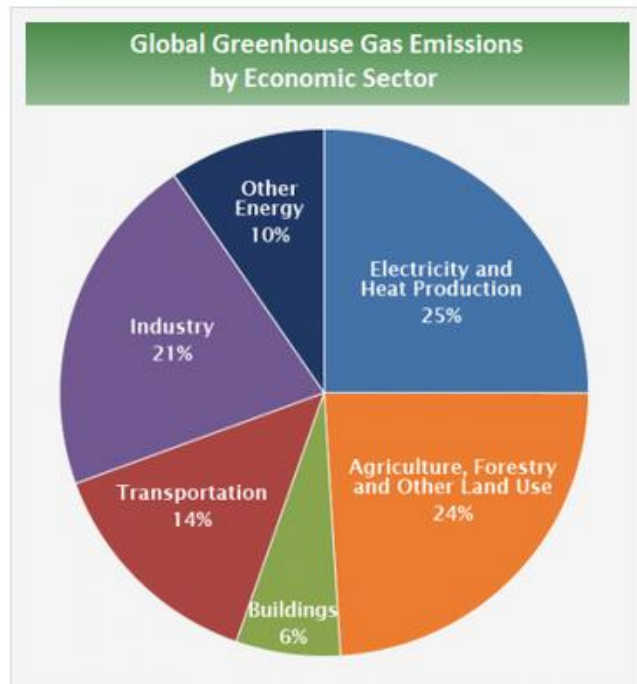
5.2 Government incentives for electric vehicle charging stations

There are currently no government incentives for construction of electric vehicle charging stations in Finland. There was an incentive program aimed specifically at electric vehicles and electric vehicle charging infrastructure in place by the Finnish Ministry of Economic Affairs and Employment for the years 2011 – 2017, however the approximately 10 million € of monetary support has run out. The incentive program covered 30% of the capital costs of a leased electric vehicle, and 35% of charging station investment costs. (Sähköinen Liikenne, n.d.)

5.3 Environmentalism

Non-financial reasons, especially those associated with environment and energy can influence consumers' decisions to purchase an electric vehicle. Some consumers are drawn to the social benefits of owning an electric vehicle due to its

positive reduction of petroleum consumption and greenhouse gas emissions. Environmental values are powerful predictors of certain consumer actions and positively influence willingness to engage in actions that protect the environment. (Egbue & Long 2012.)



Graph 4. Global greenhouse gas emissions by economic sector. IPCC

As 14% of global greenhouse gas emissions are caused by the transportation sector, as shown in Graph 4 above, consumers are changing their consuming behavior regarding transportation especially, as it is a sector where consumers can make a meaningful decrease in greenhouse gas emissions.

5.4 Range anxiety

Range anxiety is a term coined for the fear consumers have regarding the battery of electric vehicles running out before reaching a charging station or the intended destination (Rauth & Franke & Krems 2014).

Range anxiety is a variable that also effects the electric vehicle charging infrastructure markets, as range anxiety can be a major factor in a consumer's decision to purchase an electric vehicle or not to (Rauth & et. al. 2014).

5.5 Batteries

Batteries in electric vehicles are primarily based on lithium-ion technology. The variation in the batteries comes from the size of the fuel cells and the type of cathodes used in the battery. Almost all electric vehicle manufacturers have partnerships with battery suppliers and are looking to drive the development of battery pack technology. (Amsterdam Roundtables Foundation 2014.) The batteries are currently the single most expensive part of an electric vehicle, and as the price of batteries comes down with technological development this can be seen as one of the most influential aspects of growth in both electric vehicle and electric vehicle charging station markets.

5.5.1 Small-format cells

According to the Amsterdam Roundtables Foundation, Tesla Motors was the only vehicle manufacturer in 2014 to be using small-format cells in electric vehicle batteries. This is due to the small-format cells being susceptible to reacting badly to overheating, and Tesla having proprietary technology in battery cooling and management systems. These advanced cooling and battery management systems enable the small-format cells to pass government safety requirements even with the more reaction prone composition of the battery. Tesla Motors has also started to produce the technology for Daimler and Toyota which are small stake owners of Tesla Motors. (Amsterdam Roundtables Foundation 2014.)

5.5.2 Large-format cells

Large-format cells are the battery pack of choice for almost all other electric vehicle manufacturers. The lower energy density in the large-format cells makes them less prone to overheating issues. The battery packs using large-format cells are more expensive when compared to small-format cells. (Amsterdam Roundtables Foundation 2014.)

