

Developing Electric Vehicle Charging Infrastructure in Finnish Housing Companies

Jukka Toivari

Bachelor's Thesis
Degree Programme in
International Business...
2018



Author Jukka Toivari	
Degree programme Degree Programme in International Business	
Thesis title Developing Electric Vehicle Charging Infrastructure in Finnish Housing Companies	Number of pages and appendix pages 46 + 6
<p>The ambitious targets set internationally to limit global warming require actions on all levels. Governments, societies and companies as well as individuals will have to react and search for new ways to reduce climate warming greenhouse gases.</p> <p>Transportation is a major source of global warming greenhouse gas emissions. Restrictions on transportation could cut emissions immediately, but they have a significant economic impact and are politically difficult. A more acceptable means is to control emissions with stricter limits for vehicles. The electrification of transportation seems to be an effective way to decrease emissions. At the moment, charging infrastructure is one of the limiting factors when it comes to increasing the number of electric vehicles.</p> <p>This thesis aims to reveal the underlying reasons why developing the charging infrastructure for electric vehicles in housing companies seems to be difficult and to find effective solutions the commissioning company could use in its operations to promote the charging infrastructure.</p> <p>Several market research methods were used in this thesis. The data was collected by using surveys implemented with a pluralistic method, containing both quantitative and qualitative data. A so-called human search, an interview with an expert, was also used to gain an understanding on the topic.</p> <p>The findings of this research indicate that housing companies are aware of the topic of charging infrastructure, but they are waiting for more demand before starting pricey projects. The decision making and purchasing processes in housing companies are complex and valid information is needed as the base for decisions.</p> <p>This study gives the commissioning company a better understanding of the target group and provides a toolkit and recommended actions through a service design process to communicate the topic of charging infrastructure towards housing companies.</p>	
Keywords Electric vehicle, Charging, Housing company, Infrastructure, Service design, Marketing research	

Table of contents

1	Introduction.....	1
1.1	Background.....	2
1.2	Research Question	4
1.3	Demarcation.....	5
1.4	International Aspect	5
1.5	Benefits.....	6
1.6	Key Concepts.....	7
1.7	Case Company	9
2	Research Methods.....	11
2.1	Quantitative, qualitative and pluralistic methods	11
2.2	Primary data collection	11
2.3	Secondary data collection	13
3	Theoretical framework	16
3.1	Diffusion of Innovations	16
3.2	Chasm	18
3.3	Service Design	19
3.4	Double Diamond Design Process.....	19
4	Analysis	22
4.1	Analysis of the current situation in housing companies.....	22
4.2	Decision making in housing companies.....	34
4.3	Purchasing process in housing companies.....	36
5	Discussion	37
5.1	Focus group and DOI-categorization.....	37
5.2	Conclusions and recommendations.....	38
6	Self-evaluation	46
	References.....	47
	Appendices	1
	Appendice 1. Survey questionnaire.....	1

1 Introduction

It is evident that electric cars, also known as electric vehicles (EV), will become increasingly popular within next years and decades. Practically all the car manufacturers have announced large investments on research and development projects of EV's and some companies, like Tesla, have already quite refined products in market. For example, Volvo announced in July 2017 that all of its new car models from 2019 onwards will be either fully electric or will have hybrid drivetrain. (Volvo 2017). In third quartal of 2018 Tesla's Model 3 was already fifth best-selling car in US market and being fairly expensive, produced most revenue of any car model. (Electrek 2018.)

Electric Vehicle market is growing fastest in China, but also other market areas are seeing remarkable sales growth. In the first half of 2018, 195 000 EV and Plug-In hybrids (PHEV) were sold in Europe, a growth of 42 % compared to previous year. (EV-Volumes 2018.)

At the moment EV's are pricey due to production cost of batteries and limited selection of models suitable for peoples' everyday needs is still limiting EV's becoming more common. According to Bloomberg's analysis, electric vehicles will become price competitive (without subsidies) with traditional cars from 2025 onwards, mostly due to decreasing battery production costs. (Bloomberg 2017.)

PHEV cars which are equipped with smaller capacity batteries and an internal combustion engine, are at the moment much more popular than pure EV's, because they are not dependent on charging infrastructure. (Bloomberg 2017.) But naturally Plug-In hybrids need the charging infrastructure too to fully utilize the possibilities for emission free and inexpensive mobility provided by electric drivetrain. Term "Electric Vehicle" (EV) will be used in this paper as a generic term in a meaning of both fully electric and plug-in electric vehicles.

Until recently, EV's have mostly been small sized city cars. Although all kinds of EV models are entering the market, it's still in cities where EV's have biggest benefits compared to traditional cars. EV's produce no tailpipe emissions and are quieter than Internal Combustion Engine (ICE) cars. (Union of Concerned Scientists 2018.)

At the moment the infrastructure is not ready for the increasing number of chargeable vehicles and the lack of charging possibilities is clearly one of the most important reasons slowing down EV adoption. Public charging infrastructure is easier to develop by political decisions than private. Electric companies and service providers are also more interested in public charging stations, because they want to commercialize the charging.

Although, public chargers are used on only 5 % of the charging events. The bottleneck of charging infrastructure appears to be the residential areas and apartment buildings in urban areas. (Transport & Environment 2018). Electric vehicles throw a challenge for the housing companies, as the electric systems might not be on the level required for safe home charging. The housing companies which are typically owned by the people living in the apartments, are afraid of the costs of building charging stations. Therefore, housing companies' attitude towards developing the charging stations in premises has been often reluctant. (YLE 2017.)

1.1 Background

The climate change has forced the officials in both governmental and communal level to commit to cut emissions of greenhouse gases, especially carbon dioxide CO₂. In intent to decrease the emissions of transportation the Finnish government has announced the goal of at least 250 000 EV's in Finland by year 2030. (Ministry of Economic Affairs and Employment 2016.)

To reach this ambitious goal, subsidies and regulations need to be used to speed up EV adoption and the building of both private and public charging infrastructure should be on priority list. Many cities like Paris, Mexico City, Madrid and Athens (BBC 2016.) are already planning bans of diesel cars which in addition to greenhouse gases also produce large amounts of carcinogenic particulates. Outdoor air pollution caused globally estimated 4.2 million premature deaths worldwide. (WHO 2018.) The problem is worst in developing countries, where energy production and industry is largely responsible for the pollution. But also European cities are suffering from air pollution and here the main source is transportation. According to European Environment Agency's (EEA) report "Air quality in Europe - 2016" estimated 520 000 premature deaths were caused 2013 by particulate matter, nitrogen dioxide and ozone which are common pollutants caused by transportation and power generation.

The new cars sold in Europe in 2017 emitted on average 118.5 g CO₂/km. The figure actually increased 0.4 g CO₂/km from 2016, despite the longtime trend has been steady decline of emissions. (EEA 2018.)

The energy efficiency of an electric car depends on the method the electricity is produced. In Sweden, production of one kilowatt hour (kWh) of electricity produces only 10 g CO₂, while on the other end of the spectrum of EU countries, Estonian figure is 762 g CO₂/kWh.

In Finland the figure is 106 g CO₂/kWh and the average of EU-28 is 276 g CO₂/kWh. Iceland produces 100 % and Norway 98 % of their electricity with renewable sources, mostly hydropower. (EEA 2016.)

No exact figure for electric car energy consumption is available. If we assume the average consumption is 20 kWh/100 km based on popular EV models like Hyundai Ioniq, Tesla Model S and Volkswagen E-Golf (consumption numbers reported by users in EV forum), we can calculate that EV CO₂ emissions are 5 520 g CO₂/100 km on average EU-mix electricity, while in Sweden it would be only 200 g CO₂/100 km. The emission for an average new ICE car would be 11 850 g CO₂/100 km.

While the energy production emission intensity is continually improving, the difference in favor of EV's increases. It is projected that the average energy production emission intensity of EU-28 drops from current 276 g CO₂/kWh to below 120 g CO₂/kWh by year 2030 and as low as 70 g CO₂/kWh by 2050. (Bracker, Haller, Kasten, & Purwanto 2016, 33.)

Comparing a Full Lifecycle Assessment results of an EV and an ICE car reveals that production of an EV results approximately 15% more greenhouse gas emissions than production of a conventional car. Reason for this is the energy-intensity of a battery production. Although, the difference in emissions of production is easily negated by the decreased emissions of driving an EV. The results of a study made by Union of Concerned Scientists reveals that the full lifecycle reduction of GNG emissions is approximately 50% compared to gasoline powered car. The result is based on average U.S. electricity grid emissions. While the energy production continually gets cleaner, the difference against conventional ICE cars grows bigger. (Union of Concerned Scientists 2015.)

Public fast chargers are a visible sign of the electrification of transport. Maybe they represent the electrified version of gas station in peoples' minds. However, with EV's the mental image of "refuelling" is going to change. Public charging stations are not the primary choice for EV drivers. According the report by Transport & Environment, only 5 % of the charging events happen at public charging stations and 95 % of the charging takes place at home or at work. (Transport & Environment 2018.)

The commissioning company, Helen Oy, operates in the business of developing charging infrastructure. They want to determine the factors the housing companies evaluate when trying to make decisions on building charging infrastructure on their premises.

1.2 Research Question

The main purpose of this research is to reveal the underlying reasons why developing the charging infrastructure for Electric Vehicles in housing companies seems to be difficult and find effective solutions the commissioning company could use in its' operations to promote charging infrastructure.

To answer the research question (RQ) it is divided in three investigative questions (IQs) through which the results of the research will be analysed.

Research Question: How to speed up the development of the charging infrastructure in Finnish housing companies?

IQ 1. What are the most important reasons restricting housing companies from building charging infrastructure?

IQ 2. What kinds of laws and regulations are limiting the development of charging infrastructure?

IQ 3. What alternative business models could be used to improve charging infrastructure availability?

IQ 4. What recommendations for communication towards housing companies can be given to the case company based on findings of the research?

Table 1 below presents the theoretical framework, research methods and results chapters for each investigative question.

Table 1. Overlay matrix

Investigative question	Theoretical Framework	Research Methods	Results (chapter)
IQ 1. Limiting reasons	Diffusion of Innovations	Pluralistic methods (quantitative & qualitative survey)	4.1, 4.2 & 4.3
IQ 2. Legal barriers		Interview (qualitative method, human search, desktop analysis)	4.2
IQ 3. Alternative models	Double Diamond Design Process	Pluralistic methods (quantitative & qualitative survey)	4.1
IQ 4. Recommendations	Double Diamond Design Process	Double Diamond Design Process, desktop analysis	5.2

1.3 Demarcation

This study's primary focus group is the decision makers in housing companies, first and foremost the members of Board of Directors. The study concentrates mainly on issues in charging infrastructure development from the viewpoint of housing companies.

The end customers are mostly excluded from the focus group. However, the experiences of end users, in this case EV owners or users, has been included to give insight on practical solutions already put in use.

1.4 International Aspect

Although the research concentrates on issues found in Finnish housing companies, the commissioning company Helen also operates on international markets of charging infrastructure. Also, the key concepts and sources used refer to international materials.

1.5 Benefits

The purpose of this study is to help the case company better understand the needs and problems faced in housing companies. With the survey questions concerning the business model, the commissioning company also gets to test focus groups interest for alternative models to arrange the charging service. The conclusions and recommendations given could help in communication towards housing companies.

For housing companies and their representatives, this study is a channel for expressing the concerns, restraints and ideas related to the topic towards a company that is actively developing charging infrastructure. Possibly and hopefully this would result better understanding of interests and needs and thus facilitate better communication between the parties and accelerated progression in building charging infrastructure.

Also, for the end customers, i.e. users of electric vehicles, the possible accelerated progression in building charging infrastructure is a benefit.

The research is applicable for other electricity companies, as well as service providers and other companies interested in developing the charging infrastructure in Finnish housing companies.

The research concentrates on the supply chain of delivering the electricity from the supplier to the end consumer from the housing company's point of view. This is a novel approach to the problem.

One important purpose of this study is of course to showcase the know-how of the author and apply the skills learned during the studies. The end result will be interesting and relevant reference for many supply chain management related jobs.

The results of the research could potentially be interesting for larger audiences as well. Possible reportage of the topic in media could provide interesting contacts.

1.6 Key Concepts

Electric Vehicle (EV) is a generic term for cars that have fully or partially electric drivetrain and can be charged from the electric grid. EV's could be also called for example Electric Chargeable Vehicle (ECV) in some sources. Two main types of EVs are;

- Battery electric vehicles (BEV) have electric motors and electricity from the chargeable battery as their only source of power.
- Plug-in hybrid electric vehicles (PHEV) have two engines; an electric and an internal combustion engine. PHEVs have typically smaller batteries than BEVs and can operate on fuel when battery runs out of power. (Center for Sustainable Energy 2018.)

Housing Company is defined as follows in Finnish law:

A limited liability housing company is a limited liability company whose purpose, provided in its Articles of Association, is to own and control at least one building or part thereof in which at least half of the combined floor area of the apartment or apartments is reserved in the Articles of Association for use as residential apartments possessed by the shareholders.

On its own or combined with other shares, each share of the limited liability housing company provides the right of possession to the apartment or other part of the building or real estate as provided in the Articles of Association, within the building or real estate in the possession of the housing company. (Finlex 1599/2009, ch. 1, § 2.)

All shareholders have equal power of decision in housing company and all important matters are usually dealt in the General Meeting organized annually. The Board of Directors (Board) is responsible for administration, maintenance and finances of the housing company.

Charging Infrastructure in this paper symbolizes chargers, charging stations or recharging point used to recharge EVs'. Typically, chargers are categorized in European system Mode 1 to 4 or American Level 1-3 chargers. (Falvo, Sbordone, Bayram, & Devetsikiotis 2014.)

Table 2. Electric vehicle charger categorization.

