MASTER THESIS

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The future of hydrogen fuel in Norway:

The road transportation industry's perspective

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Samandrag

Formålet med denne masteroppgåva er å generere ei forståing og vidare avklare korleis den norske vegtransportindustrien oppfattar moglegheita til å endre til eit hydrogen drivstoff produsert av fornybar energi. Hovudfokuset i oppgåva er på den noverande marknadssituasjonen for hydrogen, dei påverka aktørane i marknaden og korleis dei potensielle forbrukarane oppfattar hydrogen drivstoff og teknologi. Problemstillinga for oppgåva er gitt som *«Hydrogen produsert av fornybar energi – Er den Norske vegtransport industrien klar for eit drivstoffskifte?»* Dette er eit svært relevant emne for det Norske næringslivet, sidan den norske transportindustrien har blitt påkrevd frå den norske regjering å auke deira fokus på utsleppsreduksjon og miljøvennlegheit. Dette for å tilfredstilla forskriftene satt av den Europeiske Union.

Denne oppgåva har ein blanda metodetilnærming for innsamling og analysering av datamaterialet. Dei kvantitative data blei innhenta igjennom ein spørjeundersøking utført på ein konferanse for Norsk lastebileigar forbund, medan dei kvalitative data er innsamla gjennom intervju og sekundærdata. Den kvantitative metoden er dominant, kvar dei innsamla kvantitative data lagar ein form og struktur for innsamling og analysering av dei kvalitative data. Dette generera ei analyse med meiningar og forklarande synspunkt.

Funna frå denne forskinga illustrerar at i den noverande marknadssituasjonen er det fleire aktørar som har moglegheita til å bli påverka eller sjølve påverke marknadssituasjonen. Forskninga fokuserar på tilbydarane og etterspørjarane i marknaden, og den estimerte marknadsdynamikken. Denne dynamikken er estimert gjennom den noverande marknadsprisen, forbrukaranes betalingsvilligheit for hydrogen og forbruksnivået for hydrogenlastebilar. I tillegg er fokuset retta på regjeringa som ein svært viktig aktør i marknaden, sidan regjeringa har moglegheita til å regulere marknadsdynamikken gjennom midlar og subsidier. Vidare er viktigheita av dei ulike rammevilkåra for potensielle forbrukarar diskutert. Forbrukarane sin positive åtferdsmessige intensjon mot hydrogen er forklara igjennom konsepta holdning, sosiale normer og oppfatta åtferdskontroll.

Oppgåva konkluderar med følgjande utsagn; for at hydrogen skal bli eit konkurransedyktig drivstoff er det viktigaste å utvikle ein drivstoffsinfrastruktur igjennom dei noverande drivstoffstasjonane sin infrastruktur og vidare generere statlege subsidiar for forbrukarar for å føre til at hydrogen blir eit levedyktig drivstoff på den norske marknaden.

Preface

This master thesis completes my time as a student at the Master of Science program in Energy Management at Nord University in Bodø, Norway and MGIMO University in Moscow, Russia. In addition, it marks the ending of my five years of higher education. The thesis focuses on the future of Hydrogen fueled vehicles in Norway, and its potential consumers. I have chosen this topic because of the highly relevance and importance towards an environmental friendly society.

The thesis is written by request from the potential hydrogen producer Østfold Energi. I hope that the conducted research will be helpful for potential producers and other actors in a future hydrogen market. I therefore would firstly like to give my gratitude to my contacts at Østfold Energi, Egil Erstad and Roy Braathen. Their inspiring view towards hydrogen ignited a sparkle for me to develop and continue the process of this master thesis. In addition, Østfold Energi has been financially supporting this conducted research.

A formal thank you should be given to all of my respondents and informants, and especially Olav G. Hermansen at Norsk Lastebileier Forbund, for giving me the opportunity to participate at their conference, in order to collect information for the thesis research.

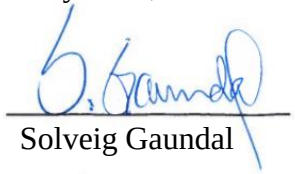
Special thanks should be given to my supervisor at Nord University, Gisle Solvoll for constructive criticism, help and guidance related to this conducted research. He's viewpoints have had an inspiring importance for this thesis.

My family and friends is one of the reasons that this thesis is completed, and deserves all my gratitude. Supporting me through my years of study has been one of the reasons that I have accomplished this degree.

Last but not least, I would like to give a special gratitude to my fellow students at Nord University. Behind this thesis are long days, heavy reading and a lot of constructive discussions with fellow students.

I take full responsibility for any mistakes or misunderstandings presented in this thesis.

May 2017,



Solveig Gaundal

Abstract

The main aim of this thesis is to generate an understanding and further clarify how the Norwegian road transportation industry perceives the opportunity to change towards a hydrogen fuel produced by renewable energy sources. The focus of the thesis is majorly on the current hydrogen market situation, the affected actors in the market and how the potential consumers perceive hydrogen fuel and technology. The problem statement is given as *"Hydrogen produced by renewables - Is the Norwegian road transportation industry ready for a fuel shift?"* This is a highly relevant topic for the Norwegian business environment, as the road transportation industry in Norway has been required by the Norwegian government to increase their focus on emission reduction and environmental friendliness, in order to meet the regulations set by the European Union.

This thesis uses a mixed method approach for collecting and analyzing the data material. The quantitative data is collected through a survey conducted at a conference, while the qualitative data are collected through interviews and secondary data. The quantitative method is the dominating method, where the quantitative data collected shapes and structures the collection and data analysis of the qualitative data. This generates an in depth analysis with opinions and further exploratory viewpoints.

The findings from this research illustrate that in the current market situation several actors have the possibility to affect or be affected in the market. The research focuses on the suppliers and demanders in the market, and the estimated market dynamics. This dynamics are estimated through the current hydrogen market price, the consumers' willingness to pay for hydrogen and the consumption level for hydrogen. Additionally the focus is on the government as a major important actor in the market, as the government has the opportunity to regulate the market dynamics through funds and subsidies. Further the framework conditions of importance for the potential consumers are discussed. The consumers' positivistic behavioral intention towards hydrogen is described through the concepts of attitude, social norms and perceived behavioral control.

