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Business development in emerging value chains: The case of electric vehicle charging infrastructure in Norway

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Entrepreneurship and Innovation

Preface

Dear reader,

This thesis was written as the final project of our Master of Science in Entrepreneurship and Innovation at Norwegian University of Life Sciences (NMBU). We chose to write about the Norwegian EV charging market due to the relevance to our education and our personal interest in the electric vehicles value chain. This thesis has given us such insight into the Norwegian electric vehicle market, strengthened our personal business network and will hopefully make us attractive on the job market. For us, this thesis represents a bridge from our roles in academia to our roles in the business world, and has therefore been an inspiring and forward-looking final project for us.

Furthermore, we want to show our gratitude to all the people in the EV community for their time and willingness to take part in our interviews. Their contribution has been essential for a deeper understanding of the market and the mapping of it. One person we especially want to thank is our supervisor, Professor Joachim Scholderer, for all the advice, insight and guidance throughout the work process.

Ås, 15th May 2019.

Magnar Gya

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Abstract

Changes in consumer preferences are resulting in a surge of electric vehicle sales all over the world, and the associated charging infrastructure is thriving. But prospective e-mobility actors are burdened with a complex and at times uncharted market situation. The objective of this thesis is to provide e-mobility actors with relevant insights for business development. We conduct two studies: Study 1 is a secondary data analysis to identify the relevant background conditions that can promote (or hinder) the development of strong EV value chains in general. Study 2 employs key informant interviews with the objective of identifying the emerging structure, the role of key actors and modes of business development in the Norwegian market for electric vehicle charging stations. As a total market, Norway is limited by its relatively small size compared to other markets, but it is the arguably a global lead market in terms of EV adoption rates and governmental support. A network representation of the business relationships identified is created.

Sammendrag

Endringer i forbrukerpreferanser resulterer i en økning i salg av elektrisk kjøretøy over hele verden, og den tilhørende ladeinfrastrukturen er blomstrende. Men potensielle e-mobilitetsaktører er belastet med en kompleks og til tider uoversiktlig markedssituasjon. Formålet med denne oppgaven er å gi aktører i e-mobilitetsbransjen relevant innsikt om forretningsutvikling. Vi gjennomfører to studier: Studie 1 er en sekundær dataanalyse for å identifisere relevante forhold og omstendigheter som kan fremme (eller hindre) utviklingen av sterke EV verdikjeder. I studie 2 brukes intervjuer av nøkkelperson for prøve å identifisere den fremvoksende strukturen, rollen som sentrale aktører og forretningsmessige utviklingsmåter i det norske markedet for ladestasjoner for elektrisk kjøretøy. Som et samlet marked er Norge begrenset av relativt liten størrelse sammenlignet med andre markeder, men det er uten tvil et globalt ledende marked når det gjelder elbil adopsjon og statlig støtte. Det ble laget en nettverksrepresentasjon av de identifiserte bedriftsrelasjonene.

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Introduction

Background

Global warming has become a market force to be reckoned with. The looming threat of carbon emissions has occupied a figurative seat at the table of the world's largest corporations for years - and is impacting the emergence of new technologies, industries and products across the board. In the transport industry, electric cars have gone from being the choice of fringe early adopters only 10 years ago, to becoming a genuine competitor to internal combustion engines today. Before being overtaken by Chinese BYD earlier this year, Tesla lead the charge as the world's largest electric vehicle manufacturer, and the behemoth manufacturers of Germany and Japan are following suit - Volkswagen recently unveiled a €44b plan to invest in new technologies, and Toyota says all their cars will come with an electric option by 2025. Volvo, GM, Porsche, Audi, they are changing into electric at blazing speed - and they are not shy about it.

Energy providers and vehicle charger manufacturers are also starting to find their stride. With the newest technology, a car can become fully charged in a matter of minutes. With their fastest DC chargers, manufacturers like ABB and Tritium are challenging the car manufacturers to a game of catch-up, since modern car battery technology can only handle a fraction of the torrentous power-output upwards of 500 kW offered in their top-of-the-line chargers. Proactive governments and grants also play a key role in fostering the innovation and competitiveness of the industry by offering significant incentives to site-owners and developers who want to invest in the latest, most cutting-edge technology. Even without incentives, Deloitte recently reported that electric vehicles will be as cheap to own as petrol or diesel by 2022. But even price itself is quickly becoming irrelevant, as countries like Norway, India, Israel, U.K, Netherlands and France are proposing an all-out sales-ban of diesel and petrol in the coming future.

However, pumping out electric car options and state-sponsoring charging stations at every street corner is only half of the answer; a global shift from internal combustion to electric requires more than blunt instruments and good intentions. Denmark is among the world's most environmentally minded countries, but their EV-sales doesn't hold a candle to its more environmentally relaxed neighbour Norway. Or Finnish energy company Fortum, who quickly found its main market by a large margin to be Norway, not their native Finland. The market is

characterised by these unpredictable developments, and we think that a thorough market analysis will shed more light on the currently unclear market drivers.

Objectives

The electric vehicle (EV) market, and by extension also the charger market is evolving rapidly. The heavy industry and main applications are dominated by some of the world's largest companies, but these macro-focused big players often leave many of the details to be desired by new players that wants to establish themselves in the EV-market. These niches are quickly filling up with innovative start-up companies that are trying to solve the rapidly growing list of pains and needs in an industry that is still growing into itself.

One such company is EcoG, a Munich-based software company sprung out of Siemens. EcoG delivers an operating system (OS) and application programming interface (API) for charging stations. Charging stations of varying strength and manufacturers, in different locations and managed by different operators, can then be treated on a coherent unit by 3rd party stakeholders. EcoG will provide updates and maintenance for its charger fleet, meaning that the introduction of new standards, protocols, cars, and so on to the market will be easily facilitated - remotely and scalable - on chargers that have the software installed. The deep, embedded level access to the charger also enables stakeholders to integrate charging stations into their business models. Again, meaning that with the open-source, publicly available API that EcoG offers, third-party applications can be independently created and implemented on a total-scale in a similar way that they are on smartphones.

Actors like EcoG are burdened with a complex and at times uncharted market situation. The relatively small economy of Norway is already populated by hundreds of companies in the emerging EV value chain, and ownership structures, interests and competition can be hard to identify. Hence, the objective of this thesis is to provide actors like EcoG with the relevant insight for business development:

- How attractive are the Norwegian EV and charging station markets, compared to other markets in the EU/EEA;
- How can a software company like EcoG, and other companies like it, most effectively enter and take part in the rapidly growing Norwegian EV market;
- With whom (and how) should they establish value chain relationships and try to develop sustainable business models;

- Can solutions developed within the Norwegian EV/charging-station value chain be scaled up and introduced in larger markets once these are reaching Norway's level of infrastructure development.

In order to address these objectives, we conduct two studies. Study 1 is a secondary data analysis, using publicly available statistics and information regarding new car sales, policy, and infrastructure developments on global, EU, Nordic and Norwegian level, respectively. The specific aim of this study is to identify the relevant background conditions that can promote (or hinder) the development of strong EV value chains in general. Study 2 uses key informant interviews with representatives of companies involved in the Norwegian EV value chain. The specific objective of this study is to identify the emerging structure, the role of key actors and modes of business development in the Norwegian market for electric vehicle charging stations.

Limitations

In the market analysis in Study 1, we limit our scope to the European market. This has several reasons: Europe is a natural extension of the Norwegian market and represents a relatively similar market in terms of political structure and economic governing, yet with the scope and attributes of an international-market. Furthermore, it can be challenging to judge the quality of data from international markets such as China or the US, and we think it is more appropriate and beneficial for the result to limit our scope to data collected from economies that are mostly transparent. In Study 2, we limited our area of analysis to the Norwegian EV market, and to the actors that are active in this market. In order to ensure significant penetration of the market, to get the insights and the data we needed, we limited our scope to a clearly defined market. Norway met the criteria for this kind of study.

Overview

This thesis is structured into six chapters, excluding references and attachments. Chapter 1 (the current chapter) describes the background and objectives of our research. Chapter 2 introduces the theoretical framework and reviews relevant previous research. Chapter 3 is the first empirical study, a secondary analysis of market conditions and market growth in the electric vehicles market and its implications for supplying industries. Chapter 4 is the second empirical study, an investigation into value chain structure and business development in the

Norwegian market for electric vehicle charging stations. Chapter 5 is a general discussion and conclusion, relating to the findings from Study 1 and Study 2 to theory and previous research, giving recommendations for companies and policy, and making suggestions for future research.

Theory and previous research

Effectuation

A useful framework for the analysis of business development in an emerging value chain is Sarasvathy's (2001) effectuation concept. The concept sparked a controversial discussion in the entrepreneurship research literature about the nature of opportunity (for a recent review of the discussion, see Foss & Klein, 2018). For a long time, it had been widely accepted in the literature that any given iteration of a product, process or system is associated with a set of opportunities that can be discovered and acted on by a keenly observing entrepreneur—hence, the classical term "opportunity recognition".

However, such a passive perspective on entrepreneurship can be counter-productive in the context of a value chain that is just emerging such that the downstream markets may not (yet) be known. Applying the opportunity recognition construct is then only possible in a retrospective analysis where the end users and the values created for them have been identified with the benefit of hindsight. However, entrepreneurship is not retrospective but prospective, and it is exceedingly difficult to tell in advance what exactly the market needs. Instead, entrepreneurship is a creative process characterised by uncertainty and subjective judgments (Foss, Klein, Kor & Mahoney, 2008; Foss & Klein, 2018; Foss, Klein & Bjørnskov, 2018). The outcomes of the process are co-determined by the interactions of an entrepreneur with potential business partners and other stakeholders.

Relationship building in value chains

The activity-resources-actor (ARA) model is a network model that provides a conceptual framework of the outcomes of business interactions (Håkansson & Johanson, 1992). It was developed by the Industrial Marketing and Purchasing Group (IMP), an international network of researchers in the fields of logistics, procurement and industrial marketing. According to the ARA model, the content of a business relationship is made up by three layers (Snehota & Håkansson, 1995):

- *Activity links.* The first layer consists of relationship-bonds based on a set of activities that two firms share.

- *Resource ties.* The second layer consists connections that are based on two firms sharing the utility of a specific resource.
- *Actor bonds.* The third layer relates to the interpersonal links between two companies.

The model further goes on to describe how these layers relate to and influence each other: "actors carry out activities and activate resources. Activities are resource-consuming and evolve as the capabilities of actors develop. Resources limit the range of activities an actor can pursue" (Håkansson and Snehota, 2002). This interplay between the three layers influences and controls how business relationships develop.

Harrison and Prenkert (2009) used the ARA model to analyse how network connections are considered in the strategy for this case Nortura, taken each activity phase into account. One of their findings was that when applying this model, it does not simply focus on the one company, but also on the connections revolving around. For instance, the model additionally looks at relations to other actors and the network structure as a whole. Therefore, we could expect applying this model enrich insights regarding each connection, but also the network structure.

Lenney and Easton (2009) have researched the concept of commitment and how this connects with the ARA-model. By adding commitments as an overhead layer over the elements in the ARA-model it helps determine how particular events take place and it further articulate this model. By taking commitment into account researching the Norwegian EV market, we could expect getting more deep insights and knowledge into these relationships.