6 Empirical research

6.1 Methodology of this study

The author of this study has chosen to use an inductive approach to the study. The inductive approach was taken, as the aim of the interviews was to find common patterns in the interviewees answers which can be later used to set up a theory based on the findings. This enables the author to collect data and explore the information gained to increase understanding of the subject. As the answers from the interviewees are based on how they perceive the current market, it is not possible to measure the data in numbers in most circumstances. (Saunders & Lewis & Thornhill 2009.)

The author also chose to use a mixed model when selecting between qualitative or quantitative approaches. Quantitative approach is very number-centric way to approach data, and mainly uses methods like questionnaires, while qualitative approach is a more interpretative way of researching a subject. According to Saunders, it is possible to distinguish these approaches by viewing them as numeric or non-numeric data. (Saunders et al. 2009, p. 150) The author used a mixed approach to gain as much information as possible by not limiting the conversation to just a questionnaire. Some answers which can be analysed quantitatively will be displayed graphically or as statistics.

According to Saunders (et al. 2009, p. 320) there are three types of interviews: structured interviews, semi-structured interviews and unstructured or in-depth interviews. The structured interview uses a questionnaire to predetermine responses, while the semi-structured interview allows variation in the questions and answers to promote further discussion. In-depth interviews or unstructured interviews are usually very informal and the interviewer talks freely of the subject and does not pre-determine questions in advance. The author chose to use the semi-structured interview to be able to ask more questions on subjects of interest or speciality of the interviewee. (Saunders et al. 2009)

6.2 Interviews with industry insiders

As this thesis focuses on the electric vehicle charging station infrastructure and its future outlook in Finland, the participating interviewees were selected carefully from fields which are currently most aware of the market. All interviewees are from companies that are relevant in the field of electric vehicle production, or charging station infrastructure development.

6.2.1 Data collection and data analysis

All data will be gathered as interviews over the telephone. The author records all conversations in order to transcribe them after the interviews have been completed. After the data has been transcribed the author will search for repeated terminology, common themes and a general consensus among the answers of the interviewees. Data that can be expressed quantitatively will be displayed in bars or graphs. Results will be reported according to the authors research objectives and questions.

6.2.2 Interview participants

As can be seen in Table 2 below, nine interviewees were interviewed for this thesis. All nine interviewees are in positions where they actively work within the electric vehicle production or electric vehicle charging station infrastructure development fields. This amount of interviewees was expected when drafting possible companies to contact for this thesis, as the field is relatively new and the infrastructure is still quite small. The amount of possible interviewees operating in the field was a limiting factor, however as the author was able to contact almost all of the companies operating in the field, the author believes this thesis to be encompassing of the field.

66,7% (6/9) of the interviewees work in the charging station infrastructure development field, while 33,3% (3/9) work in electric vehicle production.

Also evident in Table 2, is the years of experience the interviewees have. The author was positively surprised on the amount of experience most interviewees had, as the field is relatively new. Over half of the interviewees have had over

five years of experience in the electric vehicle production or charging station infrastructure development fields.

Interviewee	Industry	Years in the field	Position
1	Charging station infrastructure development	8	CEO
2	Charging station infrastructure development	9	CEO
3	Electric vehicle production	6	Middle management
4	Electric vehicle production	6	CTO
5	Charging station infrastructure development	6	R&D Manager
6	Charging station infrastructure development	4	Development manager
7	Electric vehicle production	1	Middle management
8	Charging station infrastructure development	6	Production manager
9	Charging station infrastructure development	1	R&D Management

Table 2. Interview participants (Muhonen 2016)