Mode 1	Slow charging of light vehicles (moped, e-bike) from household AC network. Typically not used for EV's.	Level 1
Mode 2	Slow charging from household AC network using a specific cable with inbuilt protective system. Typically used temporarily.	Level 2
Mode 3	Slow or semi-fast charging from an AC charging device equipped with protective and control systems. Typical day-to-day charging method at home or workplace.	
Mode 4	Fast charging from DC charging station. Public chargers.	Level 3

1.7 Case Company

Helen (formerly known as Helsingin Energia) is one of the biggest energy companies in Finland. Its predecessor electricity company of the City of Helsinki was established in 1909 when many small electric companies were transferred to the ownership of the city of Helsinki. The company changed its name to Helsingin Energia in 1995 and it is a limited company owned completely by the city of Helsinki. (Helen 2018.)

Helen Group consist of the case company Helen Ltd and four subsidiaries. Helen Ltd.'s main business operations are energy production and sales, district heating and cooling and energy distribution and sales. The other subsidiaries are the electric network company Helen Electricity Network Ltd, a hydropower company Oy Mankala Ab, tunnel company Helsingin Energiatunnelit Oy and Suomen Energia-Urakointi Oy, a service company specialised in electronic urban technology, providing design, installation, operation and data transmission services for networks and equipment related to electricity transmission, distribution and use. (Helen 2018.)

Helen Ltd had 888 employees at the end of 2017. Helens' net sales were 681 million euros with an operating profit of 51 million euros. (Helen financial statement 2017, 15.)

At the moment, Helen offers charging station solutions for housing companies. Helen can offer full service, starting from the review of capacity and condition of the housing company's electric network, to the physical charging stations and assembly services. Naturally, as an electricity company, Helen supplies the energy used in the chargers as well.

Helen also provides charging as a service model solution. (Helen 2018.) When service model solution is used, the operator is responsible for the costs of the assembly and charging devices. The operator then invoices the users for the electricity used, instead of the housing company. Benefit of this model is lower requirement of capital needed for the housing company. For the service provider this kind of model brings steady flow of revenue.

When a housing company considers building charging stations, Helen can carry out so-called "distant review" where the housing company's electrical capacity is monitored and reviewed. After conducting the distant review, Helen produces a report which assesses how many charging units can be assembled without any modifications, with small

modifications or with major modifications on housing company's electricity system or by raising the capacity of housing company's electric grid interface. Cost of the distant review is 200 € (excl. VAT) for the housing company. (Helen 2018.)

Helen's price for a single Mode 3 charging unit is 1 250 € (excl. VAT). Cost of the assembly depends on the circumstances at the premises, but starts from 500 euros and includes delivery, cabling work of max. 10 meters, electrical couplings and deployment of the unit. (Helen 2018.)

Helen's charging units operate in Virta-service. Virta is the most comprehensive charging network in Finland, operating more than 350 chargers. Helen operates 40 public chargers and they are also part of the Virta-network. Virta-service invoices the user based on the electricity usage and the housing company does not need to take care of monitoring the consumption of electricity or invoicing the users. The Virta-service lets the user to optimize hours for charging based on electricity market prices and the charging unit can be shared publicly, allowing the owner (e.g. housing company) generate little income.

Through Virta-service the customers also have access to thousands of charging stations in most Western European countries. In October 2018 Virta signed a contract with Europe's largest energy company E.ON to create an extensive charging network in Europe. (Virta 2018.)

With this research, the commissioning company Helen wants to gain better understanding on the underlying reasons that keep housing companies from making decisions to build charging stations for EV's and test interest towards alternative models for charging infrastructure development.

2 Research Methods

Marketing research can be defined as the process of collecting, analysing and interpreting information to solve a marketing problem. According to The American Marketing Association, the function of marketing research is to find a link between a consumer and marketer by providing information for making marketing decisions. (Burns & Bush 2014, 34-35.)

Different kinds of marketing research methods were chosen for different purposes in the data collection process of this study. The research was implemented using pluralistic methods in data collection, utilizing both qualitative and quantitative methods.

2.1 Quantitative, qualitative and pluralistic methods

Quantitative method is the traditional method of conducting marketing research. It usually involves a set of structured questions with predetermined answer options and a large number of respondents. Surveys are a typical example of quantitative data collection. The data gathered from the respondents with quantitative can be compiled and formatted in numerical form to produce as precise information.

In contrast to quantitative, the **qualitative** method is often more free form or nonstandardized. The idea is to give more room to the opinions and insights of respondents by observing what people say and do. The answers are typically open ended.

The **pluralistic** method is a combination of both quantitative and qualitative research methods. The aim is to gain the advantages of both methods. Pluralistic research method can for example involve a quantitative survey and an interview of an expert or other qualitative data collection method to help the researcher to get better understanding of the specific marketing problem. (Burns & Bush 2014, 146-148.)

2.2 Primary data collection

Primary data means the data that is collected or developed by the researcher for specific research project at hand. (Burns & Bush 2014, 122.)

Primary data researching the focus group, the members of the Board in Finnish housing companies, was collected by a survey on Webropol-platform. The survey was designed

with pluralistic methods (or mixed method), containing both quantitative and qualitative methods to research IQ1 & IQ3. The survey questions were mainly quantitative. This ensured data quality and standardization and made analysing the data easier and faster. To get deeper understanding of the opinions and viewpoints of the focus group, some question had options for open answers and some questions were of a qualitative nature.

The online survey platform spread through email was chosen mainly because it has the advantage of fast data collection, is low cost and can also be easily administered just by myself without involving other interviewers. (Ilieva, Baron & Healey 2002.) The survey was also published in an EV themed social media group. This brought approximately 50 % of the respondents, but means the EV users or people interested in EV's are overrepresented in the census, although ownership of an EV was not asked. On the other hand, this respondent group has first-hand experience on the issues.

As it appeared, the online survey did not reach large number of respondents. Number of respondents through Webropol was 73. As the amount of responses felt insufficient, some contacts with estate management companies provided possibility to conduct telephone interviews to gather more response. Additional 37 responses were collected by telephone interviews, to bring the total size of the census to 110. 71 % of the respondents were from capital area and additional 9% from the surrounding area Uusimaa.

In the analyses concerning decision making in housing companies, 25 of responses had to be demarcated because the respondents did not belong to the focus group, members of the Board in housing companies. For some of the more general issues concerning electric vehicles, all the responses are included in the sample. The responses otherwise excluded are mostly EV owners or users, who have insight for issues concerning EV's from own experience.

For IQ2, an interview was used as a research method. Interviewing a specialist to obtain data, in other words gather information from someone who already has the knowledge, is also called human search. (Bradley 2013, 90.)

The interview was semi-structured. In this type of an interview, the researcher provides some structure based on research interests, but is able to give room to respondent's spontaneous descriptions and narratives. (Brinkmann 2014.)

The interviewee was the Leading Legal Counsel of The Finnish Real Estate Federation (FREF), Mia Pujals. She was recommended by the contact person in the commissioning company. Ms. Pujals is undoubtedly one of the leading specialists in Finland in legal issues of housing companies. She has participated in compiling FREF's guidance for housing companies considering the development of charging infrastructure. (Pujals 28 June 2018.)

2.3 Secondary data collection

Secondary data is gathered by someone else than the researcher and for other purpose than the particular research project at hand. (Burns & Bush 2014, 122.)

Technical Research Centre of Finland Ltd (VTT), The Finnish Real Estate Federation (FREF) and Motiva Oy carried out a survey for housing companies during spring 2018 as a part of GASELLI-project. The GASELLI-project is funded by the Ministry of Transport and Communications and its purpose is to search for cost-effective ways to advance EV and Natural Gas Vehicle (NGV) adoption. The raw data of the survey and the mid-report of the GASELLI-project was obtained as secondary data of this research, kindly provided by VTT and FREF.

The VTT's survey was part of FREF's repair construction barometer and was executed on online-survey platform. The survey had parts concerning EV charging infrastructure in housing companies. The survey researched the current situation of the charging infrastructure in Finnish housing companies and implementation methods and operating models of existing charging infrastructure. Also, barriers and incentives concerning the development of charging infrastructure were researched. The survey also investigated what kind of information the housing companies lack or desire when making decisions on developing charging infra.

The primary focus group of VTT's survey was same than this research's', the members of the Board in Finnish housing companies and additionally estate managers. The survey was also publicly shared in social media channels. The survey had 1 734 respondents. The survey had also a part that was aimed to current users of electric vehicles. This was included to get insight on the user experiences of EV owners/users. To gather responses, the survey was shared in social media groups related to electric vehicles.

Similar to the analysis of Webropol-survey, the analyses concerning decision making in housing companies, a small amount of responses (29) have been demarcated because the respondents did not belong to the focus group of the study, housing company decision makers, namely members of the Board. However, the responses by estate managers were decided to include since they are often very influential in decision making processes of housing companies. In analyses of general issues concerning EV's, all the responses are included in the sample, since the otherwise excluded respondents are mostly EV owners and users.

RQ: What are the challenges in developing the charging infrastructure in Finnish housing companies?

IQ 1. What are the most important reasons restricting housing companies from building charging infrastructure?

IQ 2. What kinds of laws and regulations are limiting the development of charging infrastructure?

IQ 3. What alternative business models could be used to improve charging infrastructure availability?

IQ 4. What recommendations can be derived from the findings?

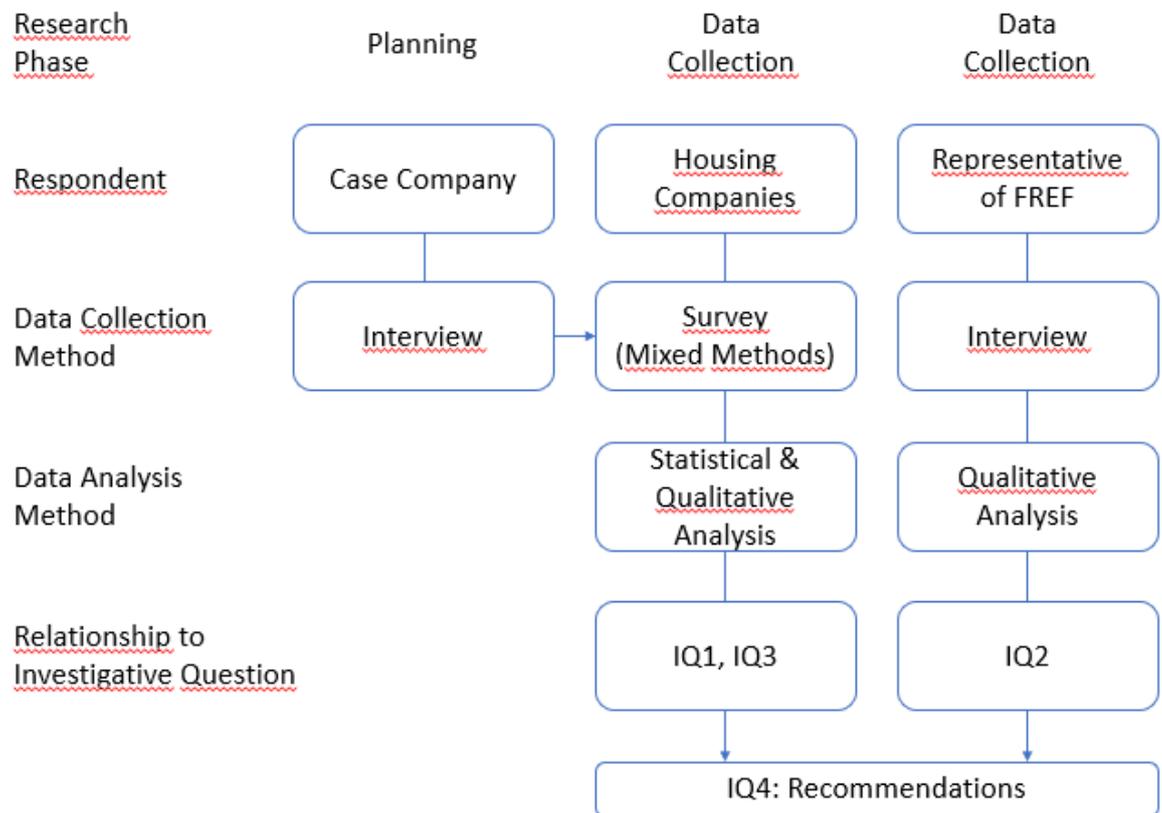


Figure 1. Research methods.

3 Theoretical framework

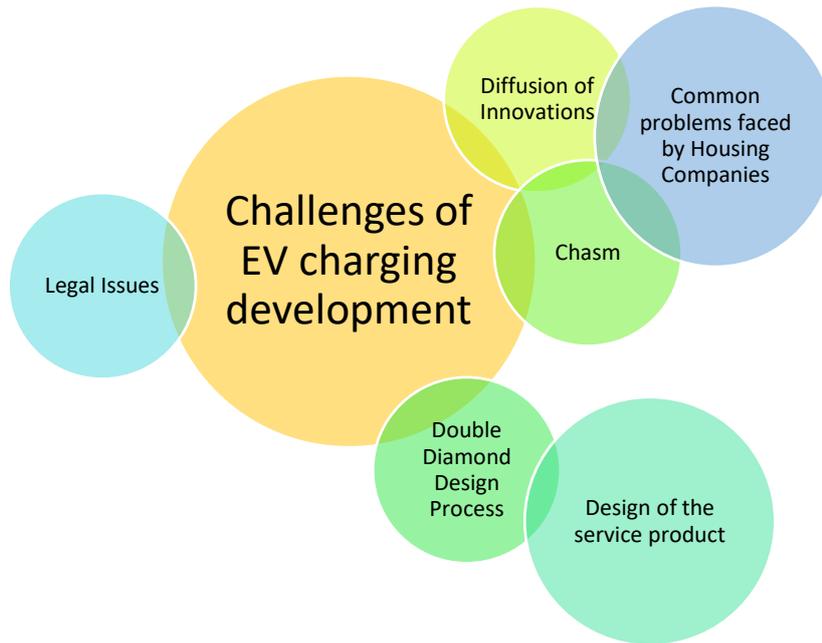


Figure 2. Conceptual figure of the theoretical framework

Several theories will be applied when researching the topic. Diffusion of Innovation and Chasm theories are covered in a relation to housing companies perceived challenges and possibilities in building charging infrastructure. Double Diamond Design Process will be applied in order to identify the customers' needs and develop service products to match the expectations.