This thesis concludes with the following; for hydrogen to be a competitive fuel the major importance are the development of a fuel infrastructure through the current fuel stations and further generate governmental subsidies for the consumers in order to make hydrogen a viable fuel in the Norwegian market.

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Abbreviations

CO_2 - Carbon Dioxide

GHG - Greenhouse gasses

TPB – Theory of planned behavior

PBC – Perceived behavior control

“It is the overall picture which is important when changing from diesel towards hydrogen”

- Informant to this thesis

1 Introduction

In this chapter the background and motivation for conducting this research is presented. Further the problem statement and research questions are introduced in order to understand the importance of this thesis and how this research can contribute to development of a hydrogen market. The chapter finishes with the thesis limitations and the thesis construction.

1.1 Background

The time for writing a thesis about hydrogen as a potential fuel produced by renewable energy sources has never been more interesting. As the leaders of the world continuously demand a greener focus from small- and large scale companies, different markets conducts a greener changes towards renewable energies.

Every day, small baby steps are made all over the world in order to make the world more environmental friendly. Never have the focus towards CO_2 reduction and GHG emissions been more specific. Every climate and environmental focused company seeks to be the best, the leader, the innovator in usage of renewable energy.

The focus on greener technology has reached a level where customers of large value chains are demanding an environmentally focus in order to seek a fully-fledged environmental friendly value chain for the product and services they consume.

Norway is currently, the year of research, perceived as a leader in generating and producing renewable energies. With high mountains and waterfalls the country is nearly self-sufficient on renewable hydropower. A total of 96 percent of all electrical power produced in Norway in 2016 were hydropower (ssb.no, 2017). Hydropower producers seek to develop and use their renewable energy source in new environmental friendly technology. Østfold Energi, as an innovator, has a desire to generate hydrogen from their green hydropower energy. This renewable solution is anticipated to be stable and futuristic production method as hydropower is estimated to be the most important , stable and persistent source to energy in Norway (Fenger, 2007).

This master thesis aims to explore the potential market for hydrogen fuel produced by renewables. The conducted research aims to understand the potential end-users of hydrogen, and has a clearly and limited focus on the road transportation industry in Norway.

1.2 Purpose and motivation

As the development of hydrogen technology is at its peak of realization, the question to be asked is, whether or not there are consumers' interested in using hydrogen technology in ordinary production. Based on this, the producer Østfold Energi has requested research in order understand the attainable markets solutions and map the potential consumers in a hydrogen market.

The thesis aims to understand and further illustrate if the transport industry at this point is ready to make a change from ordinary fuel towards hydrogen as a fuel. The transportation industry is therefore perceived and described as consumers in this thesis. The focus of this thesis is connected to the potential consumers demand and their behavior towards hydrogen as a fuel in order to create a completely established hydrogen market.

One of the main reasons that I have chosen the hydrogen topic for the thesis is because of the future value this research and its results can bring. The future will be even more focused on low emissions, renewable energy and new forms of generating green power. Hydrogen as a fuel has the possibilities to create even lower emissions, throughout the value chain if it is produced purely by hydropower.

1.3 Problem statement

The world is constantly focusing on the climate. Every day the world changes towards a greener environmental friendly perspective. Never before have the focus on sustainable development and renewable energy been higher. In 1987 the Norwegian Prime minister Gro Harlem Bruntland introduced sustainable development as a new concept and a "new way of thinking about the future environment". Now, over 30 years later the focus is continuously enhancing (Olerud, 2016). Sustainable development is defined as development that satisfies the current demand without destroying the future generations' possibilities to satisfy their own demands (Olerud, 2016). Norway is perceived as one of the leaders within sustainable development and the specific focus on a greener environment. The governmental support has been of substantial importance for developing and sustaining an environmental friendly focus.

The latter years the transportation industry has been given a higher environmental focus. Through governmental requirements and targeted goals, the development towards a greener environment has led to new technology developments for reducing the emissions from the

transportation industry. Previous conducted research indicates that hydrogen as a fuel can be the future of emission reduction technology within the transportation industry.

Hydrogen as a fuel has been discussed for several years, but the cost of developing the fuel and technology have been substantial. Furthermore, the hydrogen value chain has been highly polluting, as hydrogen depends on an external energy source. The new project developments in Norway determine to use renewable energy in order to produce hydrogen, making the value chain for hydrogen environmental friendly. As hydropower is essential and an excess resource in Norway, hydropower can be used as an energy source in order to produce hydrogen. Hydropower is used in this thesis as a reference point for renewable energy sources, as hydropower is currently the energy source that is most developed and with best futuristic prospects in Norway.

Introducing a new fuel to the market can be a revolutionary success or a costly failure. This thesis therefore focuses on the transportation industry and their behavior towards changing to hydrogen as a fuel. Based on this, the problem statement is presented and generates the focus for the conducted research for this thesis:

> ***"Hydrogen produced by renewables - Is the Norwegian road transportation industry ready for a fuel shift?"***

With this problem statement the main aim is to understand and further clarify how the Norwegian road transportation industry perceives the opportunity to change towards a renewable hydrogen fuel. In order to understand the possibilities for developing a hydrogen market the main factor of importance is to comprehend the current market situation of hydrogen fuel in Norway. As the market situation of hydrogen is perceived, the importance is additionally to understand the potential actors which can be affected by a development of a hydrogen fuel market in Norway. This in order to generate a perspective on how the market possibly can change in different directions depending on its given actors. The following research question is therefore asked in order to understand the current market situation and which potential actors are affected by the market development

> *How is the current market situation for developing a hydrogen market in Norway, and which actors are possibly affected by such development today?*

The most important actor for a new fuel market is perceived as the consumer. The consumer is presumed to have the greatest power in order to control the fuel and technology

introduction to the market. If the consumers don't have a perceived attitude and intention towards the product, the market development can be relatively slow, as a market depends on its customers. Their attitudes and intention is therefore of substantial importance for this thesis. The research question to be asked is therefore:

> *How is the potential consumers' current attitude and intention towards a hydrogen fuel shift?*

In order to understand the importance and actualization of this thesis the pursuing research question focuses on the framework conditions which are important for consumers. This question is asked in order to understand what kind of funds and subsidiary plans are important for the consumers in order to change to hydrogen fuel. Furthermore, the differences between companies that already use environmental friendly vehicle technologies are compared towards the companies that already use emission reducing technology. This in order to understand the potential differences in the demanded framework conditions between the groups. Therefore the following research question is asked.