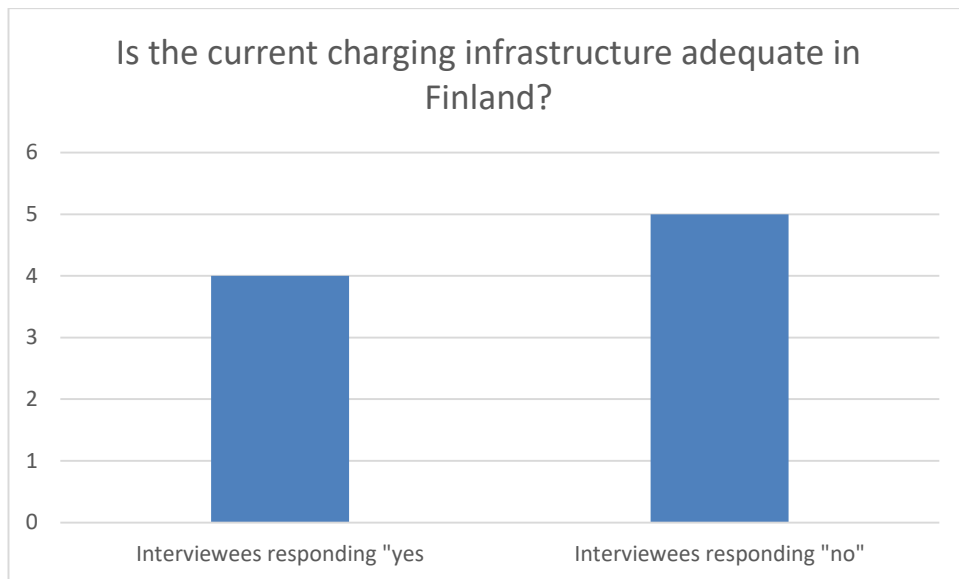
Table 2 also shows the position that interviewees have in their respective organisations. All interviewees were in upper or middle management.

6.3 Current situation

This set of questions explores how the interviewees perceive the market at the moment when this thesis is being conducted.

6.3.1 Interviewees opinions of current infrastructure in Finland

The first question the interviewees were asked was if the interviewees thought that the current electric vehicle charging infrastructure in Finland was adequate in their opinions. As graph 5 below shows, 4 interviewees answered “yes” while 5 interviewees answered “no”.

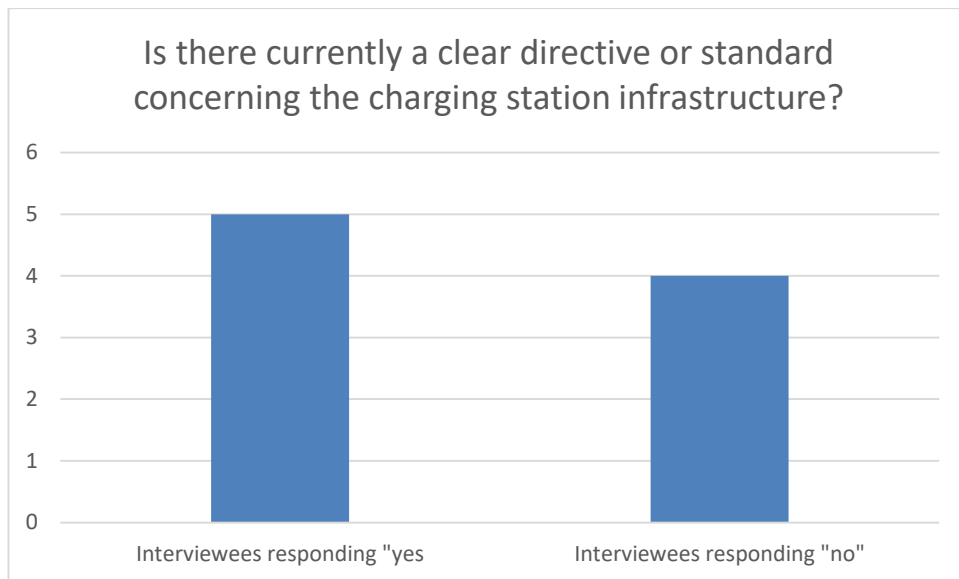


Graph 5, Adequacy of current charging infrastructure (Muhonen 2016)

However, it is important to note that all 4 of the interviewees responding “yes” specified that the current charging infrastructure is adequate for the current fleet of electric vehicles. Two interviewees also specified that there is not a lack of charging stations, but a lack of dispersion of the charging stations equally around Finland.

6.3.2 Interviewees opinions on standards and directives concerning charging station infrastructure

The second question that the author asked the interviewees was “In your opinion, is there currently a clear directive or standard concerning the charging station infrastructure in Finland? As seen in Graph 6 below, 5 respondents said that in their opinion there is a clear directive or standard, while 4 respondents answered “no”.