3.1 Diffusion of Innovations

Diffusion of Innovation (DOI) theory is a sociological science theory developed by Everett Rogers in 1962. The DOI theory explains how new ideas or technologies gain momentum and spread in a specific population or social system.

The qualities required from an innovation to succeed are:

1. Relative advantage
2. Compatibility with existing values and practices
3. Simplicity and ease of use
4. Trialability
5. Observable results.

Rogers' DOI theory categorizes the target population in 5 categories according their behaviour in adopting new ideas and technologies.

1. Innovators – The first 2.5 % of the population, who are typically of high social status, are willing to take risks and have financial resources enabling trial of yet expensive new technologies. Innovators are often also developing new ideas of their own.
2. Early Adopters – The next 13.5 % has the greatest degree of opinion leadership. Early Adopters also have higher social status, financial liquidity and education, but they need more arguments to justify the adoption than Innovators. The Early Adopters typically communicate about their choices and by this way act as vanguards for later adopters.
3. Early Majority – Representing 34 % of the population, the Early Majority is adopting innovations before average person. The social status of Early Majority is typically average, but they have contact with Early Adopters. They are rarely leaders and they need more evidence of the effectiveness of the innovation before they are ready to adopt it.
4. Late Majority – The second last group also represents 34 % of the population. Their social status and financial liquidity are below average. Late Majority are typically sceptical of change and are only ready adopt after the innovation has proven successful by the Early Majority.
5. Laggards – The last 16 % of the population, called Laggards, have the lowest social and financial status and show very little or no opinion leadership. Laggards are typically older people and they are conservative and bound by tradition. (Rogers 1983.)

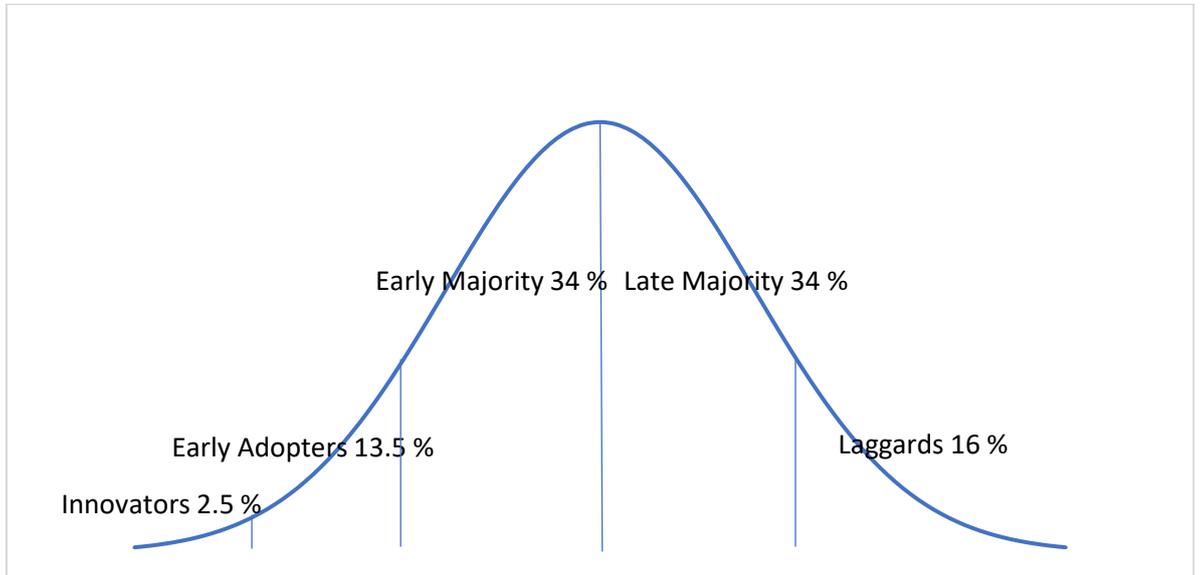


Figure 3. Diffusion of Innovations

Diffusion of Innovation theory is relevant in the case of Electric Vehicles, because EV's are still in very early stages in their imminent break trough. According to European Automobile Manufacturers Association (ACEA), number of new PEV passenger car registrations in Europe (EU + Norway & Switzerland) was 88 329 in the first quarter of 2018. (ACEA 2018.)

This translates to 2.1 % of the total amount of all passenger cars registered in Q1 and places the buyers of EV's still in the category "Innovators". It is evident that some of the qualities required from innovation to succeed are lacking. For example, the "Simplicity & ease of use" is not reached yet, as the charging is problematic for many potential EV owners.

3.2 Chasm

Geoffrey A. Moore has introduced a concept of "Chasm" as an extension to Rogers' DOI-theory. In his 1991 book "Crossing the Chasm" Moore describes the Chasm as an obstacle to overcome before technological innovation can become self-sufficient. According to Moore, Chasm takes place in between Early Adopters and Early Majority. Moore believes that marketers should concentrate on one DOI-group at time and the transition from Early Adopters to Early Majority is the most difficult, therefore creating the Chasm. (Moore 2001.)

3.3 Service Design

Service design in general means activities and methods used to create and improve the quality of a service product. Professor of Service Design in Aalborg University, Nicola Morelli, describes the characteristics of service products in comparison with physical products in his publication "Designing Product/Service Systems: A Methodological Exploration". (Morelli 2002, 4-5.)

Relationship between users, designers, and service providers.

The manufacturers of physical products usually do not have a contact with customers during design process. Providers of services instead usually involve the end users to participate shaping the service product.

Production and consumption times.

Products become existing when they are produced. They are used and consumed by customers later. The services exist right when they are supplied and used. They are developed and delivered in a specific time period and the configuration varies according to use.

Material intensity.

While the products are usually tangible items, the services are a composition of intangible features or functionalities. Because they are immaterial, they can not be stocked and their ownership is not transferrable. Other material difference between products and services is that product exist in time and space, while services as processes exist only in time. (Morelli 2002, 4-5.)

3.4 Double Diamond Design Process

Design has different kinds of definitions, but essentially it is a process of transforming ideas to reality, creating abstract concepts and putting them in concrete and tangible form to real life use.

Designers try to understand the needs and desires of the end users by for example using the end product themselves or observing the users. The design process is iterative, meaning that often several versions of the end product are tested and them improved by redesigning them. Prototyping gives designers feedback from the end users and can be applied to designing of both products or services. (Design Council 2018.)

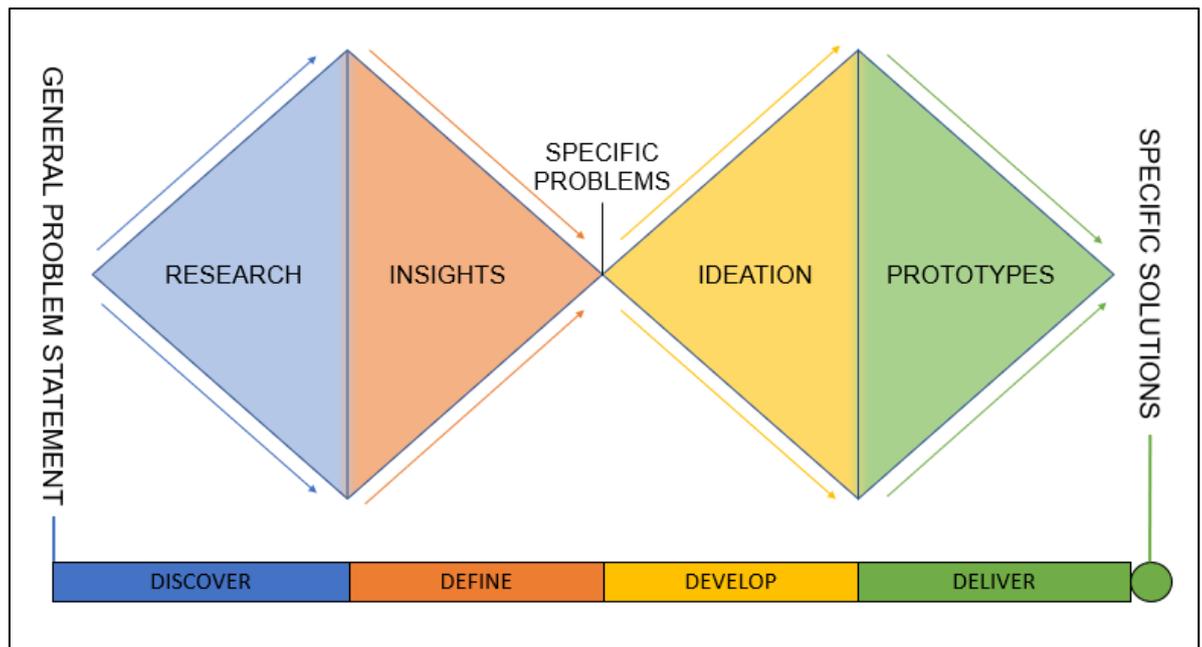


Figure 4. Double Diamond Design Process

The Double Diamond Design Process is a model developed by British enterprising charity, Design Council. This model is well applicable in the design process of the services. Double Diamond Design Process is divided into four phases; Discover, Define, Develop and Deliver.

The Discovery phase is the start of the project. The designers examine the subject and try to seek inspiration and insights to develop new ideas. The tools used in this stage include for example market research, user research, managing and planning and design research groups.

In the second stage, Define, the designers try to understand and define the core of the design problem. They use methods like project development, project management and project sign-off to define the primary issues and actions to take.

The third stage is the period of development, when solutions are created, tested, prototyped and iterated. Trials and errors help the designers to see what actually works. Some of the most important activities during the development-stage are brainstorming, prototyping, multi-disciplinary working, visual management and testing.

The final stage of the Double Diamond Design Process is Deliver. Here the product or service is finalized and launched. The key activities during this stage include final testing and approval, launching, setting targets and evaluation and feedback loops.

This research involves mostly the first two stages of Double Diamond Design Process. The problems experienced in charging infrastructure development are researched and identified by market research which is essentially the **Discovery** phase. The issues and problems are **Defined** and the underlying reasons explored in the conclusions and recommendations part (chapter 5.2) of this study.

The question concerning service model (figure 13) actually reaches already to **Develop** phase, as the idea is to test the customers interest towards a certain model of arranging the charging. Question about coverage of public charging infrastructure (figure 12) questions the need for charging at housing companies, and there fore the whole business model.

4 Analysis

4.1 Analysis of the current situation in housing companies

Finnish Real Estate Federation offers counselling for its' member housing companies through telephone help desk. Leading Legal Counsel of FREF, Mia Pujals, mentioned in interview that questions concerning the Electric Vehicles and especially charging, are really notable and continuing trend in calls from housing companies. (Pujals 28 June 2018.)

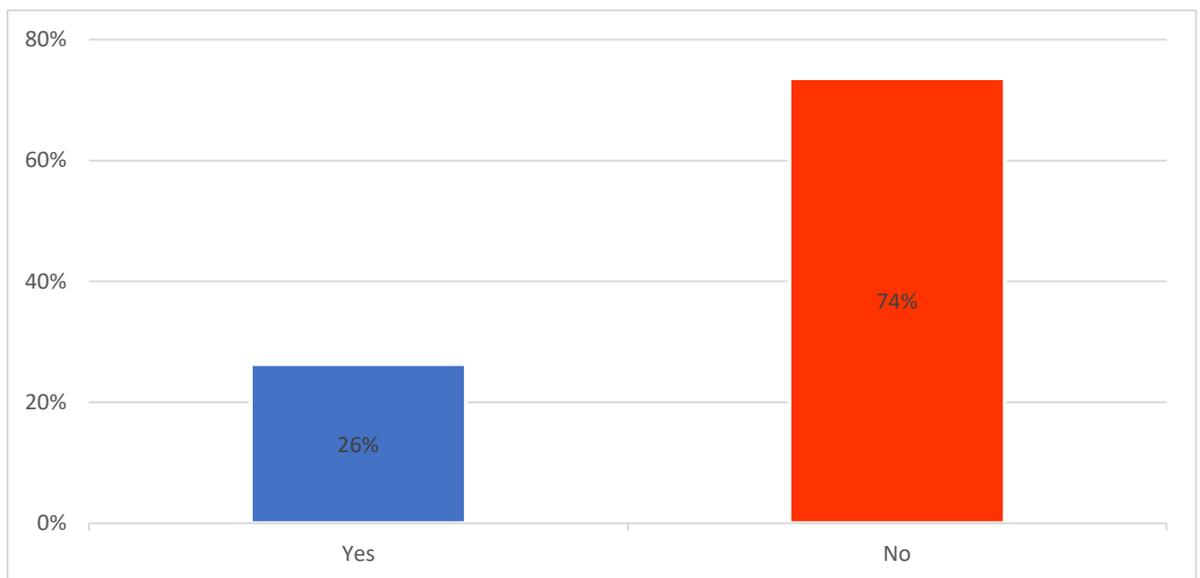


Figure 5. Has interest towards EV's been surveyed? (n=110)

In the Webropol-survey, 74 % of the respondents said inhabitants' interest to acquire an EV or Plug In-hybrid has not been investigated in their housing company, as illustrated in figure 5 above.

According to data gathered in the VTT survey, 84 % of the housing companies have not taken any actions to build or enable building of charging devices, as in indicated in table 3 below. Out of the 1734 respondents, over thousand replied that no preparations to build charging units have been done in their housing company. 400 respondents stated that the issue has been discussed in the General Meeting or Boards meeting, but no actions have been taken after that.