The role of public policy and infrastructure funding

Emerging value chains can greatly profit from policy measures such as large, publicly financed innovation programmes (e.g., see Howells et al., 2003; Howells, 2005). These can replace private venture capital in situations where the uncertainties related to technological development paths and future market potential are too high to attract private investors. In the context of the research presented here, there are two previous cases with particular relevance. The first case is the German energy market: wide-reaching policy measures to simulate the transition towards renewable energy sources were implemented very early (under the red-green coalition government that ruled on federal level from 1998 to 2005). The case is interesting because of the large amount of research and policy evaluation that has been conducted in the 20 years since the first policies were implemented.

The share of renewable electricity generated in Germany in particular has been a great success these past decades. The annual renewable shares of electricity production in Germany has gone from 8.6% in 2002 to 46.4% now in 2019 (Fraunhofer ISE, 2019). According to Wüstenhagen and Bilharz (2006) there has been correlation between this success and these following factors; government intervention, critical mass of interest groups and critical mass of politicians with momentum. In a recent critical review, Burke and Stevens (2018) highlighted the importance of cooperation between democratic political powers and the market in renewable energy transitions, as climate change is fundamentally a political issue. In an overview of the value chain of wind power, the national parliament and the politicians were placed at the start of the value chain, as they are ultimately the decision makers, or instigators of renewable energy initiatives through regulations, subsidies and direct investments (Olesen, 2015). This spur and activates the operators (energy companies and other service providers), but they too have to adhere to the regulations set by the state, as they are the owners of the natural resources and other infrastructure that is necessary for development (Olesen, 2015).

The second case is the Norwegian electric vehicle market. Here, the market has grown drastically over the past couple of years, much if not all of that development is a result of government incentives. The incentive that have most impact on buying an electric car in Norway is the zero-import tax policy (Haugneland, Bu & Hauge, 2016). One report concludes that both charging infrastructure near big cities and regional incomes had a major impact on the growth in EV sales (Mersky, Sprei, Samaras & Quin, 2016). Furthermore, (Bjerkan, Nørbech & Nordtønne, 2016) add to this and presented that more than 80% of their respondents said that purchase tax and VAT are the most critical incentives for them when buying a new car. The national climate policy has made BEV's both economically available and engaging for customers, which illustrates the power of incentives (Figenbaum, Assum & Kolbenstvedt, 2015). Both reports suggest that these market successes are mainly a result of government policy.

The role of emerging standards

A second aspect that can greatly accelerate the emergence of stable value chains is the establishment of standards (Howells, 2005). Particularly the end user part of the value chain can be heavily stimulated by government regulation and standard setting (Howells et al., 2003). A classical case in the innovation literature is the rivalry between VHS and Betamax (two competing video recording systems) and how one became the world standard. There was no

doubt that chance played an important role in VHS's success (Cusumano, Mylonadis & Rosenbloom, 1992), but the factors that really made a difference were the alliances which JVC formed for their distribution channels and production, as well as their perfectly timed strategic commitments with their alliance.

A newer case is the rivalry between operating systems (OS) for computers and mobile phones. Microsoft famously became the dominant provider of computer software by essentially riding the coattails of IBM's market entry (Zachary, 2014). By striking a deal with IBM, Windows became the standard OS on all IBM machines. Bill Gates leveraged this position of influence, and famously led Windows to become the dominant OS for computers from all notable brands except Macintosh. Similar to how Windows won the OS battle in the PC industry, Google's Android emerged as the winner of the OS battle for mobile phones. Today, Android powers around 85% of all smartphones globally (Eadicicco, 2015).

There are many stakeholders that benefit from standardisation in the software industry. Instead of spending their time learning new programming languages, developers can spend more time producing and updating high-quality applications for the 2-3 dominant operating systems. If a company wishes to do an application integration, it is a lot easier to ask for one or two complete apps across two operating systems, than to need 4-5 or more. And bug fixing, customer support, and updating virtually the same app on multiple operating systems quickly becomes unreasonably expensive. This ultimately affects the customer, who benefits from having access to well-made and supported apps on their smartphones.

Companies that want to become platform leaders should, according to Gawer and Cusumano (2002; 2008), always invest in building distribution or service capabilities. Another aspect is pricing, which is an important subject in platform wars. Still, becoming a platform leader like Intel or Microsoft in their representative industries can clearly be possible for every company. A combination of conditions must be fulfilled, including that the platform infrastructure provided by the company has no value when used alone but gains value when combined with other products and services. Establishing a sufficient number of partnerships with suppliers and, simultaneously, a sufficient number of customers of these platform-enabled products and services is a further condition.

Translated to the issues researched in this thesis, the findings reviewed above suggests that the EV industry and its customers will gravitate towards - and benefit from the emergence of - a dominant OS across chargers from different OEM's operated by different CPO's. Hence, another key aspect we will focus on in our empirical research is the key actors' reflections on potential and current standardisation and consolidation processes.

Research questions

This thesis was spurred out of a real-life, current problem of a software start-up company that is in the early stage of entering the Norwegian EV market. Actors like EcoG are burdened with a complex and at times uncharted market situation. The relatively small economy of Norway is already populated by hundreds of companies in the emerging EV value chain, and ownership structures, interests and competition can be hard to identify. Hence, the objective of this thesis is providing actors like EcoG with the relevant insight for business development. The research questions are:

- How attractive are the Norwegian EV and charging station markets, compared to other markets in the EU/EEA;
- How can a software company like EcoG, and other companies like it, most effectively enter and take part in the rapidly growing Norwegian EV market;
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In order to address these research questions, we will conduct two studies. Study 1 will be a secondary data analysis, using publicly available statistics and information about new car sales, policy, and infrastructure developments on global, EU, Nordic and Norwegian level, respectively. The specific aim of this study is to identify the relevant background conditions that can promote (or hinder) the development of strong EV value chains in general. Study 2 will use key informant interviews with policy makers and representatives of companies involved in the Norwegian EV value chain. The specific objective of this study is to identify the emerging structure, the role of key actors, and promising opportunities for business development in the Norwegian market for electric vehicle charging stations.

Study 1: Market analysis

Method

Data sources

The forecasts and scenario analyses in Study 1 are mainly based on secondary data sources. As a way of "triangulating" the information, reports and data sets by different actors and interest groups were chose, including government sources, industry associations, international organisations and private-sector sources. These main data sources included:

- *International Energy Agency (IEA) Global EV Outlook 2018*. The Global EV Outlook 2018 (GEVO2018) report provides a comprehensive look at the global EV market and infrastructure development, policy and governmental sentiments, and scenario forecasts. The IEA is regarded as an authority on energy related statistical research. The agency exists within the OECD framework, and is funded by the member countries to provide data analysis and insights on energy related industries.
- *IEA Nordic EV Outlook 2018*. The Nordic EV Outlook 2018 (NEVO2018) report provides a comprehensive look at the EV market and infrastructure development, policy and governmental sentiments, and scenario forecasts in the Nordic region. See above description of IEA, the agency issuing the report.
- *Norsk elbilforenings rapport "Ladeklart Norge 2025: En kur mot ladeangst.* The Norwegian EV Association is an important and influential actor in the Norwegian EV eco-system, and their report about the Norwegian market is based on data from Nobil; The Norwegian Centre for Transport Research; and the Norwegian Road Federation.
- *European Alternative Fuels Observatory (EAFO)*. EAFO provides statistics about the EV fleet and market developments, infrastructure status and developments. The agency is funded by the European Commission and aims to raise awareness around EV charging and mitigate the negative perception of EV usage to be a burdensome effort due to few charging points.

When deemed appropriate, additional raw data and summary statistics were extracted from publicly available and commercial online databases and APIs. These include data from Circle K's commercial charging app "Circle K Charge" and BKK/Lyse's publicly available maps

showing their charge points. In addition, Grønn Kontakt provided us with their internal numbers on charging stations and charge points.

Secondary analysis

Parts of the secondary data will be reported in terms of summary statistics, for example total numbers of electric vehicles and charging stations or % market penetration, broken down by geographical area and/or time. Forecasts were generated in Microsoft Excel™ and the statistical analysis software SAS JMP®.

Results

Driving forces: the interplay of technology and policy

Technology. Electric powered vehicles are still a relatively new field compared to petrol- and diesel-powered vehicles. The general construction and design of a car remains the same, but there are limitations to driving electric compared to internal combustion, and that is largely a difference of technological development. The main technological disadvantages of electric powered vehicles are: The energy density of a battery is much lower than that of gas, and batteries are heavy. With growing battery packs in the vehicles, the weight also increases, which in turn affects both power and wear negatively. Furthermore, the batteries often take up space that otherwise could be used for interior or storage purposes. All cars eventually need to stop and refill energy, but EVs are at the added disadvantage that they require a more significant infrastructure to do so. The concept described as "range anxiety" has become a theme in the industry and describes the worry a driver experiences when they think that their car will run out of power before they can find a charger. As technological development advances, these disadvantages are gradually diminishing. We are already seeing this, with the best EVs almost catching up to traditional cars with regards to total range.

Price. Situated between technology and policy, there is the economy dimension. Due to a lower general demand for EVs, and therefore a reduced scale of production EVs are more expensive to manufacture than traditional cars. Price and economics mainly come down to two elements: Base price of vehicle: The price of electric vehicles decreases when demand increases. Fuel/energy price: Price of energy is tied up to regional location, as well as environmental factors, and can often fluctuate.

Policy. With EVs at a disadvantage technologically and price-wise, policy has played a central role in the popularisation of EVs. The surge of EVs is in many ways environmentally motivated- an effort to reduce carbon emissions and improve air quality. It is not necessarily a cost/technology driven innovation, but rather one driven by a more environmentally concerned population. According to the International Energy Agency's "Global EV Outlook 2018: "The uptake of electric vehicles is still largely driven by the policy environment." (Busnen, et al. 2018, p. 22). Interestingly, the same analysis also concludes that the car models with the lowest prices experiences the highest growth in sales (2018), indicating that the market is still largely driven by purchase price.

Interplay. In innovation theory, there is often talk about the role of technology push and/or market pull (see Sandmeier et al., 2004 for a comprehensive analysis on this topic). When deemed necessary, a third dimension coined regulatory push/pull is added to include the cases where the main driving force of a market is neither market pull nor technology push, but rather a policy element - like in Horbach, Rammer and Renning's (2012) article on the determinants of environmental innovations, in which regulatory push/pull is seen as 'particularly important' for pushing firms to certain environmental innovations. Adding to this, in an article aiming to explain innovation performance in the biofuels sector, researchers examined the impact of demand-pull and technology-push policies (Costantini, Crespi, Martini, Pennacchio, 2015). They conclude that environmental regulations spur innovative activities in the biofuel sector; that policy is an important driver of innovation in the sector. Our results, and the regional discrepancies in EV adoption, suggest that the conclusions from the biofuel industry can also be extended to the EV industry. There is a strong effect between high governmental support and development: in the countries with high political support, we also see the more advanced EV industry.

Market growth

In Europe alone, there are more than 380 million total vehicles in active use - a number that grew by 6,2% from 2012 to 2016 (ACEA, 2018). From 2017 to 2018, 15 million total cars were sold, and of these, 200.000 were electric (see Figure 1). There are also a number of announced policies, international- and national climate ambitions, as well as commitments, that will be instrumental in the development rates of the EV market. From 2011 to 2019, the EV market has grown by an average of 73% year over year.