Graph 6. Clarity of directives and standards. (Muhonen 2016)

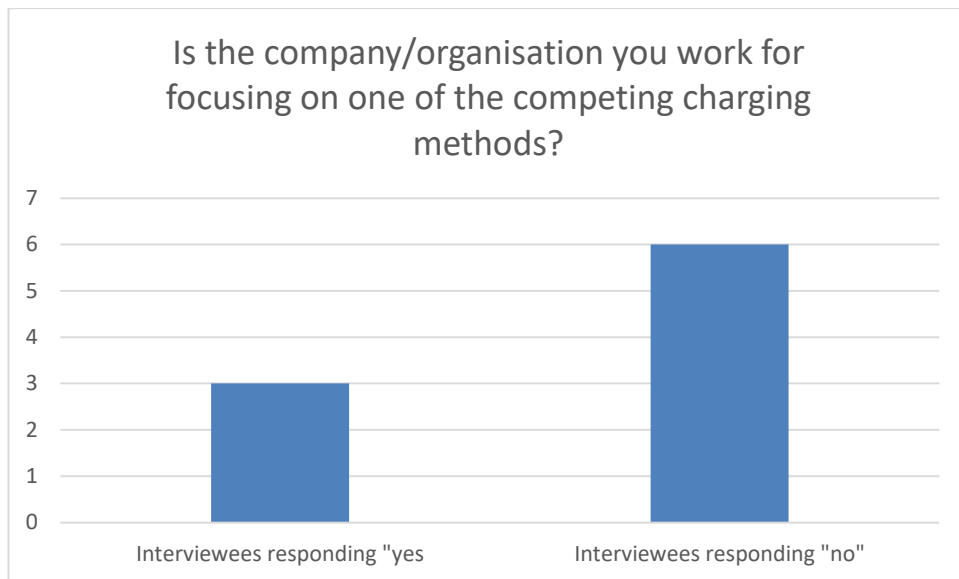
Two of the interviewees who perceived that there is currently a lack of a clear directive or standard concerning the charging station infrastructure referred to a fuel-neutral law concerning service stations. Currently a certain amount of service stations must also be able to provide biofuels, but this fuel-neutral law is not doing its task as electric vehicle charging is not a part of this law.

One interviewee who perceived the current standards and directives as clear thought that they are too restraining.

Three of the 4 respondents that answered "no" to the current clarity of directives and standards thought that there should be a clearer set of standards and directives concerning the field. One respondent hoped for more incentives towards electric vehicle purchases to increase the market size for electric vehicle charging, and thus bringing clarity along with market growth.

6.3.3 Interviewees commitment to certain charging methods

The third question the author asked the interviewees was "Is the company/organisation you work for focusing on one of the competing charging methods?" The answer was again a divided one as graph 7 below shows.



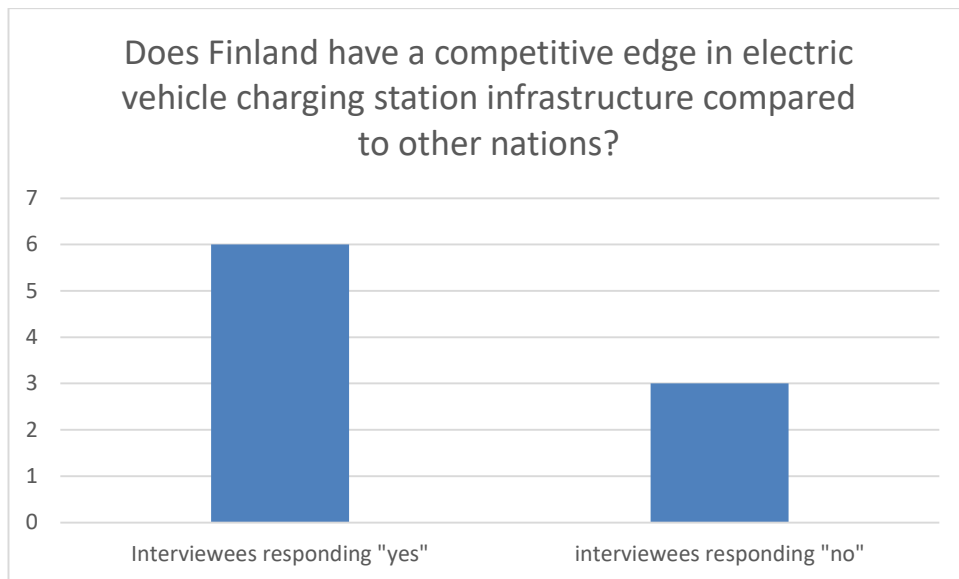
Graph 7. Commitment to a certain charging method (Muhonen, 2016)

Three interviewees disclosed that their companies or organisations are focusing on one of the competing charging methods. One of these respondents said that their company/organisation is focusing on the low-power Schuko charging method. One respondent disclosed that their company/organisation focuses only on their proprietary charging technology, while the third said that their company/organisation focuses solely on AC charging.

The six interviewees who answered “no” had all focused on a wide range of charging methods.