> *What kinds of framework conditions are important for the consumers in order to become an actor in the hydrogen market?*

Based on this question the thesis focuses on enlightening the market situation, the potential affected actors of a hydrogen market and further focus on the consumers' behavior towards hydrogen. In addition, the thesis focuses on the framework conditions in order to develop a fully-fledged hydrogen market.

1.4 The thesis construction

The thesis is separated in to six chapters with several subchapters. The first chapter describes the background and actualizing of the theme before the problem statement for the thesis is presented. Furthermore, the concept of hydrogen is presented in order to get an understanding of the foundation for the research topic and the actualization of it. Then the theoretical framework is presented in chapter three, elaborating about the market theory of supply and demand, the theory of planned behavior and stakeholder theory. In chapter four the choice of methods for the thesis is presented, described and discussed in order to give the thesis a methodical framework for conducting research. Chapter five presents the empirical findings of the research and are firmly analyzed towards the theoretical and methodical framework of

the thesis. To summarize, chapter six contains the conclusion, implications and suggestions for further research. The thesis construction is illustrated in the following model.

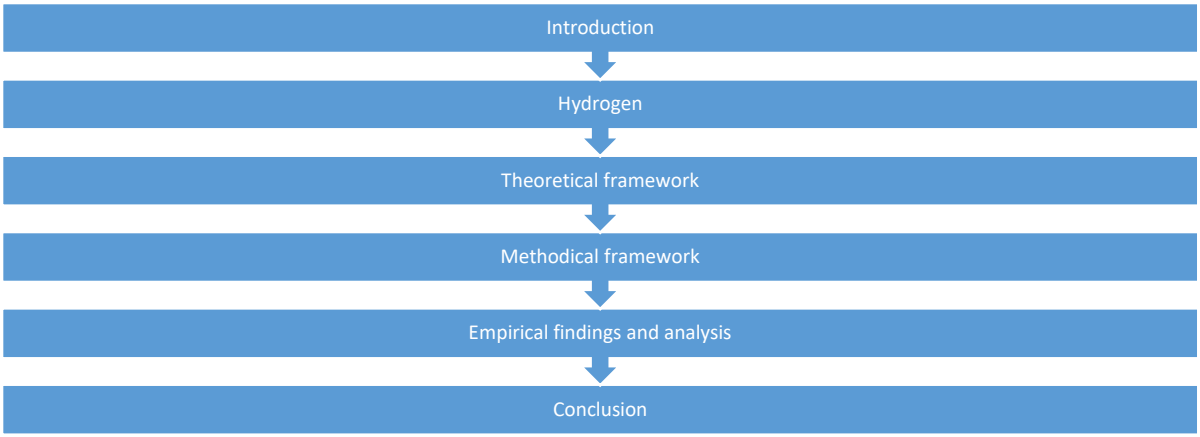


Figure 1-1 The thesis construction

The research is grounded in the levels of the hydrogen market, and the following model is an illustration of the research for this thesis. The focus for the thesis is grounded at three different levels of the market. Firstly the market and its offsets are presented and analyzed. Further the different actors of the market is determined and discussed, with a main focus on the government, the suppliers and the demanders of the market. Finally the consumers' intention towards hydrogen is analyzed for further understanding of the future market development.

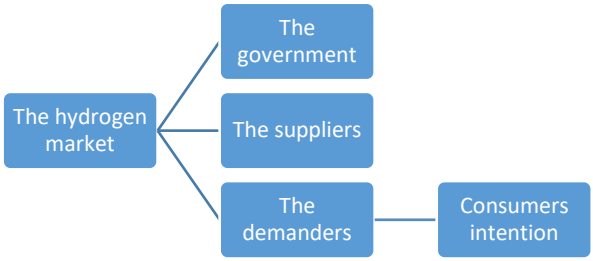


Figure 1-2 Framework construction

1.5 Limitations

This thesis and its research topic are limited to the Norwegian transport industry and mainly the freight transportation on road, within the country. The thesis is limited to this industry in order to create a understanding of the transportation industry's perspectives towards hydrogen. The thesis has been encouraged to be limited to only Norwegian transport industry on land due to implications from Østfold Energi and prior research within the field of hydrogen. Additionally several governmental reports such as the HyWays- report created by the European Commission and previous research have been illustrating that the potential hydrogen market will be for duty vehicles (HyWays, 2007).

2 Hydrogen – concept and development

This subchapter aims to enlighten hydrogen as an energy source and the different perspectives on a national and international level. Firstly the hydrogen concept is firmly described in order to get an overview of the topic, furthermore the transportation industry is addressed.

2.1 Hydrogen

Hydrogen is the basic element that is most common in the universe. Hydrogen is usually found connected to other elements generating water, oil and other fluids and living organisms. An ignition of hydrogen generates an explosion, and this explosion can be used as a source of energy with today's technology (Nord and Tvedt, 2001).

There is only 1 percent pure hydrogen in our atmosphere. In order to create energy from hydrogen it is demanded usage of another energy source in order to perform the element separation process (Nord and Tvedt, 2001). Hydrogen is not defined as an own energy source, as it doesn't occur naturally as energy, therefore in order to generate hydrogen, the production depends on an external energy source (Barbir, 2005). Hydrogen can with today's technology be generated from sources such as water, biomass, natural gas or coal (after gasification). Hydrogen has the resent years mainly been produced via steam methane reformed from natural gas. This method for generating hydrogen isn't termed as a sustainable method, due to relatively high emissions levels (Turner, 2004).