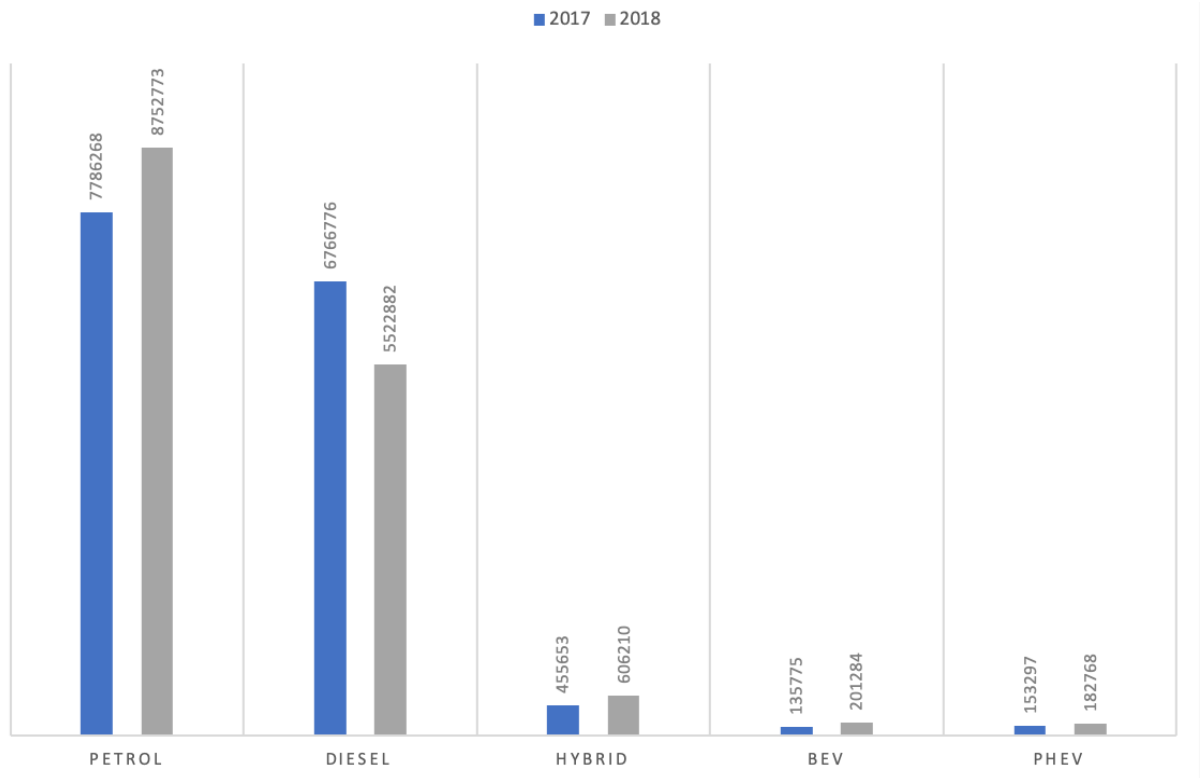

Figure 1: New cars sold in Europe sorted by energy source

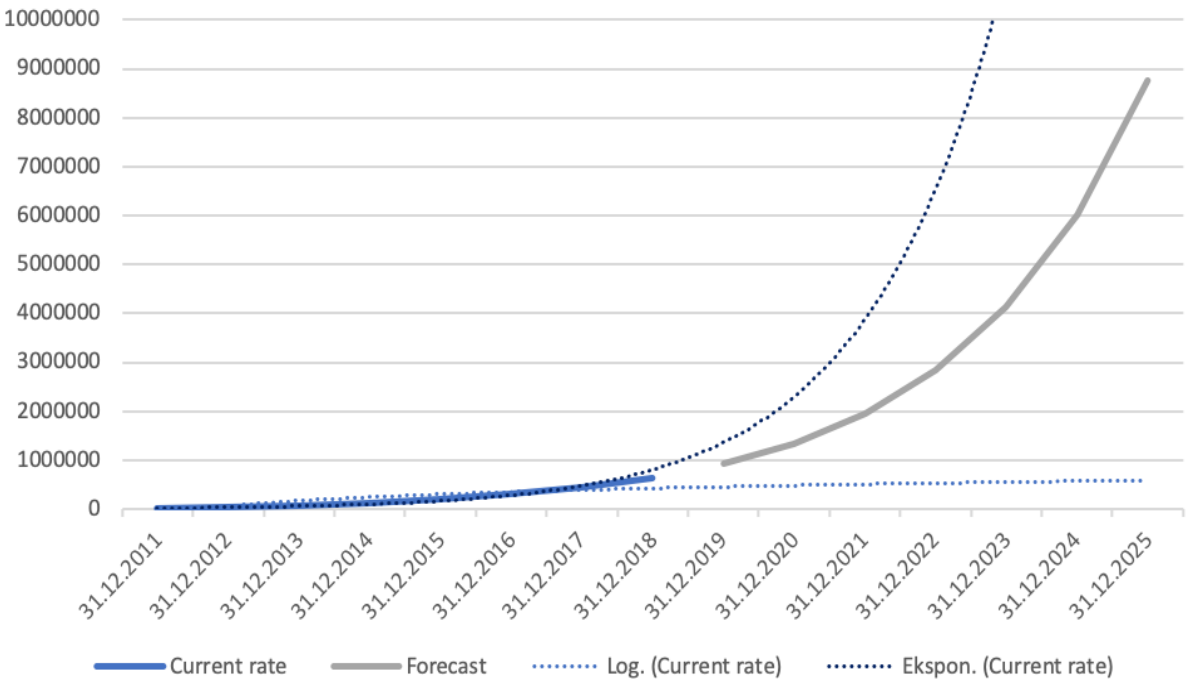

Figure 2: Market growth BEV Europe (scenario forecast)

Due to the relative size of the market in the early years (2011-2015), the percentage increases in EV sales is not very predictive for use in a scenario forecast of EV growth: from 2011 to 2012, there was an 135% increase in sales, but this large percentage-wise increase came from only 20,000 more EVs sold. After 2015, the year over year increase in sales have seemed to normalise between 40% and 50%.

Figure 2 illustrates various scenarios of market growth forecasts, which is based on current rate of the European market. The thick blue line is the current rate of the market growth from 2011 to 2018, based on numbers from the European Alternative Fuels Observatory (EAFO, 2019) database. Using the current rate as a base we created a logarithmic (light blue dotted line) and an exponential (dark blue dotted line) forecast. These forecasts were calculated with Microsoft Excel's own algorithms. The logarithmic forecast appears to low, while the exponential forecast to high. Therefore, we constructed our own forecast which the thick grey line illustrates. This forecast is based on an average year over year growth between 2015-2018 of 45%. Thus, this predicted growth does not take into account surrounding factors, such as increasing political incentives, more affordable base prices of EVs due to production scaling and higher commitment from car manufacturers or increasing quality and availability of infrastructure. By all accounts, this can be seen as a modest forecast for BEV growth for the years to come, but the growth will eventually flatten out.

The leading global automotive forecasting agency LMC is more optimistic in its forecasts, predicting EV sales of 600,000 by 2020, and 1 million by 2022 (Transport & Environment, 2018).

Figure 3 shows the International Energy Agency's (IEA) scenarios for the development of the Global EV market under different levels of nationally determined commitments (NDCs) with increasing ambition. The reference technology scenario (IEA RTS) is the least ambitious scenario, in which member countries deliver on their current commitments to taking steps towards climate change. The Paris declaration scenario (Paris Declaration) assumes that partner countries commit to sustainable electrification of their fleet, aiming for 20% electrification by 2030. The 2°C scenario (IEA 2DS) has more ambitious assumptions in which partner countries aim for a 70% reduction in emitted CO_2 by 2060. The beyond 2°C scenario (IEA B2DS) is the most ambitious scenario, assuming that partner countries pushing current and pipelined technologies to their theoretical limits in order to achieve net-zero emissions by 2060 (for additional details, see IEA, 2019).

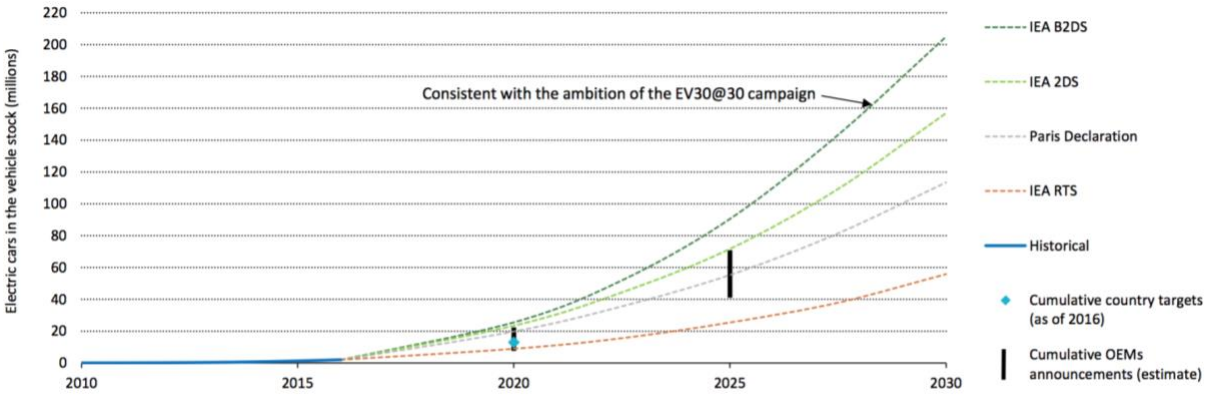

Figure 3: Global electric car fleet (scenario forecast)

Market saturation

As discussed above, 200,000 cars represent a very low proportion of the total cars sold, which is illustrated in Figure 2. Furthermore, from 2017-2018 EU experienced a record 28% increase in electric car sales, but that still only represents 1% of total cars sold. The pie chart in Figure 4 illustrates the surprisingly meagre 1% BEV market share in EU and EFTA countries, compared to Norway's 31% market share. This comparison illustrates the important flagship-effect the Norwegian market may have for the con'siderably larger markets in the EU. These numbers indicate that there is strong reason to believe that the EU EV market is undersaturated and will experience significant growth in the coming years.