Table 3. Current EV charging unit development in Finnish housing companies (n=1734)

No preparations done so far	1017
Issue has been discussed in the board/general meeting, no actions taken	400
Housing company examines acquiring the charging units	63
Housing company has not permitted shareholder to assemble charging unit at own cost	39
Current situation has been examined (e.g. how many charging units can be assembled without major renovation)	36
Housing company has built possibility for Mode 2 charger assembly on all parking spots	31
Shareholders need/interest for charging units examined	30
Decision made to acquire charging devices, not completed yet	28
Charging devices assembled, on shareholders own cost	24
Charging devices assembled by the housing company	21
A review of the electrical system conducted and shareholders interest on EV's examined	19
Housing company has compiled a guidance for assembly on shareholders own cost	15
Housing company has permitted shareholder a charging unit, not completed yet	11

Interests, needs or current situation of the electrical system had been researched in 8.5 % of the respondents housing companies.

2.6 % of the respondents replied that charging devices have been assembled in their housing company, either on housing company's or shareholders cost. Additionally, 2.2 % has made the decision to assemble chargers, but they are not yet completed. 1.8 % has the readiness for chargers built in.

39 respondents (2.2 %) told the housing company has not permitted shareholders to build charging station on own cost.

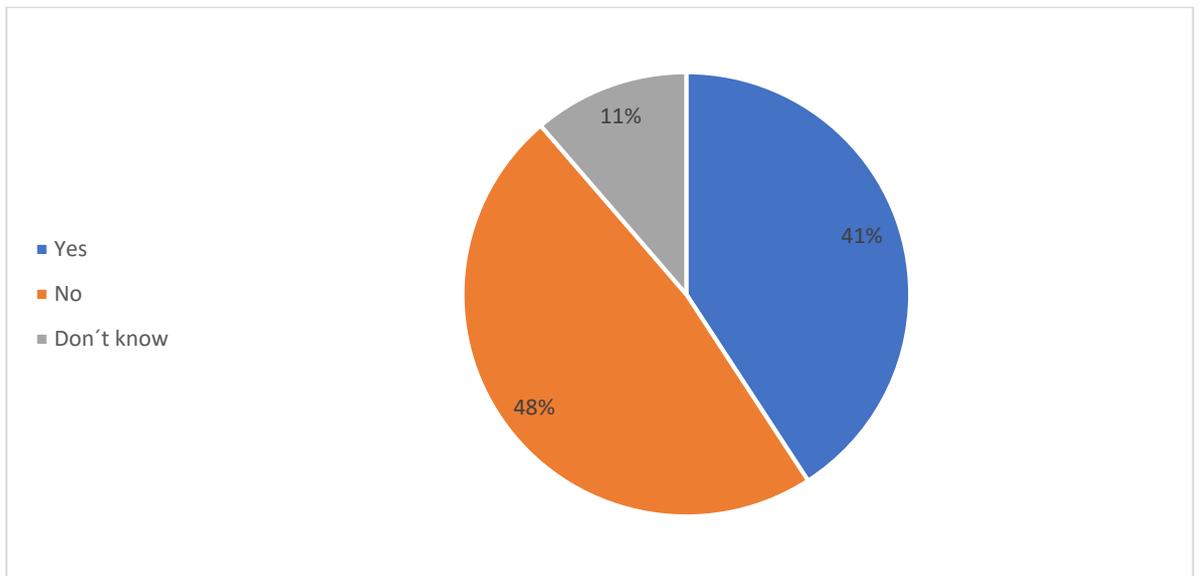


Figure 6. Decision in principle made in General Meeting. (n=71)

As indicated in figure 6, of the housing companies which have chargers installed, have decided to install them or have permitted a shareholder to install a charger, 48 % did not make the decision in principle in the General Meeting. 41 % of these decisions were made in General Meeting.

In Webropol-survey, 102 respondents out of 110 lived in a housing company. 34 % of the respondents living in housing company said charging EV's is possible in their housing company, either from designated charger or from normal wall plug. This result is definitely skewed by the strong representation of EV owners replying the survey.

Of the 80 Webropol-survey respondents living in apartment building, 76 % said charging is not possible in their housing company. Of the respondents (22) living in other types of housing companies (row house, semi-detached house, other) 73 % of the respondents had the charging possibility.

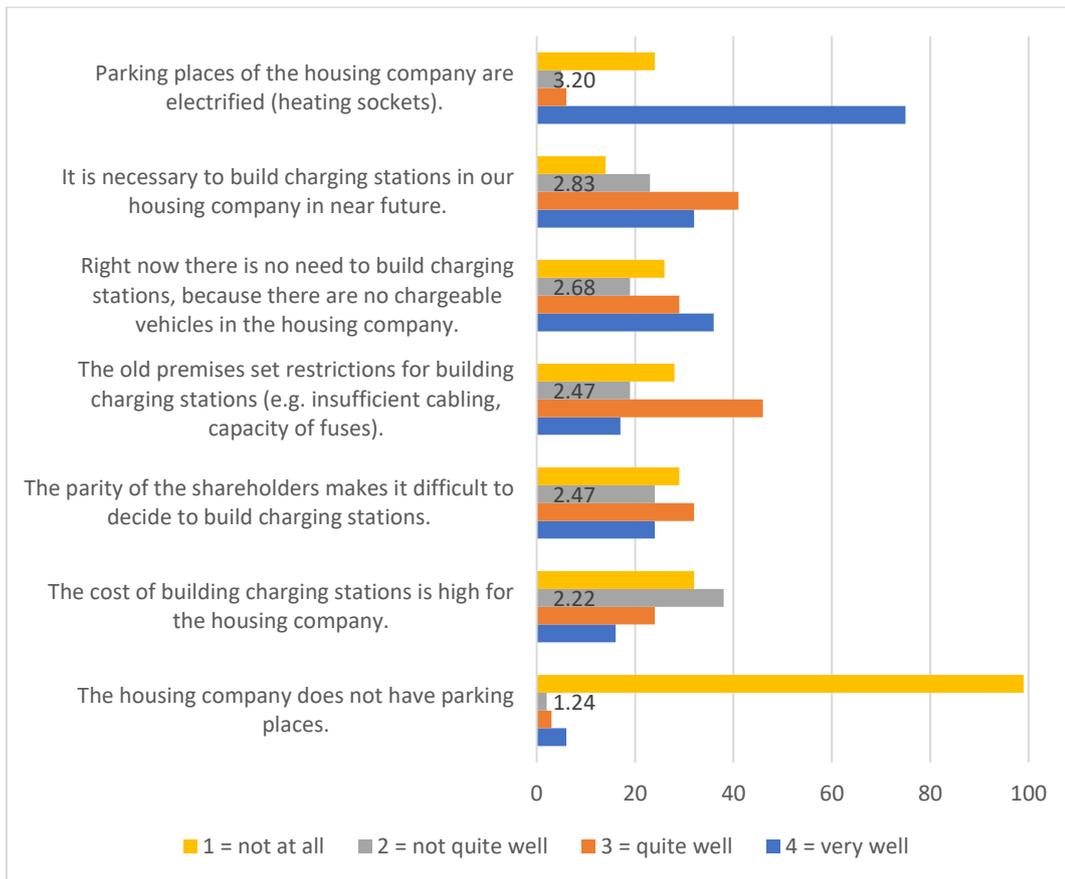


Figure 7. How well statements describe respondents housing company? Average values shown. (n=110)

The respondents were asked how well certain statements describe the situation in respondents housing company (figure 7). The responses in most questions are quite dispersed. It can be clearly derived that almost all of the respondents housing companies have parking places and they are electrified with heating sockets.

66 % of the respondents think it will be necessary to build charging stations in their housing company in near future. At the same time 59 % state that there´s no need to build them now, because no one has a chargeable vehicle in their housing company. Only 36 % of the respondents think the cost of building charging stations is high for the housing company.

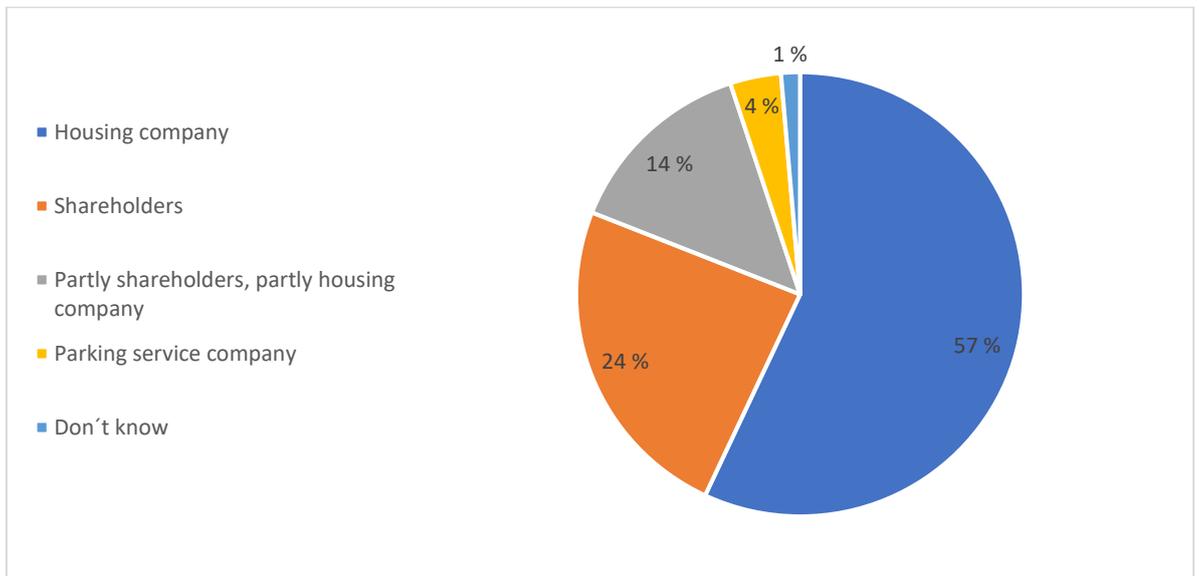


Figure 8. Ownership of parking places in housing companies. (n=1685)

Majority (57 %) of the parking places in housing companies are owned by the housing company amongst the respondents of VTT's survey (figure 8). Also other modes of ownership exist. This is significant, because the ownership has an effect on what can be done on the parking place.

FREF's Mia Pujals stated in the interview that if the shareholders own the parking places, they have more power to decide what to do, for example assemble charging station. In this case the housing company can't necessarily deny the shareholder to build a charging unit, unless it would cause a problem with housing company's electric system. (Pujals 28 June 2018.)

In small number (4 %) of the housing companies the parking places are also owned and administered by an outside parking service company, as shown in figure 8. For example, separate parking buildings in newly developed residential areas are often implemented with this model. When a resident or a housing company would like to have charging unit assembled on the parking place, the negotiations are to be dealt with the parking company. The charging infrastructure could potentially be easier develop with this model, as the parking company is providing the parking as a service. If the user wants better service (e.g. charging) the company could charge more for the service.

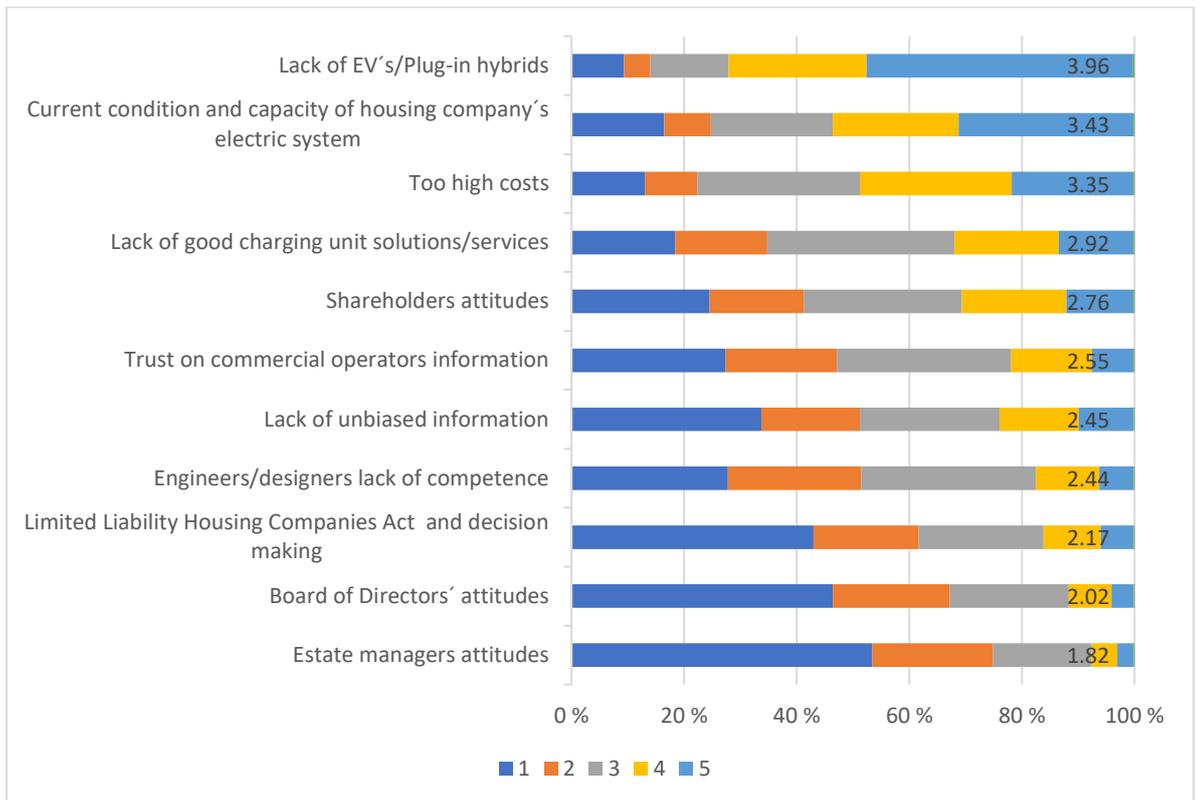


Figure 9. Main blockades for charging station implementation, averages. Scale 1-5 (5 = major blockade, 1 = no blockade) (n=1625)

In VTT's survey the respondents were asked what they consider the most important blockades for charging station implementation in housing companies. The respondents could assess with numeral values 1-5 how important they considered given blockade (figure 9). The respondents were also able to give open feedback. Distinctly the most important reason was the lack of chargeable vehicles with 72 % of 1574 responses giving values 4 or 5. 317 respondents gave open feedback. In these responses it was also highlighted that no demand has come up so far.