Every year it is produced approximately 45 million ton hydrogen gas in the world. Over 90 percent of this amount is from natural gas. This energy source creates enormous amount of greenhouse gasses, such as CO_2, emitted to the air. Up until today, this has been the most profitable way of producing hydrogen. Now, as times has changed, the focus on GHG has been higher, energy companies' tries to create hydrogen from renewable sources such as sun-, water-, wind- and wave technology (Nord and Tvedt, 2001). Several companies in Norway are willing to try to produce hydrogen from their renewable energy sources today.

The price of hydrogen is estimated to stay at a level close to diesel in the nearest future. A unit of hydrogen is sold in the measurement unit of kilos and not liters. The price level of hydrogen today, the year of research, is estimated to be at 90 NOK per kilogram hydrogen (Norskhydrogenforum, 2016).

The US department of Energy has published a report on hydrogen and what they anticipate to be the key benefits of using hydrogen as a fuel in the future. One of the major benefits of using hydrogen as a fuel is that vehicles fueled by hydrogen would be nearly emission free (Nikolamotor.com, 2016). Further a fuel shift towards hydrogen will in addition create a reduction in the current oil consumption in the world. Hydrogen can be a highly efficient energy conversion and could possibly advance the usage of renewable power. Change towards hydrogen generates a new fuel flexibility (DoE, 2013). It is anticipated that hydrogen will represent an important factor in reducing the greenhouse gas emissions in the future. The focus is steadily growing for a greener environment and many initiatives and actions have been taken towards this.

2.2 Hydrogen globally

The European Union goals suggest that the GHG emissions should be reduced by 40 percent compared to the 1990 level (ec.europa.eu, 2017). Implementing this target statement to the road transportation sector in Norway would require that the emissions should be more than halved (55 percent) between the period of 2015 and 2030. This large percentage is generated as a targeted goal because the emissions of the road transportation has already increased by the amount of 32 percent from 1990 until 2015 (Fridstrøm and Østli, 2016).

Hydrogen as a fuel is an especially hot topic because it has the ability to lower the worlds GHG emissions. Hydrogen has in the latter years had a great focus within the European Commission. The HyWays project was co-founded and created in order to map the possibilities for hydrogen energy usage. HyWays was an integrated project in the European Commission launched in 2004 in order to create a potential Hydrogen Energy Roadmap for the future. The project was co-funded by several research institutes, the industry and the European Commission under their 6th Framework Programme. Their project lasted for 39 months, from April 2004 until it was finalized in June 2007 (HyWays, 2007). The main conclusions from the project were within the topics of emission reduction, security of supply, impact on economic growth and employment, end-use applications and the competitiveness of hydrogen as a fuel.

The project stated that if hydrogen as an energy source was introduced to the energy system the cost reduction for one unit CO_2 would decrease by 4 percent in 2030 and 15 percent in 2050 (HyWays, 2007). This research implied hydrogen as a cost effective resource in

performing specific emission reduction actions. However, an introduction of a new energy source to the system would apply initial investments. The cash flow analysis applied in the project showed that a total well-to-wheel reduction of CO_2 emissions would be approximately 190 – 410 Mton per year in 2050. 85 percent of this reduction would be mainly related to road transportation. This indicates that the overall CO_2 emissions created by road transport would be reduced by approximately 50 percent (HyWays, 2007).

Hydrogen is a type of energy that requires demand from an external energy resource (HyWays, 2007), as it is not found as a pure energy source in the nature. This indicates that for hydrogen to be a potential energy resource there is a necessity for a strong and substantial improvement of the existing security of supply. Introducing Hydrogen to the European energy system could potentially lead the total road transport oil consumption to decrease to an approximately level of 40 percent by 2050, compared to the 2004—2007 numbers of the HyWays report (HyWays, 2007). Hydrogen produced by a renewable energy source is anticipated to be of substantial importance for the current energy consumption. Even though Hydrogen demands energy from another source in order to be produced, it will still be a pure source of energy, with a low emission value chain.

Switching to hydrogen as a fuel for vehicles could potentially lead to a strengthening position for the car- and energy equipment industry in Europe, which will further lead to a substantial economic growth in the area. The major benefit from positive economic growth is the impact of decreasing the economic vulnerability in Europe. The factor of economic vulnerability is usually controlled by shocks and structural high oil prices (HyWays, 2007).

The HyWays-rapport states that the main markets for end-use hydrogen applications are preferably within passenger transport, light duty vehicles and city busses. Further the rapport states that it expects about half of the transport sector to make a shift towards hydrogen fuel. Furthermore is the heavy duty transport, and long distance transport expected to switch to alternative fuels, such as biofuels. The rapport states that *"in order to develop hydrogen to be an attractive fuel and facilitate its deployment among users it is necessary to supply hydrogen along the road network"* (HyWays, 2007).

The competitiveness of hydrogen as a fuel represents a major role when considering to use hydrogen as a fuel. In a full commercialization phase of a hydrogen market, the rapport states that the hydrogen and oil-based fuels are comparable as long as the crude oil price level is remained above $50 per barrel (HyWays, 2007).

2.3 Hydrogen in Norway

In 1993, 24 years back in time, approximately 40 percent of the total CO_2 emissions of Norway came from mobile sources in the transport sector. Included in this number, approximately 50 percent was sourced from the road transportation, about one fourth from national shipment and approximately one tenth from the national air traffic (Grøvdal and Hjelle, 1998).