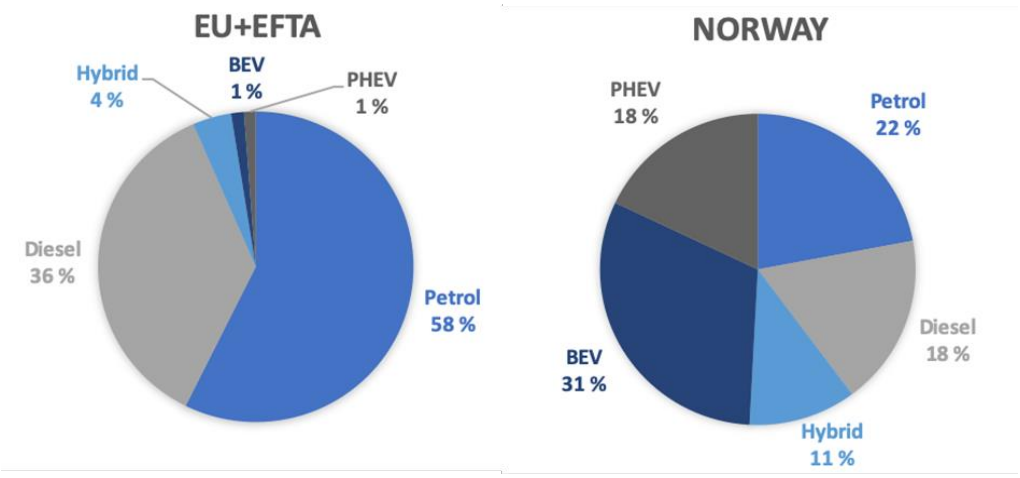

Figure 4: Proportion of new cars sold sorted by fuel type

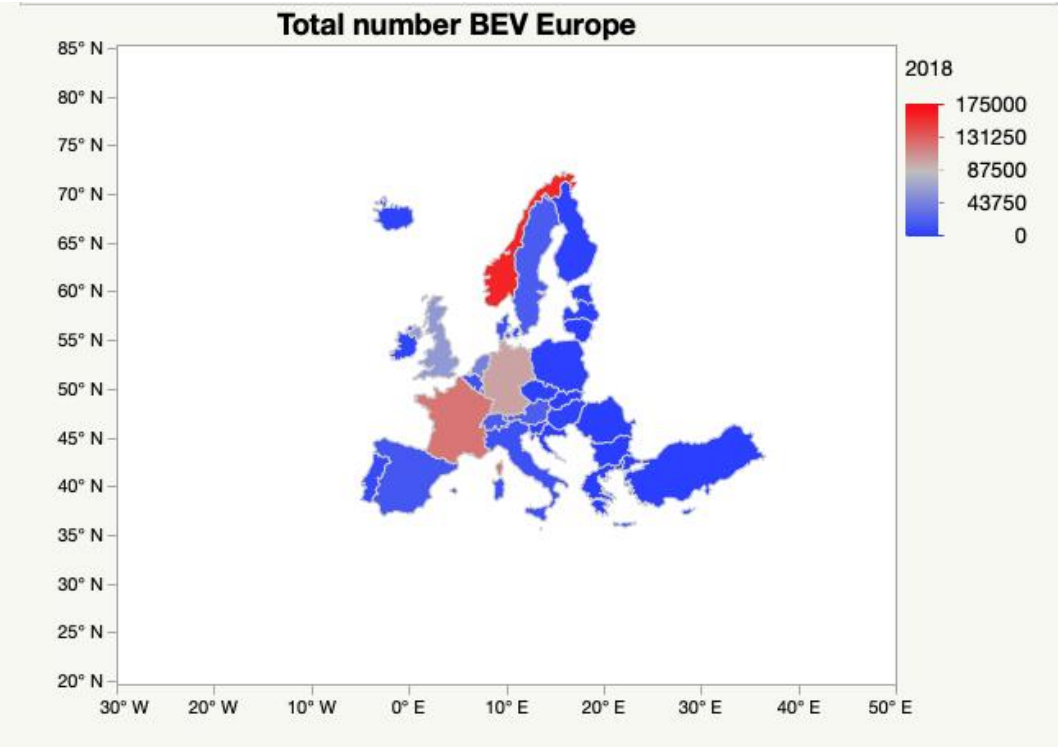

Figure 5: BEVs in Europe (total number by country)

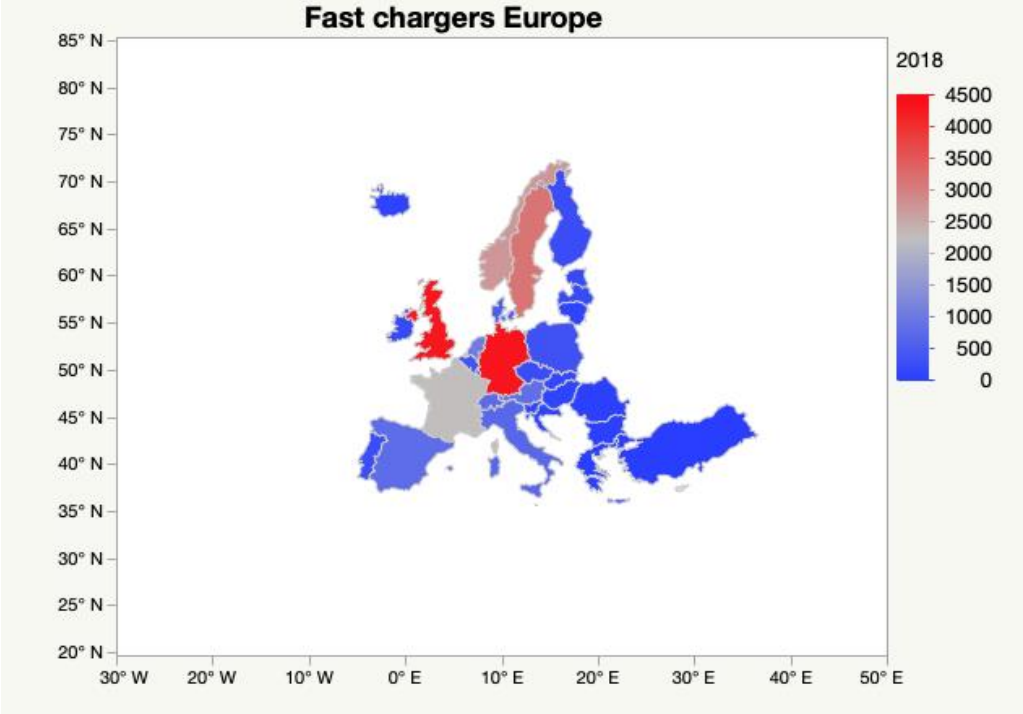

Figure 6: Fast-chargers in Europe (total number by country)

Figure 5 illustrates the amount of BEVs in each country in Europe (see EAFO, 2019). It is clear that the numbers of BEV in Europe are as yet low and may therefore have a potential to increase. The same applies to the number of fast chargers in Europe (Figure 6). Even though there are several countries that have a fair number of fast chargers as part of their national EV infrastructure, there are only two countries where the presence of such infrastructure coincides with elevated BEV market shares: Norway and France. Considering this situation, the Norwegian and French markets may currently offer the best prospects for business development.

The market for electric vehicle chargers

The EVI Global EV Outlook 2018 report concludes that there is going to be a need of one publicly accessible slow charger per 15 EVs, and one publicly available fast charger per 80 EVs. In EcoG's target market Norway, the Norwegian EV Association recently released the report "Ladeklart Norge 2025", in which they were a bit more optimistic, proposing a 100-150 EVs per fast charger estimate as the necessary minimum (Elbilforeningen, 2019). This equals roughly 1100 new fast chargers every year - or a doubling of the current rate of expansion.

Cases of holdup

The history of the Danish EV market demonstrate the detrimental consequences of a disconnect between electric vehicle market share and available infrastructure. Figure 5 shown the total amount of BEV in Denmark by year. Between 2014 and 2015, Denmark experienced an explosion in EV sales, as the total numbers of EVs went from 2967 in 2014 to 7491 in 2015: a 152% increase. However, in the following year, from 2015 to 2016, the sales only went from 7491 to 8686: a mere 15% increase.

This trend continued. From 2015 to 2018, the total number of electric vehicles increased by a mere 45%, a disappointing result compared to the record year of 2015. In our interviews (see Study 2, below), the "Danish story" was a common reference for a failed market, and there are a number of reasons for why this might have happened. On paper, Denmark is a an attractive EV market: According to the 2014 environmental performance index (EPI), Denmark was ranked best in the world for CO_2-emissions per capita, and number 4 in the world for environmentally friendly countries (Hsu & Zomer, 2014).

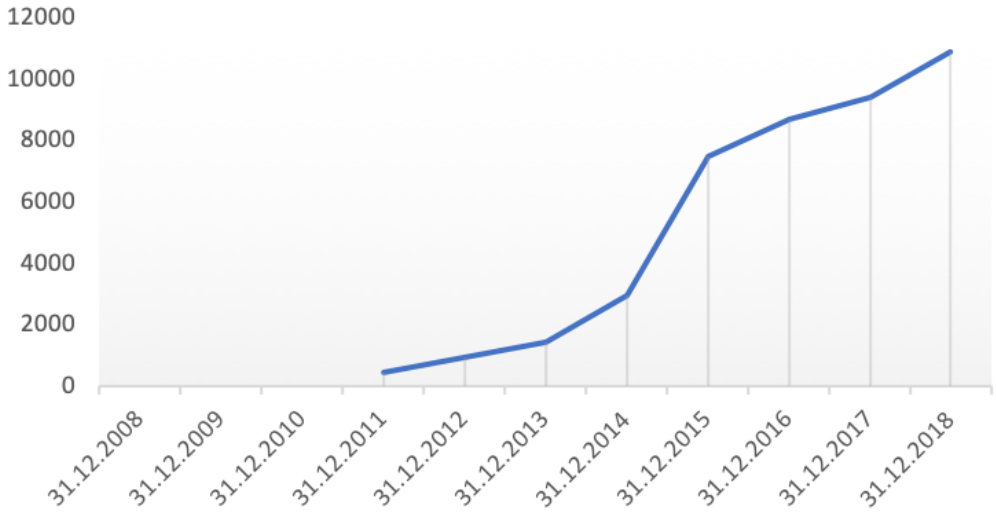

Figure 7: BEVs in Denmark (total by year)

Furthermore, according to numbers from Rasmussen and Vittrup, 2016, 42% of the total electricity demand in Denmark is supplied from their own wind power. These conditions convinced Danish energy giant Dong Energy, together with the Israeli start-up Better Place, to invest over €100 million Euro (750 million Danish Kroner) to establish a cutting-edge charging network infrastructure in Denmark (Schwartz, 2009). The partnership happened in 2008, which by all accounts is early in the EV timeline.

Denmark's tax on new vehicles are notoriously high. When combining the purchase tax and VAT, the total tax on a new ICE car in Denmark can be as high as 150% of the base price of the car (OECD/ IEA, 2018; ACEA, 2018). In 2008, at the time of the Dong/Better Place partnership, policy regulations allowed Danes to waive the registration tax for new vehicles when they bought an EV. This policy allowed electric vehicles with a significantly higher base cost to compete with combustion engine powered cars.

Still, this appears not to have been enough. Citing high development costs, and achieving much lower market penetration than expected, Better Place Denmark filed for bankruptcy in 2013 (Blum, 2017). Furthermore, in 2015, the year of the sales plummet, the Danish government decided to cut the incentives on EVs, by gradually phasing the registration tax waiver. Here it is also worth noting that electricity is particularly expensive in Denmark - according to Eurostat Denmark has the highest electricity prices in all of Europe, tied with Belgium and Germany (Eurostat, 2017). The cost of owning and driving an EV, post-purchase is therefore also amongst the highest in Europe.

It is impossible to uniquely determine what was the "final straw" for Denmark's EV market, but it is reasonable to assume that it was a combination of the reasons above. A fragile, evolving market was put to the test by a premature cut on government incentives, high electricity prices, and a public crash and burn story of a failed EV start-up. Such a conjunction of negative events surrounding an emerging technology does not warrant the confidence that is needed to inspire mass adoption. Danish tax minister Karsten Lauritzen admitted to Bloomberg that the government had reconsidered the phaseout of incentives after the unexpected decline in EV sales, and with the reintroduced cuts to registration cost, EV sales are increasing again, according to news reports (Kane,2019).

Discussion

Market attractiveness

Table 1 summarises opportunities for and threats to the Norwegian market. As a total market, it is limited by its relatively small size compared to other markets, but it is the arguably a global lead market in terms of EV adoption rates and governmental support. At a higher than 50% EV adoption, Norway has effectively fast forwarded to a level of adoption that is expected to take the EU or US 15-20 years minimum. In addition, Norway offers a clear-cut and transparent "canvas" with the entire infrastructure and logistics aspects existing in clearly defined regional areas. There may be an opportunity to design, build and test products and business models quicker than in larger, more complex markets. In practice, actors may be able use the Norwegian market as a testing ground for their business models, and then move into EU markets with a sense of confidence that they are bringing business models to the market that have been validated in a lead market which has already reached critical mass in terms of sufficient density of customers and value chain partners.