Also, the current condition and capacity of housing company's electric system and high costs of such project were considered major blockades.

The respondents did not find attitudes of Board members or estate managers as a considerable blockade.

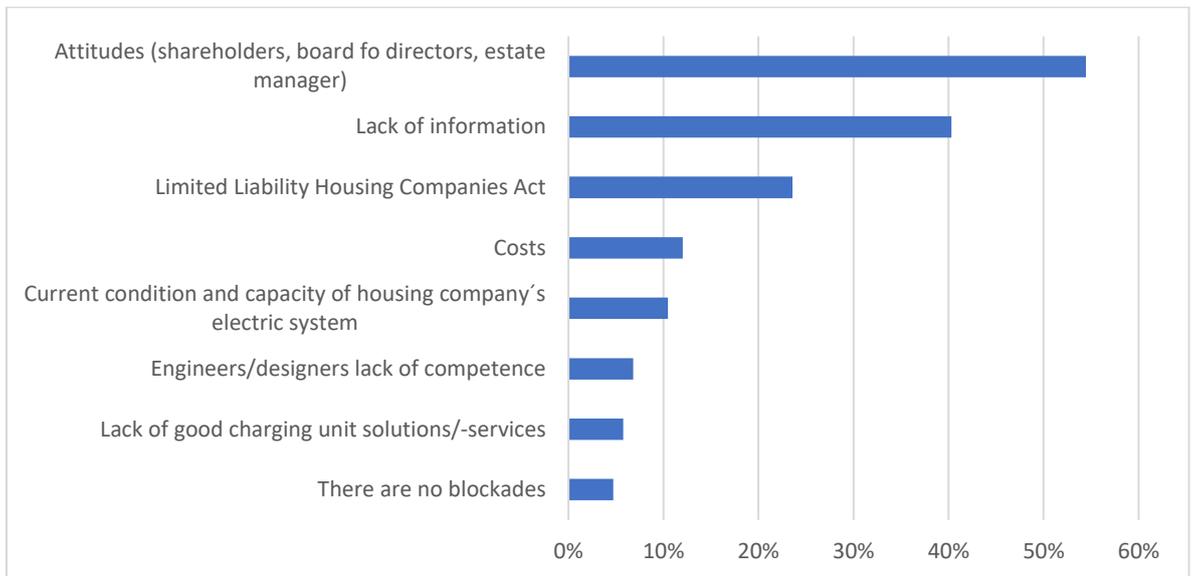


Figure 10. Main blockades for charging station implementation, EV users. (n=191)

The question of blockades for charging infrastructure implementation was composed slightly differently in the VTT's survey's consumer survey part that was directed to EV owners/users. The respondents could name as many answer options as they wanted. The figure 10 above indicates that users of EV's found the attitudes of other shareholders, board of directors and estate managers the most important blockade in charging infrastructure development in housing companies.

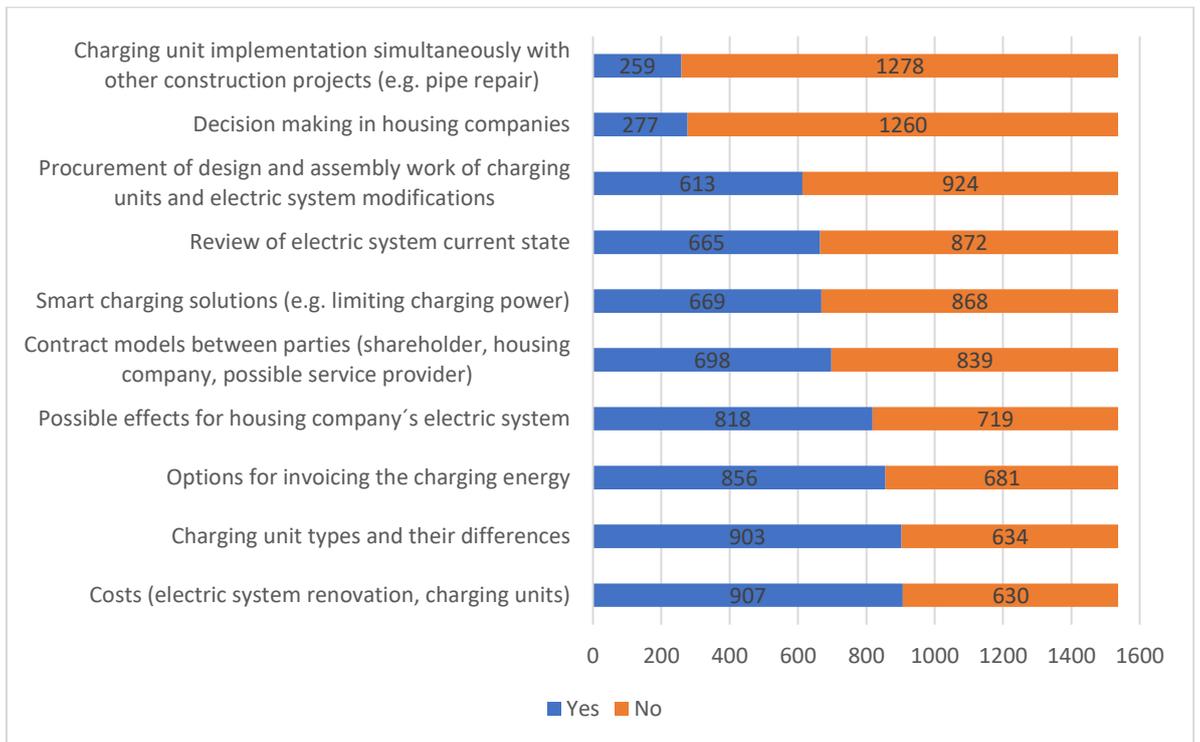


Figure 11. What kinds of information is desired on charging units and their implementation (n=1537)

In VTT's survey the respondents were asked what kinds of information about the charging stations and their planning and realization process in housing companies the respondents would like to have.

As figure 11 addresses, the single most popular option amongst respondents was information concerning the costs of charging units and associated costs of renovations. Technical information about the charging units and the effects on housing company's electric system and information about solutions for invoicing and contract models were also commonly desired.

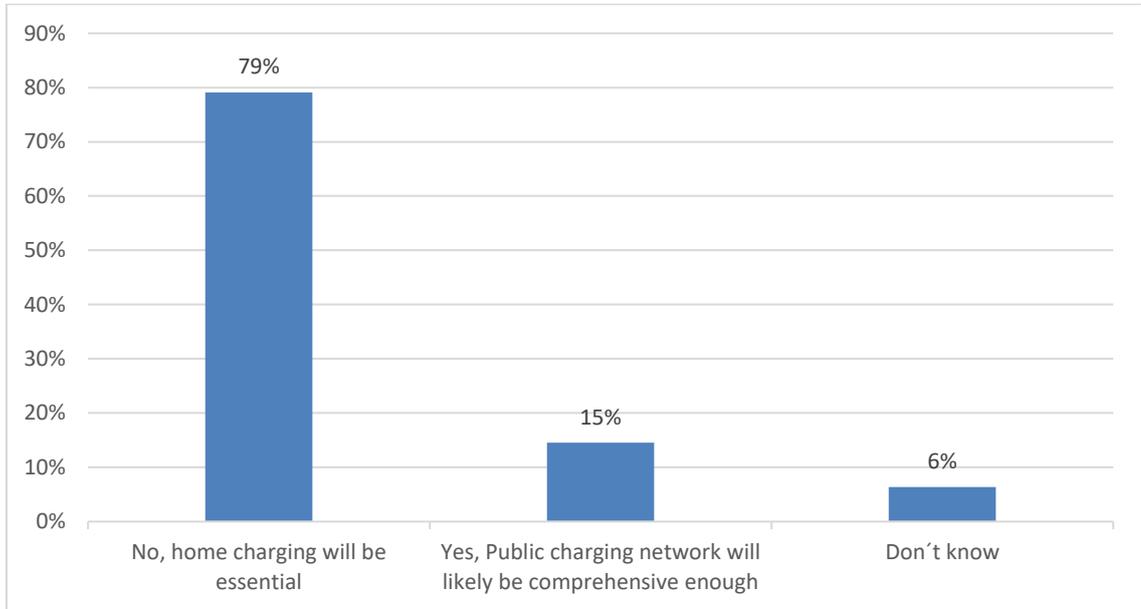


Figure 12. Will public charging network be comprehensive enough? (n=110)

The respondents of Webropol-survey were given an example, K Group's announcement that K-Group will start building charging stations on all Neste gas stations and in several K Store locations. The respondents were asked whether they think the public charging network in future could be so encompassing that the housing companies would not necessarily need to build chargers. Almost 80 % of the respondents thought there will always be a need for home charging (figure 12).

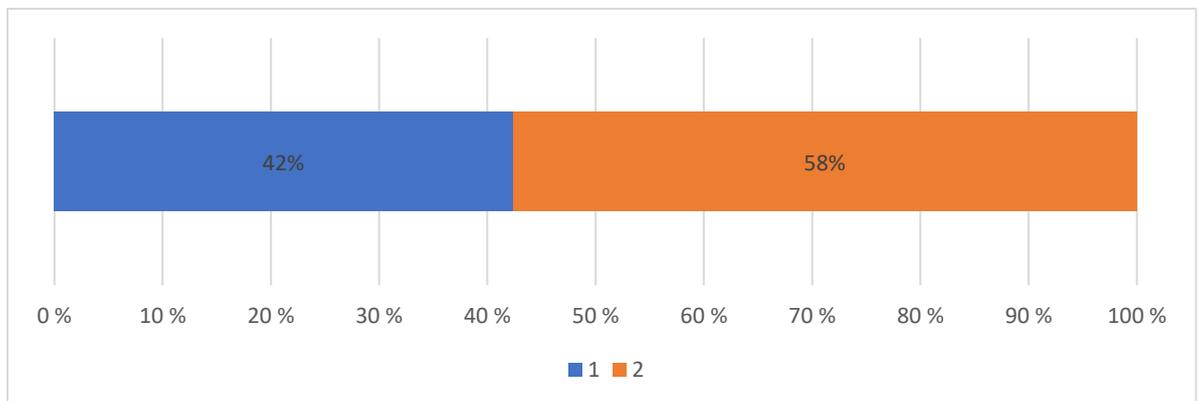


Figure 13. Charging infra construction models. (n=85)

Legend of figure 13:

1 = The housing company takes care of the procurement and construction of the charging stations. The housing company invoices the users for the electricity.

2 = A service provider constructs the charging stations on the premises. If large excavations are not needed, the service provider is responsible for the costs of construction and equipment. The service provider invoices the housing company a monthly fee (e.g. 70 €) and charges the users for the electricity. The contract is fixed term, for example 5 years.

The respondents of Webropol-survey preferred the service provider model over housing company's own project for building charging stations, as indicated in figure 13. In this model, the service provider would be responsible for all related costs of construction and equipment, except for large excavations. The service provider would charge the housing company a monthly fee for the service and the users for the energy used. The contract between the housing company and service provider would be fixed term.

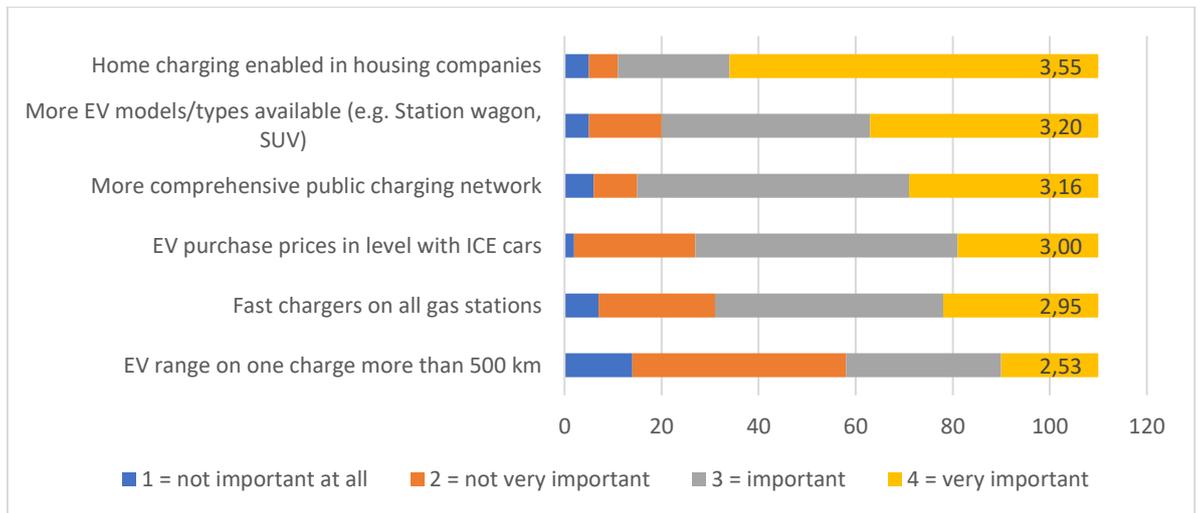


Figure 14. Importance of different factors in diffusion of EV's, averages. (n=110)

Respondents of Webropol-survey were asked about importance of certain factors for spreading of Electric Vehicles. Figure 14 above shows that possibility to charge EV's at home (in housing companies) was clearly the most important factor, with 90 % of the respondents stating it very important or important factor. Public charging network coverage was also considered important factor by 86 % of the respondents. Fast chargers assembled on all gas stations was important for 72 % of the respondents.