Today, one third of the emissions in Norway originate from the transportation industry (Regjeringen.no, 2014b). The transportation industry is therefore the sector releasing the highest amount of emissions, with approximately 13, 6 million tons CO_2-eqvivalentes (Olje-ogenergidepartementet, 2016). The government of Norway is given rules and regulations from the European Commission and follows them strictly. These rules and regulations are connected to targeted environmental goals. This is a strategic decision in order to get a certain goodwill connected to the EEA trade agreement (Holm et al., 2007). An interesting fact to observe is that Norway is the EEA country that uses the most renewable energies, measured as shared of total consumption. Norway uses approximately 58% renewable energies of the overall total consumption (Bøeng, 2010). The government of Norway has introduced three ways of reducing the emission problem stated by EU, these are:

- *Reduction of the need for transportation*
- *Change to more environmental friendly ways of transportation*
- *Introduce new and emission reducing technology*

The introduction of these focus points is based on Norway's targeted mission to become a low-emission country by 2050 (Regjeringen.no, 2014b). In order to comply with these goals, drastically changes should be tactically performed, mainly through the Norwegian climate policy.

2.3.1 The Norwegian Government's Hydrogen perspective

In 2003, an expert group appointed by the Ministry of Transport and Communication was founded in order to explore the possibilities and consequences of making a fuel shift towards Hydrogen in the Norwegian transport sector.

The expert group recommended targeted investments towards implementing hydrogen as a fuel in the transport sector. The group recommended that from the year of 2003 until

hydrogen-fueled vehicles are mass produced, there should be established an organization in order to assist in developing and implementing a national initiative on hydrogen. The group further suggested that various types of research and development projects would be necessary in order to enhance knowledge of the technology and products. The expert group underlined the importance of testing the technology development in order to create satisfactory system solutions. As a selected group they suggested that the government should provide investment support or project financing as public support for usage of hydrogen at an early stage (Regjeringen.no, 2004). In addition they suggested that at a stage when hydrogen-fueled vehicles are available, tax incentives or other preferential measures should be applied in order to assist initial market penetration for hydrogen vehicles (Regjeringen.no, 2004).

The expert group stated that in the future, hydrogen should be exempted from taxes until hydrogen reaches the level of complete penetration of the market, and is able to compete at equal terms as other fuels. The success of the state subsidies for electrical vehicles, such as access to bus and taxi lanes and free parking, should be considered when introducing an environmental friendly fuel to the market (Regjeringen.no, 2004).

2.3.2 The Norwegian Climate Policy

The Norwegian Climate Policy is mainly based on the targeted statement of limiting the average increase of the global temperature to no higher than 2 percent above the pre-industrial level (Miljøverndepartementet, 2015). Some of the overarching goals for the Norwegian Climate Policy are:

- *Norway will exceed its Kyoto commitment by 10 percentage points in the first commitment period.*
- *Until 2020, Norway will make a commitment to reducing global greenhouse gas emissions by an amount corresponding to 30 per cent of Norway's emissions in 1990.*
- *Norway will be carbon neutral in 2050.*
- *As part of a global and ambitious climate agreement where other industrialized countries also make major commitments, Norway will have a binding target of carbon neutrality by 2030 at the latest. This indicates that Norway will ensure for reductions in emissions that are equivalent to Norwegian emissions in 2030 (Regjeringen.no, 2014a).*

These climate policy goals create the illusion that the Norwegian government seek to reduce the overall Norwegian emissions, including the transportation industry. This gives a positive indication that the transport industry could be ready for a fuel-shift within few years.

2.3.3 The Norwegian National Transport Plan

The Norwegian National Transport Plan is the Norwegian governments twelve year futuristic plan which states the governments transport policies. The national transport plan (NTP) outlines how the Norwegian Government intends to prioritize their national resources within the Norwegian transport sector. The transport plan is a representation constructed for twelve years at a time, that is further revised by the government every fourth year. This transport-plan, which in addition includes other policy issues, provides a comprehensive foundation for decision-making for the Norwegian government. The plan is generated in order to ensure that the Norwegian transport resources are used in an efficient way, and aims to strengthen the interaction between the various modes of transport sectors in Norway (Ntp.no, 2017)

The plan is developed by four national agencies which are responsible for their separate respective sectors, these are:

1. Norwegian air traffic authority/Avinor AS
2. Norwegian Coastal Administration/ Kystverket
3. Norwegian Railway Directorate/ Jernbanedirektoratet
4. Norwegian Public Roads Administration/ Statens vegvesen

In February 2016 the transport agencies presented their joint input to the fifth NTP (2018-2029).

2.3.4 NTP 2018-2029

The NTP for the period of 2018-2029 is currently, the year of research, under development by the national agencies mentioned above. In their current draft for the NTP 2018-2029 one of their biggest focuses is their climate strategy within the transportation industry. The NTP seek to reduce 50% of the emissions from the transport sector within 2030. To reach this goal they introduce usage of low- and zero-emission technology. In the plan it is stated that *"after 2025, new private cars, city buses and light vans are to be zero-emission vehicles".* In addition the NTP for 2018-2029 desires an introduction that *"By 2030, new heavy vans, 75 % of new long-distance buses, and 50 % of new lorries are to be zero-emission vehicles*". Last but not least, the plan that is most exciting and relevant for this thesis is the plan to implement that *"By 2030, goods distribution in major urban centers are to be almost emission free"* (Ntp.no, 2016). This creates most of the motivation towards writing this thesis, is the Norwegian transportation industry ready for a zero-emission fuel-force?

The transportation industry of Norway is currently trying to cut greenhouse gas emissions in order to follow the targeted statements from the European Commission. A solution towards a

lower emission level can be to conduct a fuel shift towards hydrogen. The industry is already known for their good solutions with emission reducing technology, such as the EURO VI engines.

2.3.5 The Norwegian transportation industry

The transport industry of Norway mainly consists of transportation conducted on road, by sea, in air or on rails. This thesis mainly focuses on the goods transportation industry on road, by trucks. The decision on limiting this research to only road-based transportation is determined on previous conducted research which suggests that future hydrogen usage will be on heavy duty road transportation of goods. It is anticipated that an introduction of hydrogen as a fuel in the heavy-duty industry could potentially be more cost efficient than on other vehicles (Farrell et al., 2003).