Additionally, Norway gives a clear view of the logistic make-up the value chain. Norway is an attractive market because the whole infrastructure and logistics aspect is concentrated in a clearly defined regional area – compared to EU for example, one can use Norway to build a proven value chain model to scale in EU countries. It may be possible to develop and test business models because the market has reached critical mass; something that may not be seen in other European markets for many years still. Business models tested and developed in Norway may even have the potential to become mainstream.

Table 1: Relative attractiveness of Norwegian EV market for EcoG

Threats	Opportunities
Size of market: Around 150.000 new cars sold each year, of which electric already have a 50% market share. A Fully saturated Norwegian market is relatively small compared to most other national EV markets (Berggreen, 2019).	*Growth rate:* Extremely high at just over 50% in 2018. Uncertain whether historically strong growth rates are positive for future growth. The argument can be made that one can expect less growth the closer you get to a fully saturated market, but this is only speculation, as there aren't really any good arguments for why the growth should stop before reaching full market share. Regardless, the market exhibits the positive traits of a market in extreme growth.
Long-term profit potential: The low population density outside of the few large regional centres, and the relatively vast countryside makes infrastructure investments a relatively bleak prospect in the long-term. The limited size of the market also negatively impacts the long-term profits.	*Cost of entry/ease of reaching actors:* As discovered by this thesis, Norway represents clearly defined regional areas with relatively few established actors, and it is easy to keep track of news and developments.
Market penetration: Norway is on its way to becoming the first country in the world with full EV saturation, however still it isn't very large on a global scale.	*Competition within market:* High competition amongst those who facilitates EcoG's total market, such as charger manufacturers, car manufacturers, and backend developers, but low direct competition (Greenflux, Meshcraft and similar companies are not direct competitors). *Current solutions:* Our interviews with industry representatives revealed a desire for a solution that would simplify the current one. *Political stability and governmental support:* Either part of the political spectrum in Norway are evidently pro-EV and seems to see the advantage of being at the cutting edge of a growing market. Norwegian EV policies and incentives are amongst the best in the world. *As a step towards a more attractive market:* Norway can be used as a testing ground for solutions that can be scaled to larger, more complex markets.

Technological challenges

During our mapping of the Norwegian EV situation, we uncovered technical challenges that have to be highlighted. One challenge is that chargers experience a large amount of down-time. In the future, electricity-based energy stations will have to be able to compete with the current petrol stations. Technological advancement should mean an easier, more predictable and hassle-free experience for its users, and this is simply not the case in the current market. We consider this to be the most critical issue in the industry today. Customers are met with faulty charging stations regularly - and when this is such a regular occurrence, they are losing faith in the infrastructure as a whole.

The problem poses a tricky technical troubleshooting process (as pointed out by the OEM's themselves) - one in which all the parts of the value chain are contingent on each other for their own product to work; the chargers themselves are powered by the grid, and any problem in the connection or power transfer might simply render the charger itself useless; the chargers are also depending on vehicles with error-free hardware and software; and the grid itself is struggling with the growing challenge of supplying extremely high power at relatively short bursts to charging sites. However, most other actors in the chain must in some way interact with the physical charger or its backend, meaning that the OEM still has one of the most impactful roles in the network because of its central position.

Figure 8 illustrates a functioning charging chain. All the parts of the value chain are contingent on each other for their own product to work. A failure in either of the three components will result in a shortcut of the other parts of the chain. Figure 9 illustrates an example case of a failure in the grid, which effectively shuts down the entire chain. A system fault like this will happen regardless of which part of the cycle defuncts, be it BEV, charger or the electric grid.

The cars themselves are connected to their respective regional leading plug standard, i.e. Japanese cars use CHAdeMO (which was developed by the Japanese), German cars (and GM) use CCS (which was developed by EU/US based interests), Chinese cars use the Chinese standard, and Tesla seems to be joining the CCS standard (Herron, 2017). It becomes evident that there is a strong regional, and probably political element involved in why there are so many standards for plugs. This aversion against standardisation is also present in other aspects of the industry and is undeniably impacting the rate of adoption for fast charging. Table 2 illustrates the different plug-in standards there are in the EV market, at the moment.

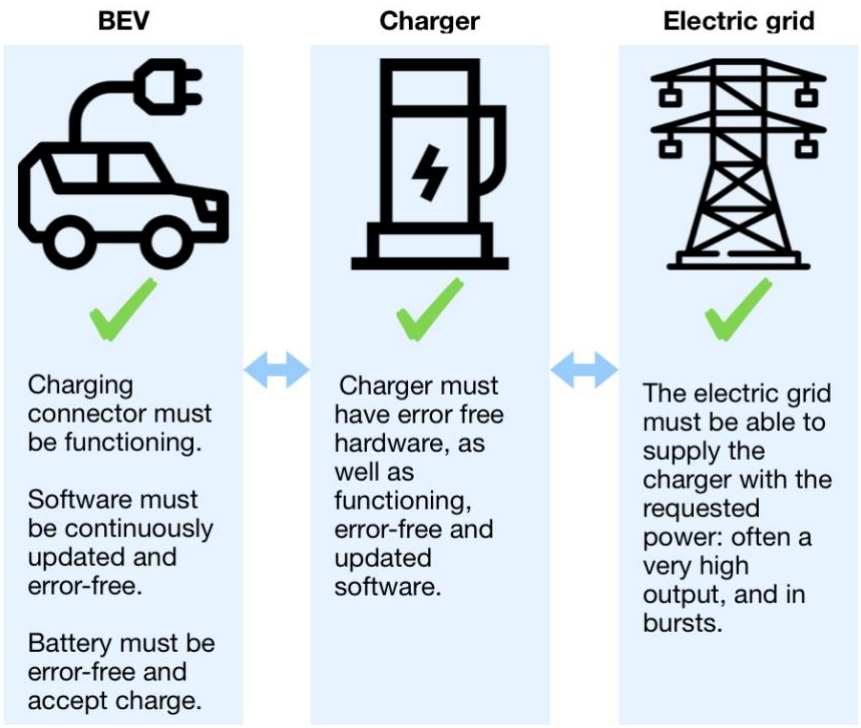

Figure 8: A functioning charging chain

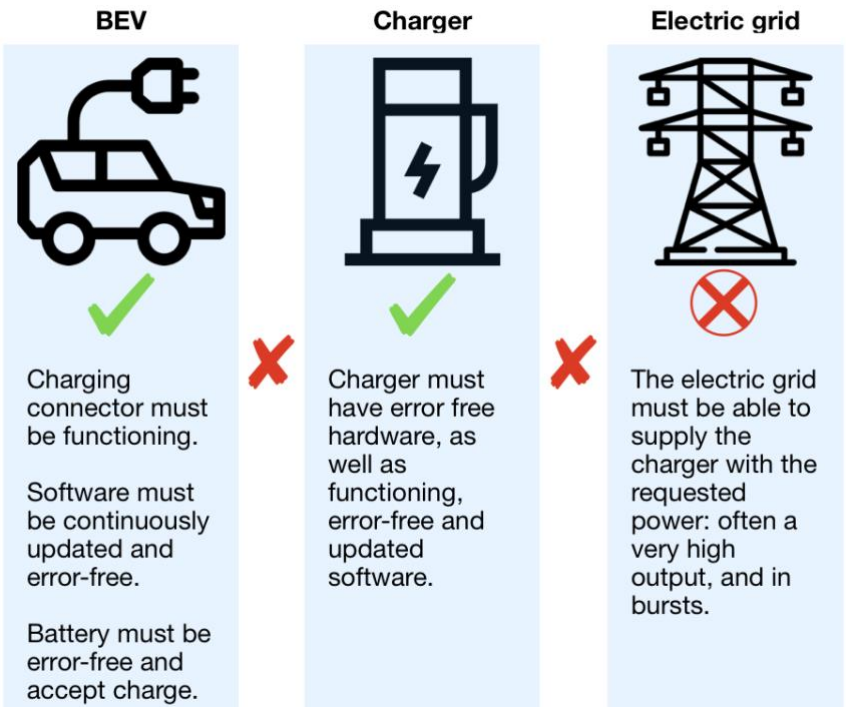

Figure 9: A non-functioning charging chain

Table 2: Multiple standards for hardware and software

Plug Type	Functionality	Region/ affiliation
CHAdeMO	First to develop DC charging	Japanese car industry
CCS	Offers AC and DC charging in the same plug	European/US car industry
Tesla Supercharger	Tesla's Type 2 connector can use both AC and DC but has been proprietary to their own Supercharger network. As of 2019, the new Tesla Model 3 will be compatible with CCS as well as Type 2.	Tesla (US)
China	China uses a plug that is similar to the German design, but with a different protocol	Chinese car industry

In the technology domain, resources are currently used to develop three (four, until recently) different technologies for the same purpose, with no immediate positive carry-over effects for the domain as a whole. This again leads to an added cost for charging manufacturers, as they need to make their chargers with multiple cables and standards; and the car manufacturers who sometimes have multiple plugs in their cars, depending on the region it is shipped to. The result is that both chargers and EVs are unnecessarily expensive.

There is strong common agreement in the EV sector that charging simplicity and user friendliness is a key concern. Multiple plugs and cables lead to confusion for the consumer. A petrol car can fill at virtually any gas pump in the world, and it is puzzling why EVs aren't offering the same functionality.

The Open Charge Point Protocol (OCPP) can be difficult to understand for all parties as it is very technical: OCPP is an initiative to create a standardised, open-source application protocol to facilitate communication between EVs and chargers. Open, standardised initiatives like these are generally positive, as there is less room for proprietary solutions that limits scalability (see previous point about the challenges with numerous plug standards). The problem seems to be that advanced knowledge about the protocol itself is uncommon. It is our observation that few people in the EV industry, including those in technical positions have a deep understanding of the capabilities of the protocol that exists on virtually every charger in Europe.

Finally. the energy grid might be too underdeveloped to deal with the requirements now on its doorstep. We do not yet know the scope of this problem, but it is potentially a future

market driver. If EV-charging becomes a detrimental strain on the grid, we must focus on technological innovation that ensures reduced strain on the energy grid.

Opportunities for innovation

DC chargers are difficult to design and make, a lot more so than the oversaturated AC market. This finding belongs in a grey area between opportunity and challenge. AC chargers are comparatively simpler to develop than DC chargers, as is reflected in the rich selection of competitors in the home/residential charger niche, while the DC fast charger niche is largely dominated by a few key OEM's. While the market reflects our impression that AC chargers is possible to make with a general understanding of the technology, it seems that designing, and manufacturing DC chargers is a more resource-intensive task.

ChargePoint one of the largest charge points, consists of 64500 charge points, yet only 400 fast chargers (ChargePoint, 2019). It is reasonable to expect that ChargePoint either is a process of high-volume DC expansion, or at least wants to. ChargePoint is the largest of a number of large-scale actors that would benefit from entering the DC market yet hasn't really come up to speed with the leading manufacturers like Tritium, ABB, and Efacec, due to reasons such as lack of technological expertise. It is our prediction that these actors are waiting for an opportunity to aggressively enter the DC market, and EcoG, with its know-how and extensive technological experience in making DC chargers might be the missing piece. By partnering with a large, powerful actor like ChargePoint, EcoG might be able to copy Windows' way to success – by "riding the coattails" of a larger, more influential actor and gaining market standard status very quickly.

Creating proprietary software solutions is both time consuming and expensive. It is resource heavy, both intellectually and time-wise, yet the market relies on simple, hardware agnostic software it to be a viable option to the current solution. EV chargers need to be as predictable and intuitive as petrol stations.