Often Electric Vehicles driving range on one charge is mentioned as major limiting factor. The survey does not support this claim. 53 % of the respondents stated the range of 500 km is not very important or not important at all. According the Finnish Transport Agency FTA, the average daily distance driven with passenger cars in Finland is 52 kilometres. (FTA 2018). This fact also underlines the relative unimportance of really long driving range on one charge.

For many drivers the EV's are simply not a practical option yet, because the current selection of EV models is scarce with lack of spacious family cars and still relatively high pricing.

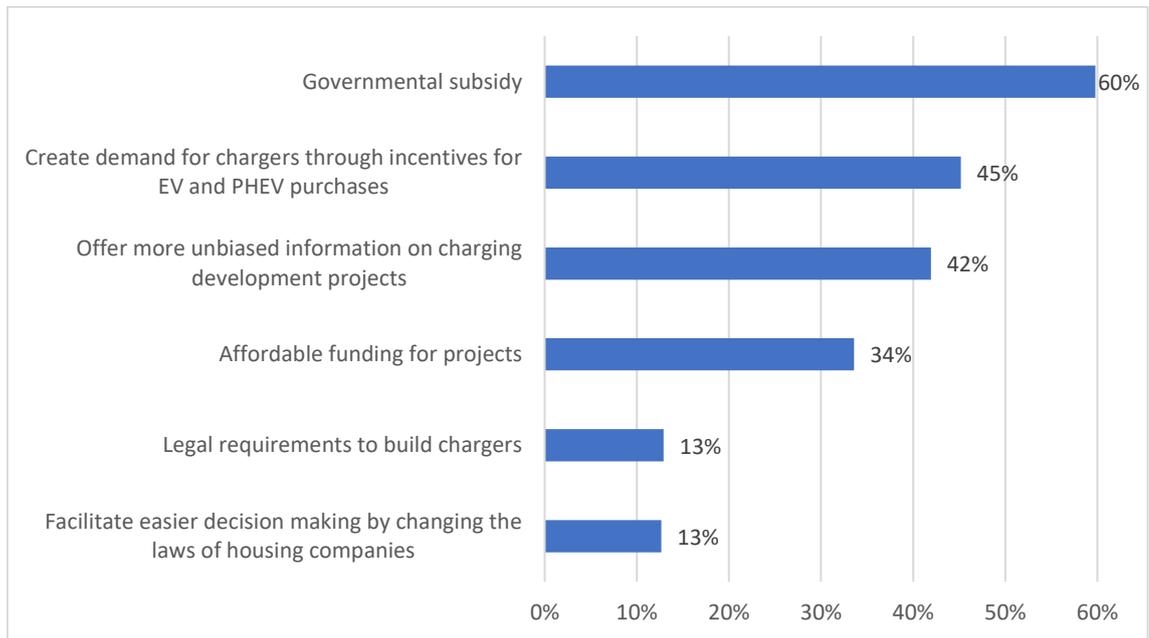


Figure 15. Best ways to promote charging stations for housing companies (n=1572)

VTT-survey respondents named governmental subsidy the best way to promote charging stations for housing companies. Incentives for EV and PHEV purchases and importance of unbiased information were also considered effective (figure 15).

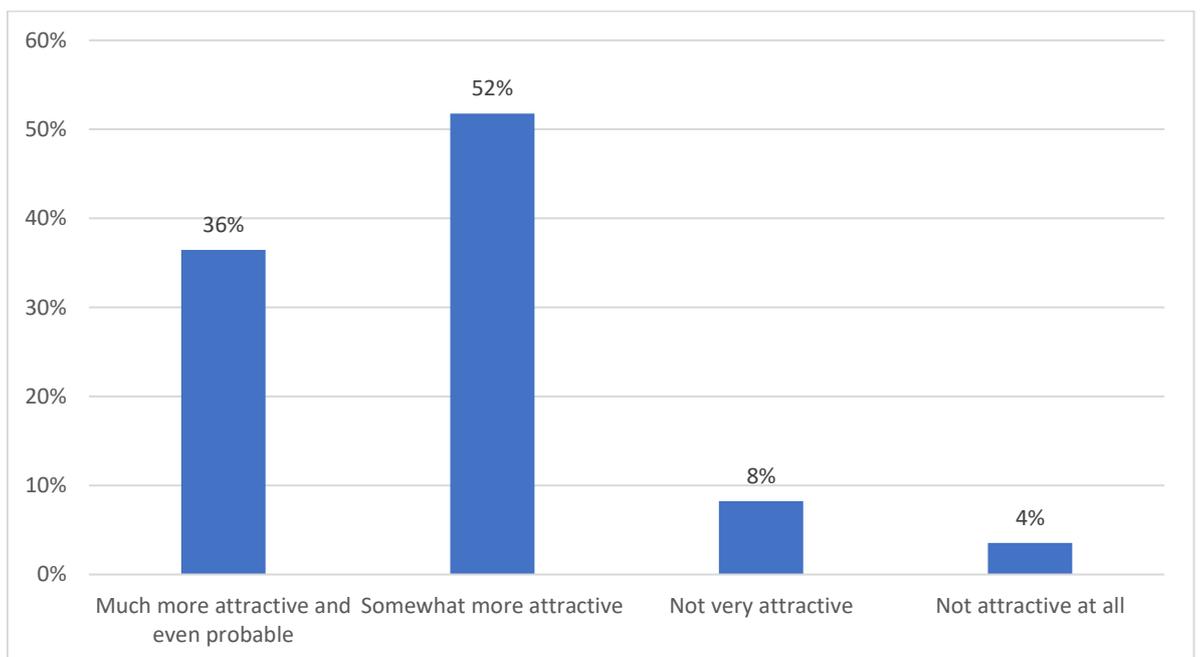


Figure 16. The influence of 35 % governmental subsidy for chargers (n=85)

The respondents of Webropol-survey were asked if a governmental subsidy of 35 % of the realised costs would make building charging infrastructure more attractive for their housing company. 88 % of the respondents stated the subsidy would have a positive effect, as indicated in figure 16. 36 % of the respondents said the subsidy would make building charging infrastructure even probable.

4.2 Decision making in housing companies

Limited Liability Housing Companies Act regulates the decision making in Finnish housing companies. Shareholders normally exercise their power of decision at the General Meeting. The General meeting is usually arranged once a year.

The Board of Directors convenes the General Meeting and prepares the notice of the meeting including the matters to be dealt. The notice has to be delivered to all shareholders earliest two months and latest two weeks before the General Meeting. Only matters mentioned in the notice of the meeting can be dealt with. All of the shareholders have a right to demand a matter dealt in the meeting. The demand has to be expressed in written format to the Board of Directors well in advance, so it can be included in the notice of the meeting.

Decision by majority. A proposal that has been supported by more than half the votes cast shall constitute the decision of the General Meeting. (1599/2009, ch. 3, § 26.)

Normally the decision on maintenance or modernisation to be financed by all shareholders has to be made in General Meeting.

The General Meeting shall decide on any modernisation that has broad effects or that has significant impacts on a residence or on residential costs.
(1599/2009, ch. 3, § 31.)

When more than half of the votes cast in the General Meeting support a proposal, it is approved by Decision by Majority. (1599/2009, ch. 3, § 26). This is usually the case with decisions made in General Meetings.

Some administrative decisions can be made by the Board of Directors without bringing the matter to the General Meeting.

The Board of Directors requires a decision by the General Meeting for activities that:

- (1) are unusual or have far-reaching consequences, considering the size and activities of the housing company;
- (2) significantly affect the use of an owner apartment in the possession of the shareholder; or

(3) significantly affect the shareholder's obligation to pay the charge for common expenses or the other expenditures resulting from the use of the owner apartment in the possession of the shareholder. (1599/2009, ch. 7, § 2)

What is considered "unusual" mentioned above remains ambiguous. In the context of charging infrastructure development, a decision to build charging stations on housing company's cost is most likely considered kind of modernisation intended in section 2 above, since the costs are typically several thousand euros.

The Board can grant shareholder a permit to build a charging station on his/her own cost, if it does not cause significant costs for the housing company. Even with this there could be a contradiction with the section concerning Equal Treatment of the shareholders.

The General Meeting, the Board of Directors or the Manager shall not make decisions or take other measures that are conducive to conferring an undue benefit to a shareholder or another person at the expense of the housing company or another shareholder. (1599/2009, ch. 1, § 10)

If the Board grants one shareholder a permit to set up a charging station or just use the normal wall socket for charging purpose, it should give the permit to every other shareholder to do so as well. Then this decision might lead to the situation, where the electrical system of the housing company proves insufficient and has to be upgraded.

However, as indicated in chapter 4.1 (Figure X) of this study, in 48 % of the housing companies that have enabled charging in principle, the Board of Directors has made the decision instead of taking it to General Meeting.

4.3 Purchasing process in housing companies

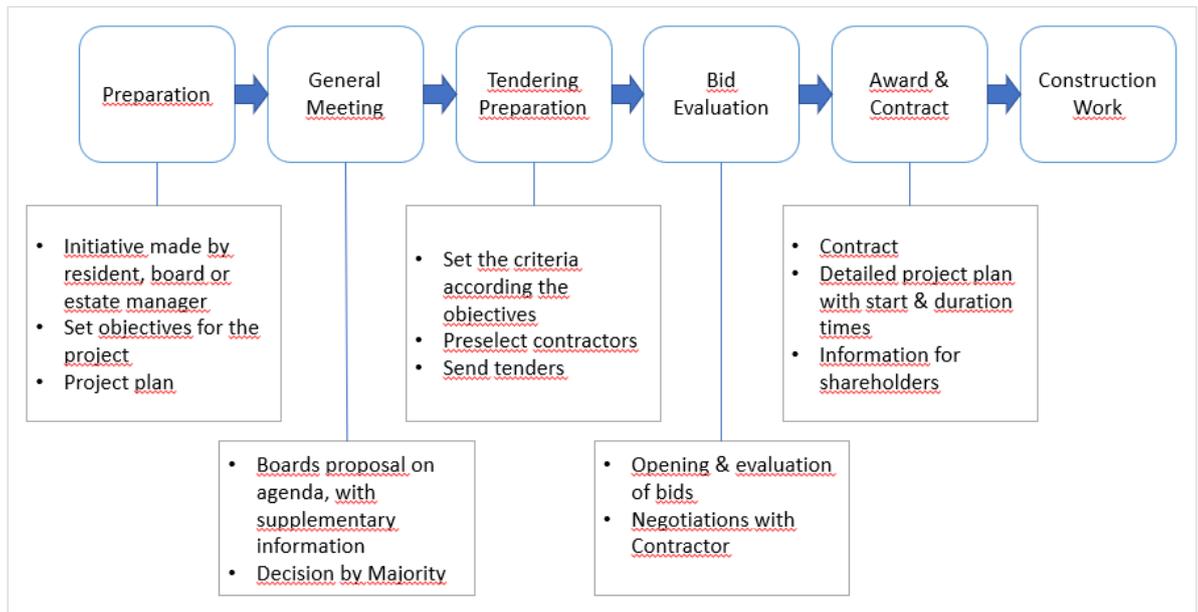


Figure 17. The purchasing process in housing company.

Above is illustrated a typical purchasing process of a housing company, when the purchase is bigger. The figure is composed by author and is based on own experience from Board of Directors-work. For example, a project of acquiring charging stations for the housing company would for the most part be like this. Acquisition of charging stations is a type of modernisation project to be dealt in General Meeting, because it has significant impacts on the residence and residential costs, as it is financed by all shareholders.

5 Discussion

As indicated in chapter 4.1 (table 3) only a fraction of the housing companies has started preparations to facilitate charging of electric vehicles. Therefore, the field is open for operators and the competition of charging infrastructure providers is very likely to get more intense in next few years.

5.1 Focus group and DOI-categorization

According to European Automobile Manufacturers Association (ACEA), number of new PEV passenger car registrations in Europe (EU + Norway & Switzerland) was 88 329 in the first quarter of 2018. (ACEA 2018.)

This translates to 2.1 % of the total amount of all passenger cars registered in Q1 and places the buyers of EV's still in the category "Innovators". It is evident that some of the qualities required from innovation to succeed are lacking before EV's final break through. For example, the "Simplicity & ease of use" is not reached yet, as the charging is problematic for many potential EV owners.

As stated by Geoffrey A. Moore in his Chasm-theory, marketers should concentrate on one Diffusion of Innovations-group at time. This is probably applicable with the electric vehicles themselves, since car buyers fit well in the DOI-categorization. Electric Vehicles on most markets are on verge of moving from Innovators-group to Early Adopters.

However, the hypothesis here is that in regard of the charging infrastructure, the situation is different. The suggestion is that marketing actions should be directed to much broader public, including other categories of the DOI-model as well.

For example, housing companies are not typically known for agile decision making and fast deployment of new technologies. The Boards of housing companies have members with diverse profiles and backgrounds, but younger age groups are usually underrepresented. According a survey conducted by FREF, an average member of the Board in housing company is aged 58. The largest age group of Board members is 65 – 74 years, representing 33 % of the respondents. The second largest group is 55 – 64 years with 26 %. Combined with group of over 75 years, it can be stated that two thirds of the members of Board in Finnish housing companies are older than 54 years. By far the largest category of profession amongst members of Board is Pensioners with 40 % share. (FREF 2018.)

This generalization based on age would suggest that many of the decision makers in housing companies would belong to Late Majority or Laggards, the DOI-groups slower to adapt to new technologies.

However, when looking at the demographics besides age, for example education background of the Board members, it can be noticed that they have many of the features of the DOI-groups Early Majority, Early Adopters and even Innovators. Of the Board members who responded the survey, 50 % have University level education background. The three most common areas of education were Technical (34 %), Trade, Administration & Law (28 %) and Information and Communication Technologies (9 %). 66 % of the Board members are men. (FREF 2018.)