6.3.4 Interviewees opinions on Finland having a competitive edge in electric vehicle charging infrastructure compared with other nations

The fourth question asked by the author was “In your opinion, does Finland have a competitive edge in electric vehicle charging station infrastructure compared to other nations?” Graph 8 below shows the interviewees to also be divided in their answers to this question.



Graph 8. Perceived advantage in charging infrastructure compared to other nations. (Muhonen, 2016)

The competitive edges the interviewees perceived Finland to have when comparing to other nations are several. Two interviewees pointed to Finland's strong energy grid and smart grids which are more developed than in most nations. In the same context one interviewee mentioned the possibility of cheaper charging during nights that is possible due to Finland's spot-market for electricity.

One interviewee saw a competitive edge in high amount of knowledge in high-power electronics within Finland, while one respondent believed the heating poles which are prevalent in Finland to bring the greatest advantage. One interviewee also perceived the two largest Finnish charging infrastructure developers to be a great asset on a national and global scale as they can develop Finland's infrastructure very fast when the electric vehicle fleet grows.

6.4 Risks in the current market

This set of questions explores the risks that the interviewees see in the current market.

6.4.1 Perceived risks in the Finnish charging station market

The question the author asked interviewees regarding local risk was "What risks do you see in the electric vehicle charging station market in Finland?" Four of the

nine interviewees perceived the lack of political will in the adoption of electric vehicles into the car fleet as a risk for the electric vehicle charging station market infrastructure. Two respondents of these thought that the current support by the Finnish government regarding biofuels is a result of oil industry lobbying, and has a distinct risk of leaving Finland even further behind in electric vehicle infrastructure development when comparing with most European nations.

Two respondents saw the price of electric vehicles remaining too high for consumers as the main risk in Finland, as the current infrastructure will only grow with the growth of the electric vehicle fleet. Both of these respondents believed that incentives for electric vehicle purchases should be established.

One interviewee did not see risks in the Finnish market due to the relative youth of the market. This interviewee disclosed that with careful investments in the correct technologies, especially based on what the automobile industry is moving towards.

One respondent saw the largest risk in the current market situation to be that operating electric vehicle charging infrastructure is not financially profitable.

One interviewee saw the environmental regulations as too strict in Finland, which limits their ability to grow.

6.4.2 Perceived risks in the global charging station market

The sixth question the author asked was “What risks do you see in the electric charging station market globally?” Four interviewees perceived no major risks in the current electric vehicle charging station market on a global scale.

Two respondents saw the global risks to lie in the electricity grids and production of energy in a manner that the grids can sustain. The risks in the price changes due to the seasonal or weather influenced methods of generating sustainable energy were also brought up. According to the interviewees, some nations also lack the electricity grid infrastructure to handle the amount of energy required to charge a large fleet of electric vehicles.

One interviewee saw the hasty decision making of politicians and bureaucrats regarding the adoption of standards as a global risk.

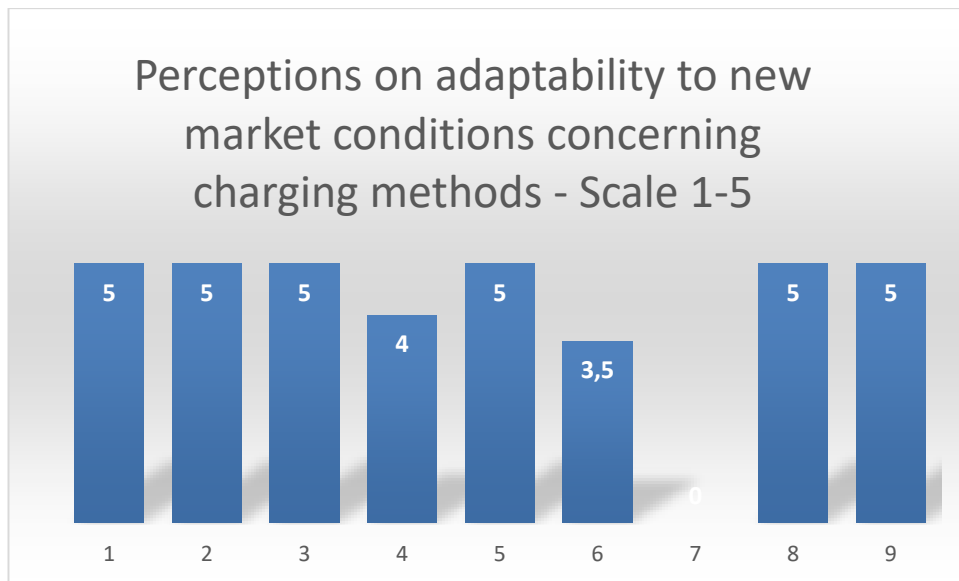
One respondent saw the forming of interest groups and lobbyists fighting over standards as a global risk that could be an issue when building electric vehicle charging station infrastructure globally, as consumers will perceive the charging situation complicated and fear that perhaps they will purchase an electric vehicle which would later not be chargeable with the new standards of charging. The interviewee also disclosed that they believe this to be a part of the oil-industry lobbying which creates confusion among consumers, vehicle manufacturers and infrastructure developers and thereby slowing the adoption of electric vehicles in general.