There seems to be a trend towards simplification and standardisation happening through partnerships and consolidations. One actor was dissatisfied with the amount of backend necessary on their part, just to incorporate and talk to all the other individual backends. Multiple key players in the industry asks for - and expresses the will to pay for - solutions that address and synthesises an increasingly complex backend scene. There are already numerous companies and initiatives that are addressing the need for a simpler and more intuitive EV charging experience: Hubject and PlugSurfing (recently acquired by Fortum) are two actors

trying to facilitate roaming, and Tesla recently added the CCS plug standard on its latest model so its drivers have one less adapter to worry about. This may represent a business opportunity for software manufacturers like EcoG.

Study 2: Value chain and business development

To best answer the research questions for Study 2 we chose to conduct semi-structured interviews with well-informed respondents both from the EV industry and EV related politicians. Semi-structured interviews were mainly chosen because we wanted an open and free dialog with our respondents. The disadvantage with standardised interviews is the lack of flexibility (Johannesen, Christoffersen & Tufte 2011). By choosing semi-structured interviews we had flexibility to ask follow-up questions and letting our respondents talk freely, which we hope led to more valuable information from our respondents.

Method

Key informants

Before gathering our informants for our interviews, we needed to establish an overview of the Norwegian EV market. This overview was necessary to help us find the most suitable informants for our interviews (Johannessen et al., 2011). We read as much as possible online about the EV market in Norway and gathered enough information to identify key informants to interview. We selected our informants based on their specific job titles in the Norwegian EV market, their political influence in this market and other related informants that had knowledge about this market (see Appendix 1).

During the outlining of the structure and methodological aspects of this thesis, we expected the main body of our findings to be naturally divided between the initial investigation of the market structure based on secondary sources, and then to not find any information that was of particular value to the research question until the interview process. However, looking back, phase between the secondary data analysis and the interviews turned out to be more valuable than we initially expected. Even though this did not relate directly to the research question, we were left with an implicit understanding of "who is who" in the industry. As a result of being sent back and forth internally in the companies when we tried to arrange an interview, we developed a sense of the culture and inner workings of the respective companies (including their organisational structure, the relevant decision makers, the complexity and the duration of the decision processes).

Interview guide

We constructed two interview guides, one for respondents related to the industry side of EVs and the other one was designed towards politicians, and those in more political roles of the EV industry. We used the two interview guides as a base but personalised each one according to the respondent. Before constructing the interview guide our focus was on making clear and understandable questions and avoid leading questions (Dalen, 2004). The interview guides are included in Appendix 2 and 3.

We structured each interview as similar as possible for each respondent, by asking each the same questions. The initial questions for each interview was related to the respondent's role in their particular company. The main part of the interviews was structured as an inquiry into who were their current contractors/suppliers, who were their customer, what were their partnerships in the EV charger market, as well as who they saw as the biggest competitor to their business model. Further on we asked more technical questions regarding their setup, issues, suppliers etc. Finally, we asked our respondents about their vision for the future and where they wanted to position themselves.

Interview procedure

In advance of each interview, we informed the respective informant of our research and how it would be documented and stored at NMBU, including the maximum length of the confidentiality period (five years). We also asked the for permission to use an audio recorder, because it was important to take care of the respondent's own statements for further examination (Dalen, 2004). In addition, we gave each respondent the opportunity to add and subtract information they had given us, and we gave them the chance to read their part before submission.

We conducted the interviews with two interviewers. One had a more central role and asked the questions detailed in the interview guide while the other observed and took notes. In addition, the observer asked follow-up questions whenever necessary. According to Trost (2010), using two interviewers with coordinated responsibilities will usually result in an interview with fart greater information and a better understanding of the topic. In addition, it may be considered more by informants that represent an organisation or a company that two interviewers attend and participate in the meeting.

Content analysis

To be able to collect all the information gained from each interview, we asked each informant's permission to audio-record the interview. We transcribed all interviews in full, either on the same day as the interview or the day after. We did that because we wanted to have the ability to take ancillary information into account that could not be captured by the recorder. For that, we needed a fresh memory. To allow transcribing, the interviews had been recorded in their entirety with the explicit consent by the informant. The data files were never shared or exported outside of the original recording device and were deleted as soon as their respective transcription were finished. When the opportunity arose, we also conducted informal "on the spot" interviews with additional actors. These were not recorded or transcribed.

During the transcription and analysis of the interviews, we used diagrams and tables. These can be a helpful means to sort and organise collected qualitative data (Johannessen et al., 2011). We transferred the relevant data from each interview into an excel sheet. In this excel sheet we categorised the collected data into smaller groups, which gave a better and clearer overview of the gathered data. The ARA business-to-business framework (see above) served as a framework for the categorisation of the interview data: we analysed each interview in terms of activities (i.e., how the informants participated in the network, distribution etc.), resources (what the participants had to offer to potential business partners, knowledge etc.) and actor bonds (who the potential business partners were, trust etc.).

Validity

Validity in research is to which extent methods and findings reflect the purpose of the study (Gripsrud, Olsson & Silkoset, 2004), and as such, Silverman (2010) states that validity is simply another word for truth. It might be impossible to do a qualitative study that measure exactly what it should, but we can try to strengthen the validity as much as possible. For this thesis, we ensured high levels of validity in several ways. Firstly, we established a thorough understanding of the EV market and its players (this process is detailed under the 'Key Informants' part of the method section) and created a framework for selecting participants. The criteria for the critical selection process were that they had either comprehensive knowledge about the EV market; had a significant and powerful network and therefore influence on the EV market; were in a position of position of power in the EV market; or a combination of these three. We only interviewed respondents that fulfilled the criteria from our critical selection

process. To avoid the potential of subjectivity influencing our interpretation of the interview material, we have been two people handling the data material (Dalen, 2014). In addition, we had the ability to go over the interview multiple times afterwards since we used an audio recorder, therefore, we could do an extra control check of the data material.

Ethical considerations

We informed all key informant about the purpose of the study, which methods would be used and what kind of risk associated to their participation there would be (Silverman, 2010). We audio-recorded the interviews with the explicit consent of all informants, and these recorded audio files were used in the transcription process and then deleted. In order to comply with "privacy by design" and "privacy by default" principles in GDPR, the transcripts were fully anonymised; no information about the identities of the key informants was stored after the transcription has been completed. The research and the information we received entailed no other contractual obligations with any of the informants. None of the informants asked us to sign non-disclosure agreements; it is therefore of our understanding that the data we collected does not contain protected business secrets.

Results

The emerging value chain

The Norwegian EV Association estimates in a recent report (Elbilforeningen, 2019) that, as of January 2019, there are approximately 1700 fast chargers in Norway. Our own estimates, combined from the secondary collected in Study 1 and the interviews conducted in Study 2, sum up to approximately 1848 fast chargers in Norway (including Tesla) as of April 2019. Table 3 shows our estimates of the market share of the different operators in the Norwegian EV fast-charger market.

- *Fortum* is a stock-exchange listed Finnish energy company. Fortum Charge & Drive is currently the leading operator of charging infrastructure for electric vehicles in Norway. According (Fortum, 2019) their charging network consists of more than 600 fast chargers located in Norway.

- *Tesla* is an American electric car manufacturer, which is among the most popular car choices in the Norwegian EV market (Nobil, 2019). Numbers from Nobil.no state that there are 622 Tesla fast chargers in Norway.
- *Grønn Kontakt* is a CPO based all over Norway. Their owners are two power companies, where one is owned by multiple municipalities and the other one is state owned. (Proff, 2019) They are accountable for approximately 419 fast chargers according to themselves, which makes them the second biggest CPO in Norway.
- *BKK* is a regional based CPO, mainly operating in the southwestern parts of Norway. BKK is owned by municipalities from the Bergen area (Proff, 2019). Furthermore, they have acquired Artic Roads, which have resulted in additional charging point all over Norway. Based on the numbers we found on their own website they should have around 121 fast chargers.
- *Lyse* is an energy company owned multiple municipalities in the Stavanger area (Proff, 2019). In the EV market Lyse is a local CPO that operates only in Rogaland, where they are responsible for 22 fast chargers.

Table 3: Estimated market shares

Company	Region	# of fast chargers	Market share (excluding Tesla)
Fortum	International	621	50.7%
Tesla	International	622	(excluded)
Grønn Kontakt	National	419	34.2%
BKK	Regional/National	121	9.9%
Ionity	International	43	3.5%
Lyse	Local	22	1.7%
Circle K	International	76*	(see text)

Note. * Ionity and Grønn Kontakt chargers

- *Ionity* is a CPO owned by some major car manufactures like; BMW Group, Daimler AG, Ford Motor Company and Volkswagen Group. Their own website (Ionity, 2019) states their goal to be "Building a high-power charging network for EV along major highways in Europe." Ionity currently have 43 fast chargers in Norway.
- *Circle K* is an American company in the convenience retail business and is owned by Couche-Tard Inc (Circle K, 2019). In the Norwegian EV market Circle K first operated as a site owner offering CPOs strategic sites in return for gathering customers to their sites. Now, Circle K is adapting more and more to become a CPO themselves. Circle K have approximately 76 fast chargers, which mainly belongs to either Ionity or Grønn Kontakt.
- *Powered by Eon Drive & Clever* is a new venture backed by both these companies Eon and Clever, and this new venture is going to be a pure CPO in Scandinavia. Their mission is to build infrastructure where they slip the risk and expenses associated with building charging infrastructure. Their business model could relate to the one Ionity have. In addition, they want to establish and design a "meaningful break", which will enforce the feeling of peace and still have the opportunity to go nearby to get something to eat.

Role of central actors

All the different actors have their own product offerings to the network, and to certain degree each one hinge on other actors in this network. A network representation of the business relationship identified in our interviews is shown in Figure 10.

ABB has historically relied on others software systems, but recently they have started having everything in-house. ABB deliver a software system that controls the charger and communicates with the CPO's backend. ABB it markets leader on fast charging and has direct connection with each of the big CPO's in Norway. Their view for ABB on the future is maintaining their position as a market leader within the fast charger market segment and their says that they will "follow the car", meaning that they have a close dialog with the OEMs and future car production.

Circle K appears as a central actor with their bargaining power for having direct connections with almost everyone in the market. They started as a site owner with their main offering being strategic sites or landscape, near all the main roads in Norway. Recently they changed their business model, from their original idea being provider of sites to become a CPO as well. This "pivot" has resulted in going from being one of the most central actors for CPO's to become one of the most central actors for charger manufactures.