With this information, it can be assumed that the members of the Board in housing companies share many of the characteristics of more technologically adaptive DOI-groups, like education, financial liquidity, high social status and opinion leadership. This should be a positive factor for companies operating in charging business.

5.2 Conclusions and recommendations

The electric vehicle diffusion is in a way an example of the classic egg and chicken causality dilemma; if the chickens come from eggs and the eggs come from chicken, which came first. With electric vehicles context this translates to diffusion. The lack of charging infrastructure can be a barrier for many car owners, who are interested in EV's but are just not yet ready to take the step due to perceived inconvenience of charging issues. And on the other hand, the faster development of the charging infrastructure seems not sensible while the amount of EV's is still so low.

In this context, the marketing actions and public coverage of new electric vehicle models will most likely also increase the public interest towards developing the charging infrastructure. And actions to promote charging infrastructure can also contribute to the EV's becoming more common. So possibly collaboration between the two operators, for example electricity company or charging service provider and an electric car importer or retailer, could be beneficial.

The common thread of the recommendations for the commissioning company is to act proactively in its' marketing towards housing companies. Although the market of electric

vehicles has developed slowly in Finland, the moment of EV's breakthrough is not that far in future.

The need for enabling charging has been identified at large in housing companies. In Webropol-survey two thirds of the respondents stated it is necessary to build charging station in near future. But the same figure tells that 59 % thinks there no need to build the chargers yet, due to lack of demand. (Chapter 4.1, figure 7.)

A vast majority (72 %) of the respondents of VTT's survey (figure 8) also mentioned the lack of demand as a major blockade for implementation of charging stations in their housing company. Open feedback given by the respondents also indicated that housing companies are waiting for the demand for chargers actualise.

As stated in the chapter 4.1 of this study, the housing companies need more information of the costs of charging units and associated costs of renovations. Technical information about the charging units, the effects of installing chargers on housing company's electric system, solutions for invoicing and contract models were also common types of information desired by housing companies.

The recommendation for the commissioning company is to compile a Frequently Asked Questions-type of information package about EV charging, including as clear answers as possible for these and other important questions raised by the housing companies. The costs of the charging units and the assembly costs' case dependency is presented really distinctly in Helen's web-pages already now.

The Housing Finance and Development Centre of Finland (ARA) is a governmental organization implementing Finnish housing policy and operates under administrative branch of the Ministry of the Environment. In August 2018 ARA introduced a subsidy aimed for renovations of electrical systems in housing companies required for assembling charging units for EV's. The aim is to advance the possibilities for home charging in housing companies and thereby facilitate the diffusion of electric vehicles, as stated in the National climate- and energy strategy.

The subsidy can be applied by housing companies and tenement houses. The amount of the subsidy is 35 % of realised costs of the project, with a maximum limit of 90 000 euros. Spread on three consecutive years, the cumulative subsidy has a maximum limit of 200 000 euros. The subsidy can be used on costs of planning, engineering, modifications

of the electrical system and construction work. The charging units can be subsidised too, if they will be owned by the beneficiary. (ARA 2018.)

The figure 15 in chapter 4.1 indicates that governmental subsidy is the most effective way to contribute to the charging infrastructure development. Also, figure 16 suggest that 35 % governmental subsidy would make charging infrastructure development much more attractive for the housing companies.

It can be assumed the subsidy now offered by ARA is ought to have a substantial influence on charging infrastructure development. The commissioning company Helen should utilize the availability of the governmental subsidy in their marketing towards housing companies.

The current condition of housing company's electric system and high costs were also named as important reason for not implementing chargers. These two are naturally linked. If the condition of housing company's electric system won't allow assembling chargers, the costs of renovation could potentially be high. In many cases, the housing company decides to postpone building the chargers until there is demand, or the renovation of electric system is actual anyway.

In Webropol-survey the respondents did not consider the costs of charging station implementation especially high for their housing company (figure 7). But it has to be remembered that census of this survey was EV-biased. The costs are actually not excessive in the scale of housing company. Mia Pujals of FREF compared the charger implementation project for elevator renovation/installation project. (Pujals Interview 2018.) They in fact have several similarities; the price range is approximately on the same level, the projects are typically not liked by every shareholder but they benefit everyone by appreciation of the apartments.

There is undoubtedly a demand for a comprehensive network of fast public chargers to help the diffusion of EV's. The cost of a common 50-kilowatt mode 4 50 public charger is approximately 50 000 euros. With the same cost, a housing company could have several mode 3 charging units assembled. Most of EV's sold at the moment can't even utilize superfast charging, because their internal chargers set limits on charging power. (VTT 2018).

But on the other hand, the home charging does not require fast charging with high output. When EV's are not in professional use, they can usually be charged during the night with low output. The benefit for the user is also that spot prices of electricity are typically cheaper during night time in the Nordic power market Nord Pool. Slow charging overnight is also favourable for the housing company's electrical system, because it prevents the power peaks forming in busy morning and evening times.

Helen could possibly communicate towards housing companies that superfast chargers are not needed at home and therefore the charging units are not necessarily expensive.

When asked about the hindrances preventing the construction of charging units, one of the major concerns of the respondents of VTT's survey was the current status and capacity of the housing company's electrical system.

Here smart charging solutions could be Helen's response in marketing towards cost conscious housing companies who fear the expenses that renovating the electrical system might bring. Smart charging takes in account the available capacity and distributes it between the users. Therefore, small amount of smart charging units could be implemented even in premises with low electrical capacity.

The commissioning company Helen could in their marketing also emphasize the fact that a housing company could keep the EV charging project low key just to get started. Most likely there is no urgent need in housing companies for full electrical system renovation with all parking spaces equipped for EV charging, simply because there are not much electric vehicles on the roads yet. So, Helen could use their distant review as a marketing argument and also point out that few charging units can usually be assembled within the capacity limits set by the current status of the electrical system. When the amount of EV's increases, the existence of prior charging units sold by Helen is a solid starting point for further development and negotiations.

The respondents of VTT survey, who represent the decision makers in housing companies, did not find attitudes of Board members or estate managers as a blockade (figure 8). The same question with slightly different composition was presented to EV owners/users in the consumer survey part. EV users could name as many of the given answer options as they wanted. Interestingly, the users of EV's saw the attitudes of other shareholders, board of directors and estate managers the most important blockade in charging infrastructure development, with 54 % of the respondents naming it. This is an

interesting observation, as the perceived experiences of the users and the decision makers are far from each other. This is maybe more of a problem in communication inside the housing companies, but it is also important for the operators. It's important to produce unbiased information for all stakeholder groups, to prevent this kind of gaps in visions.

As indicated in the figure 9 (chapter 4.1), the housing company decision makers do not think the Limited Liability Housing Companies Act forms a major blockade for charging infrastructure development. It is of course a legal framework which regulates the decision making in housing companies and on its own part makes the purchasing processes slow and somewhat hierarchic. On the other hand, the problems perceived in charging development are often case dependent, like the condition of the electric system and the costs derived from renovations needed to enable charging.

According to the VTT survey, almost half of the housing companies that have made a decision to advance charging infrastructure, did not make the decision in General meeting (Chapter 4.1, figure 6). This is an indication that the decision could be made in the Board of Directors too, if the matter to be dealt is not "unusual" mentioned in Limited Liability Housing Companies Act. In reality, the Board of Directors could most likely give residents a permit to assemble a charging station. Before many of the residents have electric vehicles, this would be easy and affordable solution. The decision to build chargers on housing company's cost will have to be made in General Meeting, because it will cause costs for all shareholders. But in many cases, this decision doesn't have to be made yet, while EV's are not yet common.

Estate managers have pivotal role in decision making in Finnish housing companies. Although the estate managers are not entitled to vote in decision making processes, they are board of directors' right hand in management of the housing company. Estate managers are often the initiators for needed renovations. In some housing companies the elected members of the board are more passive and in these cases the estate managers opinions could have even more weight. One estate manager typically manages several housing companies.

Helen should consider approaching estate managers with the topic of charging infrastructure. For example, an invitational event with open discussion on the topic of charging infra development could be interesting opportunity to share insights and opinions of both sides.

Figure 7 in chapter 4.1 describes the situation in respondents housing company. It can be noted that most of the housing companies have electrified their parking places, for the purpose of heating the cars. This is a good starting point for building charging stations, because for overnight home charging the output required is not necessarily much higher than what heating devices require.

As shown in figure 8, the majority of the parking places are property of the housing company. Other common mode is ownership of a shareholder. Also mixed mode of ownership and parking service provided by outside operator exist. The ownership has an effect on what can be done on the parking place.

FREF's Pujals states in the interview that if the shareholders own the parking places, they have more power to decide what to do, for example assemble charging station. In this case the housing company can't necessarily deny the shareholder to build a charging unit, unless it would cause a problem with housing company's electric system. (Pujals Interview 2018.)

In some housing companies, the parking places are also owned and administered by an outside parking service company. For example, separate parking buildings in newly developed residential areas are often implemented with this model. When a resident or a housing company would like to have charging unit assembled on the parking place, the negotiations are to be dealt with the parking company. The charging infrastructure could potentially be easier develop with this model, as the parking company is providing the parking as a service. If the user wants better service (e.g. charging) the company could charge more for the service.

The respondents of Webropol-survey named enabling the charging at housing companies the most important factor for EV diffusion, as indicated in figure 14. In same survey the respondents were asked whether they think public charging network could be so comprehensive in future that home charging in housing companies would not be needed. Figure 12 clearly addresses that respondents think home charging is important. This is also backed by the results of a recent study by Transport & Environment, indicating that only 5 % of the charging events happen at public charging stations. (Transport & Environment 2018).

The same study states that the bottleneck is not any more the public charging network, but the lack of rechargeable vehicles. EU commissions recommends is to have one public charging station per 10 electric vehicles on roads. At the moment this ratio is one charger per 5 vehicles and will gradually move towards one to ten by 2020. (Transport & Environment 2018).

As figure 13 indicates, there is clearly interest in housing companies towards charging stations implemented with service model. For the housing company this model has several benefits. First of all is of course getting the chargers without a big investment required. This model could also be a good way to install the first chargers in the housing company now, when there's not yet much demand for chargers.

The companies providing service model charging usually operate their chargers in a network. This way the users of housing company's charging stations would also gain access to a large network of chargers.

One important factor is the future proofing by service model. The EV's and the charging infrastructure is still in its' infancy. When the EV's and their systems develop now rapidly, it is possible the standards and requirements could change. If a housing company procures the charging as a service, it won't bind capital in equipment that could be obsolete within few years.

For the service provider the charging service model brings steady flow of revenue. The terms and pricing of the service contract should be written so that the service provider gets the investment it made back with interest.

Helen should consider offering the service model for customers and housing companies more actively.

While the development of charging infrastructure might be slow in housing companies, Helen could also research the possibilities to develop charging in the streets and public parking places. Helen Group is a commercial entity, but Helen Oy is fully owned by the City of Helsinki, as is the subsidiary network company which operates the electricity grid in Helsinki. Also, the streets in the city area are property of the city.

Although it might not be an easy and straightforward process, Helen could try to utilize the communication channels inside the city to influence the officials and politicians of Helsinki to develop charging infrastructure on the streets. This is also in line with the climate

strategy of the city. Helsinki has set the goal to reduce the greenhouse-gas emissions by 60 % until 2030 and pursues carbon-neutrality by year 2035. (City of Helsinki 2017.)

While Helen as a city-owned company having a monopoly for street charging in Helsinki seems unlikely scenario, a model utilized in Copenhagen could be useful in Helsinki too. The city of Copenhagen supports the development of charging infrastructure by making contracts with commercial charging operators, who then build the charging units and operate the parking places and chargers during the contract period. (City of Helsinki 2016.)

The city of Helsinki wants to support strong growth of electrified transportation by facilitating the market-driven growth of charging infrastructure. (City of Helsinki 2017.)

This model could be efficient especially in the central areas of Helsinki, where many of the housing companies don't even have own parking places. The typical buildings in central Helsinki are also old with electric infrastructure often insufficient for chargers.

Commercial SIR-database contains information about Finnish housing companies. It has contact information of Board members of housing companies as well as estate managers. Additionally, SIR-database offers possibilities for direct marketing, mailing and campaign services towards housing companies. (SIR 2018).

SIR-database website: <https://sir.fi/>

If Helen wants to direct marketing actions towards housing company decision makers, the usage of this (or other similar) databases' services could be a useful tool to reach this target group.

6 Self-evaluation

The idea for this thesis topic originated from own experience. The author was in the market for a new car during spring 2017. The interest towards EV's already existed and it was pondered whether a fully electric vehicle or a plug-in hybrid would be a feasible option. It soon became apparent that charging at home would not be possible, because the housing company's parking places are not electrified and charging in garages would be restricted too for safety reasons. This experience and several similar stories by people who shared the interest towards electric vehicles lead to an idea to research the situation.

The commissioning company Helen was easy to get involved in the project. Helen found the topic interesting and relatively unexplored. The research question and investigative questions were fairly easy to come up with, since the guidance given by the commissioning company was helpful. As this research is essentially a marketing research, a survey directed to the focus group was a obvious choice as a research tool. Interviewing an expert from Finnish Real Estate Federation was an idea by the contact person from Helen. When the survey was ready to be published, it became apparent the commissioning company did not have the contact details for the focus group. This was a major drawback and as a result the number of respondents on the survey made by author was left small. Luckily FREF and VTT had conducted a research with quite similar topics and objectives and were kind enough to give their research materials for use of this study.

For the author the project was really interesting, although time consuming. The research project underlined how important valid information is when making business decisions with far reaching consequences and how difficult the information is sometimes to find. At times the research felt desperate and the results too self-evident. But the end product reaches the objectives set for the research; the study contains important market insight and gives recommendations based on research work. The information this study contains is interesting for the commissioning company, housing companies and other operators in the charging infrastructure business.