One interviewee saw a global risk in charging station infrastructure not being able to keep up with the growth of electric vehicle fleets and thus creating traffic jams due to a lack of charging positions.

6.4.3 Views on adaptability in shifting markets

Concerning interviewees perceptions of being able to shift their operating models in new market conditions the author asked “On a scale of 1-5, how would you rate your company’s/organisations adaptability to shift to another charging method in the event of a shift in the markets?”

As seen in graph 9 below, all excluding one interviewee responded to this question with a positive perception of their ability to shift from current methods to new ones in case of a shift in the markets. One interviewee chose not to answer this question.



Graph 9. Perceptions on adaptability to new market conditions concerning charging methods. (Muhonen, 2016)

All of the interviewees who chose to answer the question perceived their organisations or companies are well prepared, and fast or very fast to adapt to other charging methods in case of a change in the charging station market.

6.5 Views of the future

This set of questions is aimed to exploring how the interviewees believe the electric vehicle charging market should be developed in Finland, and in which ways.

6.5.1 Interviewees opinions on development of electric vehicle charging station infrastructure in Finland

The author asked the interviewees “In your opinion, what could be done to improve the electric vehicle charging station infrastructure in Finland?”. Seven of the nine interviewees (77.7%) believed that the solution for the improvement of the charging station infrastructure in Finland lies in government incentive programs, and a clear message from policy makers.

One interviewee noted that in many other countries with large electric vehicle fleets and strong charging infrastructures there is a system in place for negating the high purchase costs of electric vehicles as the amount of value added tax (VAT) is comparatively too high due to the new technology in electric vehicles.

One respondent believed that the monetary incentives were best spent in charging infrastructure and developing the charging as a service business model for Finnish consumers.

One interviewee believed in a solution where the current biofuel subsidies and incentives would be better utilized in electric vehicle and charging infrastructure subsidies. In his opinion, Finland is the only country investing heavily in biofuels which is a mistake as the global trend is leaning towards electrification of personal transportation and not vehicles using biofuels.

Two respondents believed that there should be better instructions on how to conduct installations of electric vehicle chargers in condominiums and other manners of shared housing. The interviewees disclosed that the current situation is not clear and consumers are having difficulties being able to get charging positions installed in condominiums or other manners shared housing. One respondent said that there should be a legal obligation of new condominiums under construction to include a third its of parking spaces with electric vehicle charging positions.

One respondent saw the development of smart-grid solutions, and the construction of stationary electricity storage units which would handle the energy grids peak time deficits.

6.5.2 Most important aspects of developing Finland's charging station infrastructure

This question regards to what the interviewees perceive as the most important factor in developing Finland's charging station infrastructure, and the author asked the interviewees "In your opinion, what is the most important aspect of developing Finland's charging station infrastructure?". The author asked the interviewees to distinguish one method which they believe would most benefit the development of charging station infrastructure.

Three of the interviewees answered that they believe the best way to develop Finland's charging station infrastructure to be creating a clear and concise method for condominiums to enable their residents access to a charging point on their parking areas. These interviewees based this belief on the notion that once

consumers in condominiums are certain of the fact that they can charge their electric vehicles without having to fight for their right to charge, the consumers would have a smaller risk when purchasing their first electric vehicle. This in turn would lead to consumers purchasing more electric vehicles which would lead to an organic growth of charging stations elsewhere.

Three interviewees also saw the most important factor to lie in policies from the government, however they believe the most important factor to be incentives to electric vehicle purchases. The concrete examples given were the abolishment or reduction of VAT on electric vehicles, and other financial or non-financial (such as designated parking areas for electric vehicles or being able to use bus lanes) incentives.

One interviewee believes the most impactful factor of developing Finland's electric vehicle charging station infrastructure to be the wider dispersion of charging stations. This would help with issues like range anxiety and enable the whole country to better access the possibility of using an electric vehicle, instead of just connecting the few largest cities with adequate charging station infrastructure.