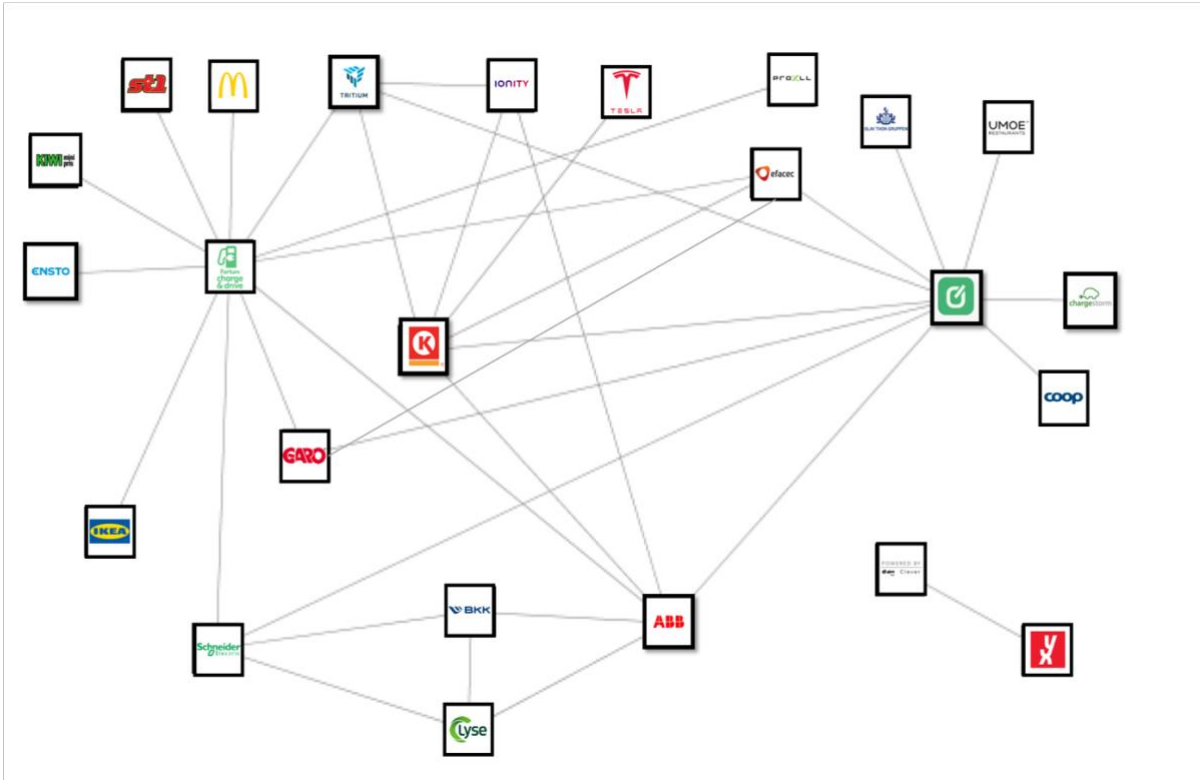

Figure 10: Network of business relationships in the emerging value chain

Fortum is the market-leading CPO in Norway at the moment, with the highest number of fast chargers located around in Norway, excluding Tesla. Tesla is proprietary and therefore not exciting in a marketing perspective even though they have a couple more fast-chargers in Norway. According to some of our respondents there used to be a lot of voluntary work done in the beginning, were actors worked more together trying to create this network of chargers around in Norway. This doesn't occur that much anymore; companies build strategic sites rather than on the most suitable sites for the community. That said, there are still a friendly atmosphere among the actors in the market, everyone wishes each other the best.

The Norwegian EV charger market is still in its early stages and still have some years to become fully established. Therefore, each one of the companies in this market play a vital role in its further development; if one fails it will have a negative impact on the market as a whole.

Types of agreements between buyers and suppliers

Grønn Kontakt used to have an agreement with Circle K in which they provided fast chargers at Circle K locations, and handled the operations and maintenance. The agreement between these two actors included terms about the job-sharing arrangement, as well as a guide

for their partnership in future site and investment strategy. The agreement was that Grønn Kontakt was allowed to install and operate their chargers at Circle K's locations, in return of attracting new customers to their sites. Grønn Kontakt had full responsibility for the charger, payment systems, 24/7 customers support and maintenance at these sites.

Ionity has an exclusive agreement with Circle K, which involves that Ionity cannot put their chargers at any other stations except Circle K. There has to be a mutual agreement between the two before Ionity are allowed to install anywhere else. To Circle K's benefit, this deal does not work both ways, as they apparently have ability to use another CPO without reaching an agreement with Ionity. Ionity goes the whole process with planning new stations with everything revolving around, and then Circle K pays a price for that. For Circle K the ownership of the chargers is not important, but they want to own the customer.

BKK and Lyse have a quite unusual agreement between themselves. They have a close relationship, where BKK exchange their knowledge about thing related to chargers, which usually leads Lyse to buy the same chargers as BKK does. Furthermore, they collaborate in both Rogaland and Vest-Agder (counties) where Lyse operate their own chargers and BKK takes care of customer support and everything goes through their system.

Powered by Eon Drive & Clever are still in their early days in Norway, therefore, not that well established. Thus, Powered by have an agreement with YX (Reitangruppen), and according to our informant there are other as well, yet to be released publicly.

Technological (in-)compatibilities

The four main fast charger suppliers in the Europe are ABB (10500 chargers), Efacec (5000 chargers), Tritium (3000 chargers) and DBT (2200 chargers; estimated based on EV Summit, 2019). Chargers from different manufacturers include varying hardware components, and at times also strongly suggests the buyer to use its proprietary software. Chargers generally follow two standards; OCPP and plug-type. However, the OEM's are not obligated by law to follow these standards, it is simply a matter of following precedent.

Not being compatible with one of the four biggest fast charger manufactures in Europe, is quite a problem. A non-compatible setup with Tritium can result a loss in revenue of approximately 12%. We would recommend EcoG performing a cost-benefit analysis, which can enlighten the level of importance. This analysis could help evaluate if that's an issue that has high reward and low effort and therefore, something one should do. To able to perform this CBA the analyst must have certain technical knowledge regarding the issue or opportunity,

which we do not at this point. Therefore, we can only display the benefit section and then recommend a future approach for the company.

Expected consolidation

There are reasons to believe that the market should expect further consolidations as it develops into a mature market. In short, this is because, with the current cost of operating chargers, especially at higher outputs (e.g. supercharger networks), it is not a high-margin business opportunity. In some cases, operating high-power chargers in remote areas are a net-expense for the operator.

The current prospect of operating high-powered charging industry is simply not very profitable. The margins are low, and it's a buyers-market. Offering high powered charging that will be used only a few times a day at random intervals is simply not sustainable in the current market. The strain on the electric grid and the cost for the operator to offer such power is not really representative of the benefit it provides to the customer. The majority of the fast-chargers in remote areas of Norway are already state sponsored by Enova, and while this will improve with rising adoption rates, it might be too little, too late. The current rate for a full charge is around €4-5. The profits that can be derived from this already meagre sum shrinks proportional to the increasing power of the charger due to unfavourable effect-based power-rates.

At this rate, the market resembles the likes of high-street fashion shops, or the oversaturated coffee-shop industry, in which the costs are so high, and the margins so low, that the space has essentially become a battle of squeezing out competitors by having the biggest bank account. Ionity's supercharger network, or Tesla superchargers are an example that this is already happening; they have never been, and never really was designed with profitability in mind. The role of the charger network can quickly develop into a means to sustain the sale of electric vehicles - an expensive support infrastructure sustained in order to facilitate the significantly more profitable car industry.

Forecast scenarios: A new type of petrol-station business model?

By employing the insights, we have gained from being closely involved in the Norwegian EV-market during this project, we are proposing three forecast scenarios for the industry going forward.

Scenario 1. Charging will continue on its path towards commoditising - the margin squeezing and unsustainable business model that is starting to materialise already. The future market will be dominated by international corporations with financial power to establish an international network of charging stations, who overcomes the challenge of low profit through the sheer scale of their operation. Charging stations networks will largely exist out of necessity and as an enabler for the car industry. This scenario is already starting to take shape, but it is unlikely that this market structure will function in the long run. It is merely a commodity-brokering market, and the profits will to a very little degree benefit the local community of the charger or stimulate the Norwegian economy in any meaningful way.

Scenario 2. Petrol stations will transform smoothly into becoming "energy stations" over time and will adopt the traditional business model of its forerunner. A scenario like this favour the large convenience corporations like Circle K, who can continue their worldwide operations with little need for innovation. Operator and energy-company backed competitors will have to partner with convenience sites to offer an attractive alternative to complete energy sites. This scenario is also very likely to happen, due to the deeply ingrained position petrol stations has in society. The majority of people are used to the concept of a petrol station, and this perception might be difficult to change in the future.

Scenario 3: Charging will be incorporated into the existing infrastructure. 15-45-minute-long charge breaks quite frankly has the opportunity to make the old petrol station model obsolete. By integrating charging into existing business arenas like city centres, shopping centres, gyms, and so on, one can potentially leverage this time-thief to positively influence local infrastructure. This alternative would arguably be the best for the local economy and innovation purposes in general, but it requires a different approach to the development. By going back to the ideas of Foss (2018), there is a job to be done by local interests, politicians and business actors from outside the traditional automotive industry- to realise that innovation is not a zero-sum game of determinism, but a product of creative, targeted action.

Discussion

Relative attractiveness of market and collaboration partners

In the EV market, EcoG and similar service providers are supplemental to the main product providers of charging stations. In the beginning of a market, supplemental actors, specifically those that builds platforms, are relying on the physical market to manifest before they

themselves can truly blossom. Using the analogy of Windows, which has long since overtaken its physical vehicle to success (IBM) in market size, or Android, which quickly outpaced its original design manufacturer HTC as soon as they hit mass market, there is an argument to be made about how a platform should effectively scale, and it seems to involve expectations and hypothetical end-users.

EcoG is depending on being able to prove their value to future customers. The reality faced by many entrepreneurs, is that their grand vision is only visible to themselves – and they have to work hard to try and transfer that vision to as many others as possible. In the case of prospective platform providers like EcoG, they have to remain focused on making that vision into existence as quickly as possible. The reality is that the true potential of a platform heavily relies on its ability to scale; and will become increasingly useful proportional to its reach and influence. In the beginning, it is therefore desirable for EcoG to seek out opportunities to demonstrate the potential of their product and bring together a group of people that understands supports this vision.

General discussion and conclusions

There is a theme of reliance in the market: in many parts of the value chain, the processes and transactions are so nascent and unestablished that they often fully rely on the partners on either side of the transactions. In a way, the market can be likened to a dome under construction; before the structure is finished, it must rely on supporting structures which in this case is represented by government policy. And the earlier it is in the construction, the more it must rely on the support. And like in a dome-structure, all the actors in the market are dependent on its surrounding actors to be stable, and as a result there is a strong sense of mutual reliance between actors. The structure isn't stable on its own until the last piece has been put in place, since a weakness somewhere in the construction can be detrimental to the whole structure- a repetition of the Danish story. It seems that the companies in the eco-system are quite openly acknowledging of the fact that before the real competition begins, they all have to lay down tools and build the arena together.

The element of reliance in the market is visible on a macro level, like with the Danish story; a public bankruptcy coupled with a cutback of government support effectively halted the development of entire national market by years. At the same time, there are strong elements of mutual reliance between particular actors. Take coverage as an illustrative example: a customer needs to get from charging point A to charging point B, which are operated by two competitors. The two competing companies then rely on each other for their own charging point to be attractive, or even relevant, to the customer. In line with this, individual players in the industry understand and value the need for the market to grow and succeed. Related network effects are present in the infrastructure (see Figures 4 and 5 in Study 1) and the mutual dependence of cars, grid and chargers on each other.

The strong correlation between government support and infrastructure development, and also the low profitability in the fast-charger market is a symptom of an immature market that is yet to find its stride. It seems that even in the world's most populated EV market, the operators struggle to offer their services and being sustainable outside of the most populated regions. Compared to the clearly profitable business model of petrol stations, in which customers spend a lot of money during every filling-stop, the future of "power stations" and their 45-minute, €5 charge stops looks rather bleak. We think that the market is overdue for actors that focuses on the added-value aspect of charging – how thousands of 45-minute stops all over the country every day can be converted into a lucrative business opportunity.

Key findings

The market analysis in Study 1 supports the assumption that the EV market is a considerable global market opportunity, and likely to become a substantial future industry. Norway has a strong strategic position in this promising market, with a very advanced EV adoption percentage, infrastructure development, and governmental support. The Norwegian ecosystem is lacking in total market size but is perhaps the first ecosystem in the world to offer a critical mass of users and actors in a confined regional area. This combination is valuable to actors, big and small, who wants to validate their product in a mature market and become acquainted with the key players of the industry. In this regard, Norway can function as a beachhead for the EU EV market.