In 2015, approximately 283, 4 million tons of goods were transported by land in Norway (Statistisk sentralbyrå, 2015). Goods are in this thesis determined as everything that is bought, sold, consumed, stored or transported inside Norway. It is defined as everything transportable, including raw materials, parts, components and manufactured goods (Foss and Virum, 2000). Due to the Norwegian terrain and land formation, nearly all goods consummation in Norway depends on transportation on land. Twenty years ago, in 1997 was nearly 81% of Norwegian goods transportation conducted on road (excluding transportation to and from the oil production on the Norwegian continental shelf) (Foss and Virum, 2000).

The Norwegian transportation industry is always exploring the opportunities for investment in new technology, and as the government suggests a lower GHG amount released, the industry desires emission reducing technology. Several of the distributors located in Norway have already ordered the Nikola one truck, which is powered by electricity with a range extender fueled by pure hydrogen (Nikolamotor.com, 2016).

2.3.6 Hydrogen projects within the transportation industry

The transportation sector is currently exploring the possibilities of finding greener solutions for their everyday distribution. Asko AS is Norway's largest grocery wholesaler and has a vision of zero- emissions from their goods transportation trucks. In cooperation with Scandinavia's largest independent research organization SINTEF (Sintef.no, 2017), are Asko currently realizing a emission free hydrogen project with hydrogen fueled trucks. The

hydrogen is produced by the energy generated from Asko's own solar panel, and therefore classified as a pure renewable fuel. This makes the part of the value-chain from Asko to the grocery shops nearly emission free (Asko.no, 2016). The project is funded by the organization ENOVA and is an important project for the futuristic goal of zero-emissions on goods transportation on Norwegian roads (Asko.no, 2016). The project has the year of research, one filling station and ten forklifts powered by hydrogen. The short-term goal for the project is to have two distribution vehicles powered by hydrogen before 2018 (Sintef.no, 2016).

2.3.7 Current hydrogen technology within the transportation industry

There are several producers of private small cars that are starting their production of hydrogen fueled cars these days. Toyota and Hyundai are leaders and have already launched their versions, respectively the models Mirai and ix35 (Norskhydrogenforum, 2016). These launchings are positive and encouraging factors towards launching hydrogen trucks within the Norwegian transportation industry, as this is an important factor for developing the hydrogen fuel infrastructure in Norway.

Hydrogen fueled trucks are currently at the final developing step towards launching. Nicola Motor Company is the current leader with complete dedication towards developing an innovative electrical hydrogen truck. It is anticipated that the Nikola One is the revolutionary technology within the transportation industry. The invention is already been called "the Tesla of trucks" (referring to the electrical car success Tesla Model S) (Johnsen, 2016). The Nikola Model one is a complete electrical truck with a range extender driven by hydrogen (Johnsen, 2016). This makes the Nikola one truck fueled entirely by emission free sources. Further the Nikola Model One is compared towards diesel trucks in order to understand the technological differences between the vehicles. The Nikola Model One will further be used as a reference point to current technology in this research.

The hydrogen fuel technology is expected to be a revolution within the transportation industry. Since the first diesel engine was created in 1885 (Jääskeläinen, 2013), there have been several changes, but the fuel has remained nearly the same. The question is therefore if the industry is ready for changing towards something completely new. As this is two completely different fuels the value chain of producing both fuels are additionally completely different. Hydrogen, with the help of renewable energy sources, can be produced and delivered to the consumer with a nearly zero emission value chain. Even though hydrogen

needs another energy source in order to be produced, the process can be purified, with usage of renewables such as hydropower. Diesel on the other hand, is produced from a polluting raw material, and both the processing of creating diesel and the usage of it is polluting to the environment.

The technologies of hydrogen and diesel are therefore compared in order to understand the interfering differences for a consumer when changing towards hydrogen as a fuel. For this research hydrogen technology is compared towards diesel and diesel technology, as diesel is the main fuel currently used in the road transportation industry. Based on Nikolamotor.com (2016) information and visualizations a table of comparison developed.

Table 2-1 Diesel technology vs Hydrogen technology

Features	Diesel	Hydrogen
Horsepower	500 HP	1000 HP
Range	805 – 1126 KM	1287 – 1930 KM
Top speed up hills (6%)	32 – 64 KPH	104 KPH
On descent	Exhaust and Friction brakes	Recharging and Saving brakes
Acceleration 0-60 MPH Under Load	60 seconds	30 seconds
Weight	8,6-10 tons	8,1-9,5 tons

This comparison between the vehicles is determined as viable for this thesis as the current price for a barrel of oil, the year of research, is above $50 (appendix 1).As illustrated in the table the Nikola One truck is anticipated to be a good replacement for diesel trucks, if it holds its given technical promises, where the technology is presumed to be even better than the current diesel technology.

2.4 Summary

Hydrogen is the most common basic element in the universe and is usually found connected to other elements. With current technology hydrogen can be separated in to its own element and be generated in to an environmental friendly fuel. Hydrogen as a fuel is estimated to generate emission reduction matching EU's targeted goals. In addition, it will reduce the overall road transport oil consumption in the world. A new fuel type, such as hydrogen, can

generate economic growth as new engines and vehicles can generate a strengthened position for the car-and energy equipment industry. The climate and environmental aspect is one of the most important reasons for the actualization of hydrogen fuel. Currently, one third of the emissions in Norway originate from the transportation sector. In order to follow the EU' targeted goals the government of Norway has introduced three methods for Norway to comply with the targeted emission goals. These are reduction of the need for transportation, performing a change towards more environmental friendly methods of transportation and introducing new emission reducing technology to the market.

Already in 2003, the government of Norway stated the importance of hydrogen technology development. A group was created in order to understand the possibilities and consequences of performing a fuel shift in the transportation sector in Norway. One of the main suggestions conducted by group was that hydrogen should be exempted from governmental taxes until hydrogen had become a fully-fledged fuel in the market. The government of Norway has several institutions for promotion and research of emission reducing technology and solutions. The twelve year futuristic plan for the governmental transport policies, the Norwegian national transportation plan, involves the environmental aspect and has targeted statements connected to the EU' s targeted goals.