One respondent believes the best method of improvement to be the development of lithium-ion technology as back-up power for peak times once the electric vehicle fleet grows.

One interviewee could not indicate a single most important factor to the development of Finland's electric vehicle charging infrastructure, but believes that all aspects should be of the same importance as Finland's charging station market is so young.

7 Summary and discussion

The present thesis has dealt with the aim to figure out what the current state of the Finnish electric vehicle charging station infrastructure is in. To answer that main research question the author researched the current state of the electric vehicle charging infrastructure in three countries, and compared them with each other.

In the theoretical part of this thesis the author found out that Finland has the weakest electric vehicle charging station infrastructure, which is likely due to the lack of incentive programs aimed at electric vehicle purchases by consumers. The author also found out that Finland has the capability to create a strong electric vehicle charging station network once the electric vehicle fleet grows, as there are companies in Finland that are capable of large-scale charging station infrastructure construction.

To answer the main research question, on the condition of the current electric vehicle charging station infrastructure and its dispersion within Finland, the author compared the Finnish charging station infrastructure with two other nations, and interviewed industry insiders for their opinions on the matter. The author found out that the Finnish electric vehicle charging infrastructure is still in its infancy, and that without a larger electric vehicle fleet it will likely not develop to be much larger.

To answer the second research question on the perceptions of industry insiders regarding the current market and its hoped development the author conducted interviews over telephone. The opinions of these industry insiders give much insight into how managers and executives see the current situation, the risks in the field and the suggested actions for improvement in the future.

Regarding the current situation, many saw the current charging infrastructure adequate for the current fleet of vehicles in Finland. Most also view the current situation regarding directives and standards to be clear. The author also found out that most companies in the field are not focusing on one form of charging, but use multiple charging methods. Most interviewees also believe that Finland has a competitive edge when compared to other nations with regards to Finland's strong energy grid, and high levels of technological knowledge.

On risks regarding the electric vehicle charging station market in Finland, the interviewees see political risk as the largest issue. The lack of incentives towards developing Finland's electric vehicle fleet and thereby the charging station infrastructure is what a majority of industry insiders fear. Regarding global electric

vehicle charging station markets, the interviewees do not share a concise perceived risk. The strong growth of the field globally leads most interviewees to believe that the only global risks are in lack of power grids and inability to build infrastructure fast enough. When discussing the adaptability of the interviewees organisations or companies to market shifts regarding charging methods, the majority believes their companies or organisations to be very fast to react in case of a shift in the market.

On the interviewees views of the future, and how they would like to see it developed most believe the best method to be government incentives towards easing acquirement of electric vehicles. Most interviewees believe the incentives are best aimed at VAT or purchase taxes. Some also saw the unclear situation in charging station installations in condominiums to be an issue, and believe clearing it up will create demand in the electric vehicle market.

To answer the third research question: after researching the current situation regarding electric vehicle charging stations and the competing charging methods and standards, the author has found in the theoretical part of this thesis that the current market is not in a situation where decisions regarding the charging methods should be made on a national level – but that these decisions should be left to the market. This conclusion also became clear when interviewing industry insiders, who's companies are currently operating with most charging methods.

Figures

Figure 1. Electric vehicles sold in Europe 2016. p. 6. <http://www.eafo.eu/vehicle-statistics/m1> Accessed 1 November 2016 (p. 7)

Figure 2. CCS Charging functions. Charin, 2016. p. 10 <http://www.charinev.org/ccs-at-a-glance/ccs-specification/> Accessed 1 November 2016 p. 12

Figure 3. Charging station. ABC, n.d. <https://www.abcasemat.fi/fi/polttoaineet/sahkoauton-pikalataus> Accessed 6 November 2016 p. 13

Figure 4. Virta charging stations in Europe. <http://app.virta.fi/> Accessed 7 November 2016 p. 14

Figure 5. Charging stations in Finland. Sähköinen Liikenne, 2016. <http://www.sahkoinenliikenne.fi/suomen-julkiset-latauspisteet> Accessed 7 November 2016 p. 16

Figure 6. Charging stations in Sweden. eGOtrip, 2016. <http://egotrip.se/> Accessed 7 November 2016 p. 18

Figure 7. Charging stations in Norway. eGOtrip, 2016. <http://egotrip.se/> Accessed 7 November 2016 p. 20

Graphs

Graph 1. Electric vehicle charging locations in Finland in 2016. EAFO. <http://www.eafo.eu/electric-vehicle-charging-infrastructure> Accessed on 1 November 2016 (p. 15)