Other key findings emerged from the network analysis conducted in Study 2. First of all, Circle K, Fortum, and Grønn Kontakt emerges as the flagship actors in the operator category. In the network analysis, these actors have the highest degree of centrality, being directly connected to almost every other actor in the network, except each other (Grønn Kontakt has chargers at Circle K locations, but according to our sources, this partnership have effectively ended with Circle K's new strategy). In addition to being an operator, Circle K is also a site owner, which gives them a certain leverage over the pure operators. However, they lack a direct activity link with the government agencies, such as energy companies. They lose out in nearness in the decision process, thereby reducing their sphere influence.

Of the OEM's, ABB, Tritium and Efacec appears as the most central nodes. Not as well connected as Fortum or Circle K, but with higher bargaining power, and perhaps in a more distinct 'gatekeeper' position. Of these, ABB seems to be the most well connected, having direct customer relationships with all of the CPO's.

Recommendations for business development in the current value chain

Circle K is the largest and most central actor in the current value chain. An obvious and attractive partner, also due to their worldwide presence, with potential for scaling. On the negative side, Circle K do not have the closeness to government that the operators backed by energy companies have. Fortum is challenging Circle K as most influential actor but lacks (as yet) the market influence that comes with owning their own sites. More connected to the energy sector in Norway, through their ownership of the established power company Hafslund Electricity. Grønn Kontakt has a smaller scope and influence than Circle K and Fortum but is

a local Norwegian actor with strong ties to government. Backed by Agder Energi and Statkraft as well as a number of Norwegian small power companies, the company has a strong presence in selected regions of Norway. However, they lack the financial power of its competitors, and are possibly also lacking the technological resources to develop their own infrastructure in a an exceedingly highly competitive market.

ABB, Tritium, and Efacec appears as the most influential OEM's. Ensuring compatibility with their current models should therefore be a main concern of EcoG. Together, these three operators accounts for almost the entire DC charger market, and EcoG should remain focused on building a strong relationship with these established players. We predict that the market is moving towards more intelligent and ergonomic systems, and that the future market leaders will be those that have succeeded in this pursuit. EcoG should work on demonstrating their own attractiveness to the OEM's and make it clear that they can be a valuable partner in the development of future, more customer-friendly chargers.

Another way for EcoG to enter the market is to offer their technological expertise about DC chargers to initiate a partnership with an OEM that is currently not offering a DC option. This scenario is particularly attractive, as a new and fresh charger with state-of-the-art hardware, combined with novel software has the potential to disrupt the market that is already being dominated by a few companies. Companies like ABB and Tritium have been spending significant resources on developing their own software systems, and to get this asset essentially for free would be an attractive asset to smaller manufacturers that are not yet in the DC market, such as Zaptec or DEFA.

Potential opportunities in future value chains

In addition to the network and partnership focused business development opportunities outlined in the chapter above, we have also been focused on the commercial aspect of EcoG's business development. Underneath, we have outlined three product-focused business opportunities that can be enabled by a standardised OS.

The Norwegian retail industry is characterised by fierce competition, price-wars and a rapidly expanding network of local stores: the main grocery chains are competing on increasingly unforgiving margins to become the grocery store of choice for the Norwegian everyday shopper. It is rare to find a town or a village that is not represented by at least Kiwi and Rema1000 in close proximity and choosing stores often comes down to small details or even chance. In a cutthroat market like this, products and innovations that can increase

customer loyalty is very valuable. A customer loyalty program offering free charging outside, or close to the store could present a low-cost, high reward opportunity for the stores to ensure customer loyalty – and is something that can be made possible with EcoG's OS. Despite the high levels of competition, the grocery store sector receives very low marks for perceived innovation by its customers (Andreassen, 2018), and according to a yearly review of Norwegian customer loyalty, the majority of grocery stores has a lot to gain in terms of loyalty (Kundebarometeret, 2018).

With the fleet of electric charging rapidly growing, so does the extensiveness and cost of repairing and maintaining it. The current system for repairing or maintaining particularly fast chargers is in every way immature and overly expensive – it is often cheaper and faster for the large manufacturers to pick the charger out of the ground and replace it with a new and functioning one, than it is to send a skilled technician to identify the problem and repair the charger on-site. This solution is absurdly ineffective and expensive and can only be seen as a testament to exactly how early-stage the charger-market currently is. A hardware agnostic, standardised operating systems with embedded access to the inner workings of a charger presents an opportunity to develop effective analysing and maintenance tools. With good analytics, software problems can potentially be resolved remotely at a fraction of the cost of today's solution. In the case of hardware problem, the technician can be informed about details of the problem in advance, also significantly reducing the cost of a reparation.

The sudden increase of EV adoption is impacting the stability of the electrical power grid. The problem has already become a reality for small resort-areas that experience outages and grid problems during weekends or holidays, during which a surge of visitors tries to charge their electric vehicles at the same time. Upholding the stability of the electrical grid is of critical importance to national safety. A standardised operating system across all electric chargers enables Statnett to effectively create applications to communicate and integrate with electric vehicle chargers – an increasingly relevant stakeholder in the power consumption sector.

Modern battery technology and infrastructure is able to not only charge a battery from the grid, but to send that power back into the grid through the same method. A carefully designed regional energy management system controlled by Statnett could offload the grid by transporting energy from high- to low-energy regions through EV batteries of cars that were travelling that way anyway. And with a bit of creative flair, everyday EV drivers can enjoy the experience and also possibly be compensated for their efforts.

It is fair to say that the US market has potential and will most realistically become an enormous EV market in the future. The market leader in the US charger market is ChargePoint,

and according to their own website they have the largest charging network in the world with 64800 charging spots in total (ChargePoint.com). That represents the largest fleet of chargers in the world owned by the same brand. However, the same cannot be said about the number of fast-chargers (express) in their network, which only account for 400 in total. That number is extremely low compared to similar markets, but the opportunity for growth is very high. We suggest that EcoG should begin establishing a relationship with ChargePoint in the US, so they can take advantage of the advantageous market position they are in.

Recommendations for policy

The Norwegian economy thrives from its position as a leader in the EV eco-system. Today, some of the largest energy, technology, and car manufacturers in the world are entering Norway to ensure their position at the cutting edge of a future industry – and Norway can potentially become an industry hub for electric mobility. It is in our view essential that the Norwegian government keep supporting and nurturing this industry to continue its further advancement. This report has presented a clear link between government support and the success of establishing and fostering transition into greener technology. The same sentiment is true for user-adoption of new technologies. In order to secure future value chain development, certain policy suggestions can be made:

There should be a better solution for the application and implementation process for installing transformer stations. Today, this process is ineffective and time consuming, and can take months. In neighbouring country Sweden, the process can take as little as a couple of days. There is reason to believe that the laborious process of applying for transformer stations in Norway is holding back the expansion rate of fast-charger coverage.

There should be continued, unquestioned incentives and support to consumers that choose to purchase and drive electric vehicles, so that a critical mass of users and actors may be generated. Using the associated infrastructure, such as chargers, should also be incentivised to support the development of an infrastructure that can sustain itself organically. The markets can't rely on incentives forever, and therefore, the importance of reaching mass adoption quickly is critical for further development.

Reaching a critical mass of users and actors for testing is essential to validate various concepts and assumptions in the industry – or simply: "how will this actually work in a genuine real-life situation?" – an attractive opportunity for large companies that wants to reduce risk in

their high-profile EV projects, and as such should not be understated as a future prospect in the Norwegian economy.

Limitations and future research

We wrote in the introductory limitations of this study that we would limit the scope of this study to the EU and Norway specifically, and stay away from the Chinese and the US market due to reasons that was outlined in that same paragraph. It has become clear during this research project that China's position in the EV scene, and extending into the e-mobility scene, is very advanced. Due to a combination of favourable economic, political, and environmental features that are unique to China, it might become the birthplace of many of the solutions that will reach mainstream in the West in future. China is a major player in the e-mobility scene, and their presence should not be underestimated by future researchers.

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Appendices

Appendix 1. Areas of expertise of key informants (anonymised)

Table 4: Key informants EV Industry

	Role in company	Company Type	Size of company	Region
Informant 1	Director for E-mobility Product Development & Operations	Convenience & fuel retail	Large	International
Informant 2	Director for E-mobility Fast-charging	Charge Point Operator	Large	International
Informant 3	Manager Business Development Energy division	Energy company & Charge Point Operator	Small	Regional
Informant 4	Project Manager E-mobility Energy division	Energy company & Charge Point Operator	Small	Regional
Informant 5	Operations Manager E-mobility	Charge Point Operator	Small	National
Informant 6	Director for E-mobility Nordics	Charge Point Operator	Small	International
Informant 7	Operations Manager Nordics	Hardware charger manufacturer	Large	International
Informant 8	Operations Manager Europe	Hardware charger manufacturer	Medium	International

Table 5: Key informants government

	Role	Work	EV relevance
Informant 1	Politician	Oslo council	Policy
Informant 2	Senior adviser	The Norwegian Water Resources and Energy Directorate	Regulations Policy

Appendix 2. Interview guide for key informants with an industry background

Background

We are writing a master thesis about business development in emerging value chains. We will use the Norwegian EV infrastructure as a case. Therefore, we are interested in hearing your opinion on the business development in this market and how your company relates to the other actors in this network. Your participation will be anonymised in our thesis, we will follow the GDPR guidance.

Introduction

- Who are you?
- What do you do?
- What is your contribution to the Norwegian EV charger market?

Main questions

- Who are you doing business with at the moment?
- Do you have any collaborations with anyone in this market?
    - If so, who and how does this work?
- Who do you consider your enemies in this market?
- What backend system do you guys use?
- Which hardware solutions do you have?
- Payment systems?
- What types of contracts are normal in this industry? Any exclusivity?
- What are your margins?

Ending

- What are you thought on the new rapport from The Norwegian EV Association "ladeklart 2025"?
- How do you evaluate the political willingness regarding fast-charger infrastructure building?
- What are the problems in the market today and what needs to be done?

Thank you so much for you time, we really appreciate it.

Appendix 3. Interview guide for key informants with a public policy background

Background

We are writing a master thesis about business development in emerging value chains. We will use the Norwegian EV infrastructure as a case. Therefore, we are interested in hearing your political views and thoughts on this industry and the future. Your participation will be anonymised in our thesis, we will follow the GDPR guidance.

Introduction

- Who are you?
- What do you do?
- What is your contribution to the Norwegian EV charger market?

Main questions

- How is the willingness in the Norwegian policy to keep operating Norway as pioneer within the electric vehicle industry?
- Oslo became the European Green Capital 2019; how does that effect your future political approach?
- What kind of advice would you give other countries that wishes the same EV adoption as Norway?
- The industry mentions that the energy tariff as one of the biggest problems for future development right now, any thoughts regarding that?
- The Norwegian EV Association made a proposal regarding “real-time data”, that it should be obligated for CPO’s to make them available. Any thoughts?
- problems in the market today and what needs to be done?

Thank you so much for you time, we really appreciate it.

Appendix 4. Abbreviation table

Table 6: Abbreviation table

Abbreviation	Meaning
BEV	Battery Electric Vehicle
CPO	Charge Point Operator
EV	Electric Vehicle
OEM	Original Equipment Manufacturer
PHEV	Plug-in Hybrid Electric Vehicle

Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

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Norway