Hydrogen projects are currently introduced in order to develop the technology and understand the effect of using hydrogen fuel. The current technology within the road transportation industry is promising as the hydrogen vehicles has more advanced features than emission reduction, such as higher amount of horsepower, longer fuel range, faster acceleration and higher top speed up hills.

3 Theory

The purpose of this chapter is to create an overview on the relevant literature in order to establish a theoretical framework for the research conducted in this thesis. The main aim for this research is to understand the possibilities of introducing hydrogen as a fuel in the transport industry in Norway. The research therefore aims to analyze the market structure, the market stakeholders and gain a perspective from the consumers.

The theory of supply and demand is included in order to gain understanding of the market structure. This theory creates a visualization of the possibilities for the actors in the market and how expanding and developing the market for hydrogen as a fuel affects the actors. The roles and actions of the other actors in the market are understood through the stakeholder theory.

Furthermore, in order to be able to completely understand and analyze the consumer behavior of the Norwegian transport industry, the theory of planned behavior is included to the thesis as one of the theoretical frameworks. The theory of planned behavior generates the main quantitative research concepts and variables for the data collection.

3.1 The theory of supply and demand

The basic model of supply and demand combines the two concepts of the supply curve and the demand curve together in order to illustrate the market situation. This theory is the ground basis for understanding microeconomics in today's business environment. Every commercial consumer good has a demand side and supply side in a market. Based on this the interaction between the two concepts the theory of supply and demand is constructed. The theory of supply and demand is a graphical illustration of the two combined concepts, where the vertical axis measures the price per unit of the good and the horizontal axis measures the quantity of the good per unit of time (Mansfield and Yohe, 2000). The theoretical framework of this thesis determines that the future hydrogen market will be a market of perfect competition, whereas the law of indifference is applicable, with only one price in the overall market perspective (Ringstad, 2003).

3.1.1 The supply curve

The supply curve is illustrated as the relationship between the quantity of a good that producers are willing to sell to a costumer and the stated price of the good (Pindyck and Rubinfeld, 2013). A shift in the price factor would intentionally manufacture a shift in the quantity that the producers are willing to sell. The higher the price of the good, the higher willingness the producers get to expand their production. Market supply curves tend to slope upwards and to the right (Mansfield and Yohe, 2000), since producers tend to increase their production as the market price of the product increases. The following figure illustrates the market supply curve (Pindyck and Rubinfeld, 2013).

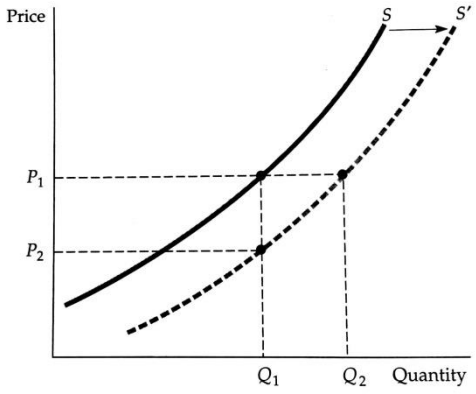


Figure 3-1 The supply curve

The position and shape of the market supply curve generally depend on the technology available, input prices, and the time interval of which the market supply curve pertains (Mansfield and Yohe, 2000). In the supply curve, a shift towards right will cause the market equilibrium price to fall, whereas a shift to the left will cause the price to rise (Mansfield and Yohe, 2000).

3.1.2 The demand curve

The demand curve is the relation developed between the quantity of a good that consumers are willing to buy and the actual price of the good (Pindyck and Rubinfeld, 2013). A shift in the price would intentionally create a shift in the quantity that the consumers are willing to buy. The lower the price of the good the higher willingness the consumers have in buying

larger quantities of the given product. The demand curve therefore slopes downward (from left to right), since the demand will increase as the price fall (Mansfield and Yohe, 2000). The position and shape of the market demand curve for a good usually depend on the consumers taste, the consumer's level of income, the price on other substitutable goods and the time period the graph illustrates (Mansfield and Yohe, 2000). The following figure illustrates a market demand curve (Pindyck and Rubinfeld, 2013).

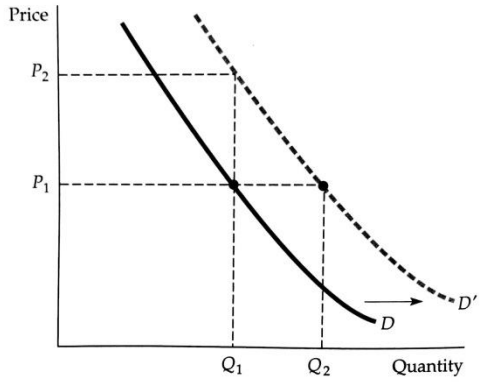


Figure 3-2 The demand curve

The price and quantity doesn't always control how the market will react. The public emphasis can create a shift in the demand curve, controlling the volume demanded. If the public take pride in reducing energy, such as the Norwegian parliament is trying to affect the Norwegian transport sector, the demand curve may shift to the left (Mansfield and Yohe, 2000). In general, a shift towards left in the demand curve will lead the equilibrium price to fall, whereas a shift to the right will make the equilibrium price to rise (Mansfield and Yohe, 2000).

3.1.3 The market mechanism

A market is defined as a gathering of suppliers and demanders that through their actual or potential interactions in the market, determines a price for a specific product (Pindyck and Rubinfeld, 2013).

Including the supply and demand curve into one model creates the equilibrium or market-clearing, where the supply and demand curves cross paths. At this point the price determined in the market equates the quantity supplied to the quantity demanded. This point indicates that

there is neither excess demand nor excess supply in the current market. This situation doesn't create any pressure in the market, neither on price nor quantity. The market mechanism tendency is that the market will always clear and create the equilibrium between the supplier and the demander (Pindyck and Rubinfeld, 2013).