References

- ACEA 2018. New passenger cars by fuel type in the European Union. Quarter 1 2018. URL: http://www.acea.be/uploads/press_releases_files/20180503_Fuel_type_Q1_2018_FINAL.pdf. Accessed 9 May 2018.
- ARA 2018. Avustus sähköautojen latausinfraan rakentamiseen. URL: http://www.ara.fi/fi-FI/Lainat_ja_avustukset/Sahkoautojen_latausinfraavustus. Accessed 26 September 2018.
- BBC 2016. Four major cities move to ban diesel vehicles by 2025. URL: <https://www.bbc.com/news/science-environment-38170794>. Accessed 15 October 2018.
- Bloomberg 2017. Electric Vehicle Outlook 2017. Bloomberg New Energy Finance's annual long-term forecast of the world's electric vehicle market. URL: https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF_EVO_2017_ExecutiveSummary.pdf. Accessed 25 October 2018.
- Bracker, J. Haller, M. Kasten, P. & Purwanto, J. 2016. Electric mobility in Europe – Future impact on the emissions and the energy systems. Öko-Institut e.V. URL: <https://www.oeko.de/fileadmin/oekodoc/Assessing-the-status-of-electrification-of-the-road-transport-passenger-vehicles.pdf>
- Bradley, N. 2013. Marketing Research. Tools & Techniques. Oxford University Press. Oxford.
- Brinkmann, S. 2014. Interview. Springer. New York. URL: https://link.springer.com/referenceworkentry/10.1007%2F978-1-4614-5583-7_161. Accessed 26 May 2018.
- Burns, A.C. & Bush, R.F. 2014. Marketing Research. Pearson Education Limited. Harlow.
- Center for Sustainable Energy 2018. Plug-in Electric Vehicles & Charging: Getting Started. URL: <http://energycenter.org/programs/pev-planning/public-facts#1>. Accessed 23 April 2018.

City of Helsinki 2016. Urban Environment Division. Sähköautojen julkinen ja yksityinen latauspistetarve. URL: https://www.hel.fi/hel2/ksv/julkaisut/los_2016-6.pdf. Accessed 2 October 2018.

City of Helsinki 2017. Helsinki City Strategy 2017–2021. URL: <https://www.hel.fi/helsinki/en/administration/strategy/strategy/city-strategy/>. Accessed 2 October 2018.

Design Council 2018. Design methods for developing services. URL: <https://www.designcouncil.org.uk/sites/default/files/asset/document/Design%20methods%20for%20developing%20services.pdf>. Accessed 13 June 2018.

EEA 2016. Air quality in Europe – 2016 report, 58-59. URL: <https://www.eea.europa.eu/publications/air-quality-in-europe-2016#tab-figures-used>. Accessed 15 October 2018.

EEA 2016. Overview of electricity production and use in Europe. URL: <https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-2/assessment>. Accessed 18 September 2018.

Electrek 2018. Tesla Model 3 becomes best-selling US car by revenue and delivers gross margin beyond expectations. URL: <https://electrek.co/2018/10/24/tesla-model-3-best-selling-revenue-gross-margin/>. Accessed 25 October 2018.

European Environment Agency 2018. No improvements on average CO2 emissions from new cars in 2017. URL: <https://www.eea.europa.eu/highlights/no-improvements-on-average-co2>. Accessed 18 September 2018.

EV-Volumes 2018. Europe Plug-in Sales Results for 2018 H1. URL: <http://www.ev-volumes.com/country/total-euefta-plug-in-vehicle-volumes-2/>. Accessed 16 October 2018.

Falvo, M. Sbordone, D. Bayram, I. & Devetsikiotis, M. 2014. EV charging stations and modes: International standards. URL: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.728.1023&rep=rep1&type=pdf>. Accessed 26 September 2018.

Finlex 2012. 1599/2009 Limited Liability Housing Companies Act. Ministry of Justice, Finland. URL: https://www.finlex.fi/fi/laki/kaannokset/2009/en20091599_20100547.pdf. Accessed 8 October 2018.

FREF 2018. Newsletter. Taloyhtiöiden hallitukset korkeasti ja monipuolisesti koulutettuja. URL: <https://www.sttinfo.fi/tiedote/taloyhtioiden-hallitukset-korkeasti-ja-monipuolisesti-koulutettuja?publisherId=1552&releaseId=67368293>. Accessed 3 October 2018.

FREF 2018. Survey. Taloyhtiöiden hallituskysely 2018. URL: <https://www.sttinfo.fi/data/attachments/00481/da68f2f9-c99a-40ae-985f-3e9b7a2a6839.pdf>. Accessed 3 October 2018.

FTA 2018. Newsletter 7.3.2018. Liikkumisen tavat muuttuvat hitaasti, alueelliset erot suuria. URL: <https://www.liikennevirasto.fi/-/liikkumisen-tavat-muuttuvat-hitaasti-alueelliset-erot-suuria#.W73LDPZuLIW>. Accessed 10 October 2018.

Helen 2018. About us, Helen Group. URL: <https://www.helen.fi/en/company/helen-ltd/about-us/organisation/helen-group/>. Accessed 23 April 2018.

Helen 2018. About us, History. URL: <https://www.helen.fi/en/company/helen-ltd/about-us/about-helen/history/>. Accessed 23 April 2018.

Helen 2018. Financial Statements and Report on Operations. URL: https://www.helen.fi/globalassets/yrityssivusto/helen-oy/taloudelliset-julkaisut/helen_financial_statements_2017.pdf. Accessed 25 May 2018.

Helen 2018. Sähköautojen lataus. URL: <https://www.helen.fi/sahko/taloyhtiot/sahkoautojen-lataus/>. Accessed 25 May 2018.

Ilieva, J. Baron, S. & Healey, N. 2002. Online surveys in marketing research: Pros and cons. International Journal of Market Research Vol 44 Quarter 3. URL: https://www.researchgate.net/publication/292105149_Online_surveys_in_marketing_research_Pros_and_cons.

Ministry of Economic Affairs and Employment 2016. Strategy outlines energy and climate actions to 2030 and beyond. Press release 24 November 2016. URL:

http://tem.fi/en/article/-/asset_publisher/strategia-linjaa-energia-ja-ilmastotoimet-vuoteen-2030-ja-eteenpain. Accessed 22 May 2018.

Moore, G. A. 2001. Crossing the Chasm. Marketing and Selling High-Tech Products to Mainstream Customers. Adobe Acrobat E-Book Reader edition v 1. URL: <https://epdf.tips/queue/crossing-the-chasm.html>.

Morelli, N. 2002. Design Issues: Volume 18. Designing Product/Service Systems: A Methodological Exploration. URL: <http://www.cs.cmu.edu/~jhm/Readings/Morelli.pdf>. Accessed 9 October 2018.

Pujals, M. 28 June 2018. Interview. Leading Legal Counsel. Finnish Real Estate Federation. Telephone interview.

Rogers, E. 1983. Diffusion of Innovations. The Free Press. New York.

SIR 2018. SIR-Database homepage. URL: <https://sir.fi/>. Accessed 5 October 2018.

Transport & Environment 2018. Roll-out of public EV charging infrastructure in the EU. Is the chicken and egg dilemma resolved? URL: https://www.transportenvironment.org/sites/te/files/publications/Charging%20Infrastructure%20Report_September%202018_FINAL.pdf. Accessed 16 October 2018.

Union of Concerned Scientists 2015. Cleaner Cars from Cradle to Grave. How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions. URL: <https://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf>. Accessed 10 October 2018.

Union of Concerned Scientists 2018. Electric Vehicles. URL: <https://www.ucsusa.org/clean-vehicles/electric-vehicles#.W9K9DvZuLIV>. Accessed 25 October 2018.

Virta 2018. Virta Global homepage. URL: <https://www.virta.global/>. Accessed 28 September 2018.

Volvo 2017. Volvo Cars to go all electric. Press release 5 July 2017. URL: <https://www.media.volvocars.com/global/en-gb/media/pressreleases/210058/volvo-cars-to-go-all-electric>. Accessed 25 May 2018.

VTT 2018. VTTblog: Miksi sähköautoa ei kannata ladata kotona 15 sekunnissa? URL: <https://vttblog.com/2018/08/30/miksi-sahkoautoa-ei-kannata-ladata-kotona-15-sekunnissa/>. Accessed 26 September 2018.

WHO 2018. Ambient (outdoor) air quality and health. URL: [http://www.who.int/en/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](http://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health). Accessed 15 October 2018.

Yilmaz, M. & Krein, T. 2013. Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles. IEEE Transactions on Power Electronics. URL: <http://up.hamkarfile.ir/557.pdf>. Accessed 8 May 2018.

YLE 2017. Sähköauto voi käräyttää lämmitystolpan ja naapurin hermot – "Pahimmillaan siitä tulee kiistakapula taloyhtiöön". URL: <https://yle.fi/uutiset/3-9809840>. Accessed 25 October 2018.

Appendices

Appendice 1. Survey questionnaire

Electric Vehicle charging infrastructure development in housing companies

This survey is conducted by a student of Haaga-Helia University of Applied Sciences, Jukka Toivari, in cooperation with Helsingin Energia.

All respondents remain anonymous and personal information remains strictly confidential.

Thank you in advance for participating!

1. City / town of residence

2. Type of accommodation

- Apartment Building
- Row House
- Semi-detached House
- Detached House
- Other, specify
-

3. What is your position in the housing company?

- Chairman of the Board
- Member of the Board
- Deputy Member of the Board
- Shareholder / Resident

No position

4. Is it possible to charge Electric Vehicles in your Housing Company?

Yes, from a charging station

Yes, charging is enabled from normal wall plug

No

5. Where did the initiative to build charging stations or enable charging from existing wall plugs come from?

From a resident

From the board of the housing company

From outside operator (e.g. electric company)

Other, please specify

6. On what share of the parking places charging is now enabled?

Less than one tenth

Less than one third

More than one third

More than half

All

7. Has the electrical capacity of the premises been investigated for the purpose of charging station installation?

Yes

No

8. What was the outcome of the investigation?

The electrical capacity enables building charging stations

The electrical capacity enables building charging stations and a decision to build them has been made

The electrical capacity does not enable building charging stations without renewing the electrical system

9. Has the residents interest towards acquiring an Electric Vehicle or Plug-In Hybrid been surveyed?

- Yes
- No

10. What was the outcome of the survey?

- The residents had no/very little interest towards EV's or Plug-In Hybrids
- Some of the residents are interested in acquiring an EV or Plug-In
- Some residents will almost definitely acquire an EV or Plug-In within near future

11. Is it planned to survey the residents interest towards acquiring an Electric Vehicle or Plug-In Hybrid

- Yes
- No

12. Consider the importance of the following things for the popularization of the Electric Vehicles (EV's). Answer this question as a private person, with your own opinions.

Scale 1-4. (1 = not important at all, 2 = not very important, 3 = important, 4 = very important)

	1	2	3	4
The price of the EV's will have to be on the same level with internal combustion engined cars.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There has to be EV models available for different kinds of purposes (e.g. SUV, station wagon).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The driving range of an EV has to be more than 500 km on one charge.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There has to be much more public charging stations available.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There has to be charging station on all gas stations.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There has to be possibility for home charging in the housing companies.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. How well the following statements describe the situation in your own Housing Company?

Scale 1-4. (1 = not at all, 2 = not quite well, 3 = quite well, 4 = very well)

	1	2	3	4
Right now there is no need to build charging stations, because there are no chargeable vehicles in the housing company.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The cost of building charging stations is high for the housing company.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The parity of the shareholders makes it difficult to decide to build charging stations.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The old premises set restrictions for building charging stations (e.g. insufficient cabling, capacity of fuses).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Parking places of the housing company are electrified (heating sockets).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The housing company does not have parking places.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is necessary to build charging stations in our housing company in near future.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. Which of the following are the most important properties of a charging station.
Choose 3 most important.

- Identification of the user.
- The costs of the charging directed to the user.
- Possibility to use same user account also on public charging stations.
- Possibility to offer charging for visiting users.
- Intelligent charging power controlling to accommodate with the capacity of electric network of the premises.
- Possibility to utilize the charging station as a normal power socket (suko).
- Possibility to charge with solar power.
- Possibility to sell electricity back to grid from the cars battery.

15. For example Kesko Group has announced building of charging stations on all Neste K-stations and many of the supermarkets.

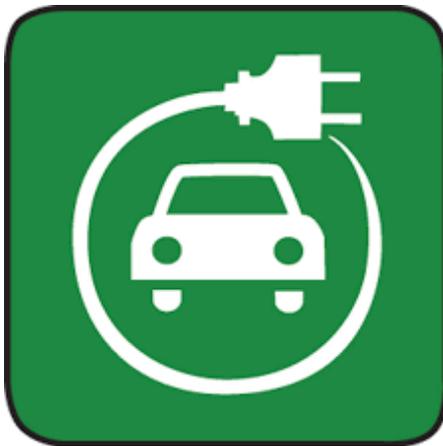
Do you find it possible that public charging network coverage would be so comprehensive that your housing company would not need to have own charging stations?

- Yes, quite possibly public charging network will be sufficient.
- No, home charging possibility will always be needed.
- Not sure.

16. Read through both scenarios and consider which one would be more interesting for the housing company.



The housing company will build the charging stations on its' premises and will buy the equipment needed on it's own expense. Charging fees will be collected from the users by the housing company.



A service provider will build the charging stations on housing companys premises. If the location does not require large excavations, the service provider will take care of the costs of installation and equipment. The service provider charges the housing company a monthly fee (e.g. 70 €) and collects the fees from the users based on energy usage. The housing company and the service provider engage in a fixed-term contract of for example five years.

17. Would there be a possibility to have a shared charging station (e.g. 2 plugs) in your housing company?

- Yes
- Possibly, but there is not a dedicated place for it yet
- No, there is no room for charging station
- No, every user needs an own charging station and parking space.

18. Would a governmental 35 % subvention of the realized costs make building of charging stations more attractive for your housing company?

- Much more attractive and even probable
- Slightly more attractive
- Not so attractive
- Not attractive at all