Graph 2. Electric vehicle charging positions in Sweden in 2016. EAFO. <http://www.eafo.eu/electric-vehicle-charging-infrastructure> Accessed on 1 November 2016 (p. 17)

Graph 3. Electric vehicle charging positions in Norway in 2016. EAFO. <http://www.eafo.eu/electric-vehicle-charging-infrastructure> Accessed on 1 November 2016 (p. 19)

Graph 4. Global greenhouse gas emissions by economic sector. IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. (p. 23)

Graph 5. Adequacy of current charging infrastructure. Muhonen, S. 2016 p. 28

Graph 6. Clarity of directives and standards. Muhonen, S 2016 p. 29

Graph 7. Commitment to a certain charging method Muhonen, S 2016 p. 30

Graph 8. Percieved advantage in charging infrastructure compared to other nations. Muhonen, S. 2016 p. 31

Graph 9. Perceptions on adaptability to new market conditions concerning charging methods. Muhonen, S. 2016 p. 34

Tables

Table 1. Vehicle fleet 2016. EAFO. <http://www.eafo.eu/eu> Accessed on 1 November 2016 p. 15

Table 2. Interview participants. Muhonen, S. 2016. p. 27

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Appendices

Appendix 1. Interview questions (asked in Finnish)

Questionnaire asked from contacted industry insiders:

1. Do you think that the current electric vehicle charging infrastructure is adequate in Finland? (Yes/No) (Why?) – Onko nykyinen sähköautojen latausinfrastruktuuri Suomessa mielestänne riittävä? (Kyllä/ei) (Miksi?)
2. In your opinion, is there currently a clear directive or standard concerning the charging station infrastructure in Finland? (Yes/no) (Reasoning?) – Onko teidän mielestänne tällä hetkellä selkeää direktiiviä tai standardia joka ohjaa sähköautojen latausinfrastruktuurin rakentamista Suomessa? (Kyllä/ei) (Perustelut)
3. If no: Should there be a clear directive or standard in Finland concerning charging station infrastructure? (Yes/no) – Jos ei: Pitäisikö Suomessa olla selkeä direktiivi tai standardi joka liittyen sähköautojen latausasema infrastruktuuriin liittyen? (Kyllä/ei)
4. Is the company/organization you work for focusing on one of the competing charging methods? (Yes/no) (If yes, which one?) - Onko yrityksenne/organisaationne keskittynyt yhteen kilpailevista latausmetodeista? (Kyllä/ei) (Jos kyllä, mihin?)
5. If no: Which ones are you focusing on? (Why?) – Jos ei: Mihin metodeihin olette keskittyneet? (Miksi?)
6. In your opinion, does Finland have a competitive edge in electric vehicle charging station infrastructure compared to other nations? (Yes/no) – Onko Suomessa mielestänne jotakin kilpailuetua sähköautojen latausasemainfrastruktuuriin liittyen verrattuna muihin valtioihin? (Kyllä/ei)
7. If yes: What? – Jos kyllä: Mikä?
8. What risks do you see in the electric vehicle charging infrastructure in Finland? – Mitä riskejä näette sähköautojen latausinfrastruktuurissa Suomessa?
9. Globally? – Globaalisti?
10. What would you name as your greatest risk for your company/organization in the current electric vehicle charging station market in Finland? – Minkä

nimeäisitte omassa organisaatiossanne suurimmaksi riskiksi nykyisessä sähköautojen latausasemamarkkinassa Suomessa?

11. On a scale of 1-5 (1: very slow, 2: quite slow, 3: mediocre, 4: quite fast, 5: very fast), how would you rate your company's/organisations adaptability to shift to another charging method in the event of a shift in the markets? Asteikolla yhdestä viiteen (jossa 1: erittäin hidas, 2: melko hidas, 3: keskitasoa, 4: melko nopea, 5: erittäin nopea) kuinka arvioisitte oman organisaationne nopeuden vaihtaa toiseen latausmetodiin, jos markkinassa tapahtuu muutos?
12. In your opinion, what could be done to improve the electric vehicle charging station infrastructure in Finland? – Mitä teidän mielestänne tulisi tehdä jotta suomen sähköautojen latausasemien infrastruktuuria voitaisiin parantaa?
13. In your opinion, what is the most important aspect of developing Finland's charging station infrastructure? – Mikä teidän mielestänne on tärkein osa-alue sähköautojen latausasemien infrastruktuurin parantamisessa Suomessa?