In the short run of a market mechanism the equilibrium between the supplier and the demander is reached when the quantum that the producers are willing to supply equals the quantum the consumers demand at a specific price. The competitive equilibrium changes if either of the supply or the demand curve presents a shift (Carlton and Perloff, 2005). A producer will, according to this theory's tendency, always try to enhance it production towards a surplus, where the quantity supplied exceed the quantity demanded from the consumers. The producers will at a point start lowering the prices in order to prevent the quantity of surplus from growing. As the price is lowered the demand from consumers will increase, and a new equilibrium will eventually occur. This is stated as the effect of the market mechanism (Pindyck and Rubinfeld, 2013).

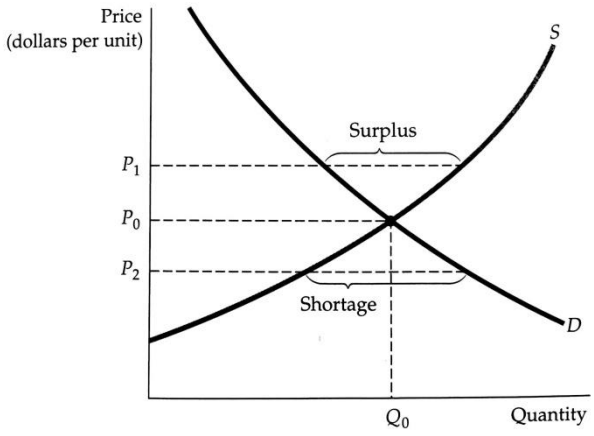


Figure 3-3 The market mechanism

Market displacements can develop in to critical situations for both the supplier and the demander in the market. The government has a substantial role in the market as it has the ability to control the market mechanism towards a healthy market structure (Ringstad, 2002).

3.1.4 Market surplus

Market surplus is a situation that occur in the specific market when the quantity supplied by the producers exceeds the quantity demanded by the consumers (Pindyck and Rubinfeld, 2013), generating an disequilibrium (Ringstad, 2002). At this point there are more products on

the market than the demanders are willing to consume. For markets with products that has low lifespan this point is critical for the market. In a market surplus the governmental role is of substantial impact as the government have the ability to smooth out the potential market surplus ripple effects such as high storage costs for the suppliers in the market (Ringstad, 2002).

3.1.5 Market shortage

When a market shortage occurs the quantity demanded by consumers has exceeded the quantity supplied to the market (Pindyck and Rubinfeld, 2013). At this point the producers are not able to fulfill the demand from the consumers. This is a critical point for the producers as the consumers can start to explore for substituting products. At a market shortage stage the consumers' marginal willingness to pay is usually higher than the actual payment level. An offset generating a market shortage can be a critical situation if it the demand exceeds the supply over time. A market shortage usually generates a price increase in the market in order to reduce the demand surplus (Ringstad, 2002).

3.2 Consumer behavior

Perner (2010) defines consumer behavior as a study of individual, groups or organizations and the pursuing process they use to select, secure, use and dispose their selected products.

One of the focuses in this thesis is the Norwegian transport industry's willingness to replace their current vehicles and perform a shift towards the renewable fuel hydrogen. Based on this, it is of substantial importance to explore the behavior of consumers, which in this case are the companies in the transport industry. Consumer behavior can be described from the three steps of: firstly defining the consumer preferences, secondly limiting the budget constraints and together this gives the groundings for defining the consumer choices (Pindyck and Rubinfeld, 2013). These steps and their underlying assumptions are described in the next subchapter.

Rational choice theory starts with the basic assumptions that consumers enter the market with already well-defined preferences towards a product. Taken into count that prices are given in the market, the consumer's task is to allocate their incomes in order to best serve their own preferences (Frank, 2010).

3.2.1 Consumer preferences

The theory of consumer behavior determines three basic assumptions for why a consumer prefers one group of products/ bundle instead of another. These assumptions are completeness, transitivity and non-satiation.

A consumer's preference is assumed to be complete. This indicates that the consumer has the ability to compare and rank the different types of product groups/bundles towards one another (Pindyck and Rubinfeld, 2013). This assumption is taken into account in order to limit the research analysis. If the completeness is taken literally, it would never been satisfied due to too many existing goods in the world (Frank, 2010).

For this research it is presumed that all consumer preferences are transitive. Valuing one product before another, would create the vision that the preferred product ranks highest of all product value rankings (Pindyck and Rubinfeld, 2013). If a higher valued product doesn't exceed a higher ranking towards another product, it is not transitive but contradictory and mutually inconsistent (Mansfield and Yohe, 2000). Transitivity is a simple consistency property and should apply as well to the "equally attractive as" and to any combination of it and the "preferred to" relation (Frank, 2010).

A non-satiation assumption determines that a consumer will prefer more of a good, than less of a good (Mansfield and Yohe, 2000), leading to the assumption that consumers are never completely satisfied and will always seek to get things better (Pindyck and Rubinfeld, 2013).

3.2.2 Budget constraints

A consumers budgets constrains are specific constrains that the consumer face as a result of a limited budget (Pindyck and Rubinfeld, 2013). It is assumable that a consumer will try to maximize its own utility by considering the prices of various commodities towards their current income (Mansfield and Yohe, 2000). In addition, a consumer's budget constraints can be determined as the set of all product bundles that exactly exhaust the consumer's income at given prices. This effect generates from a change in a consumers income is simultaneous to the effect of an equal proportional change in all prices (Frank, 2010).

3.2.3 Consumer choice

A consumer's choice is generated on the basis of the consumer preferences and budget constraints. Together these create the limitation that the consumers' choice will be the

maximal satisfaction possible, given the limited budget available. The criteria for a consumers' choice is to find the good that maximizes the consumer satisfaction. The consumers choice is the product group located on the budget line and give the highest preferred combination of both goods and services for the consumer (Pindyck and Rubinfeld, 2013).

Combining the consumers preferences, which shows the consumers ranking of goods after preferences and the budget constrain, which illustrates which goods are affordable, the consumers should be able to choose the most preferred or the best affordable good (Frank, 2010). This indicates that with the given steps of the rational choice, a consumer should be able to choose the good that is most suitable for his preferences and income.

3.2.4 Consumers' willingness to pay

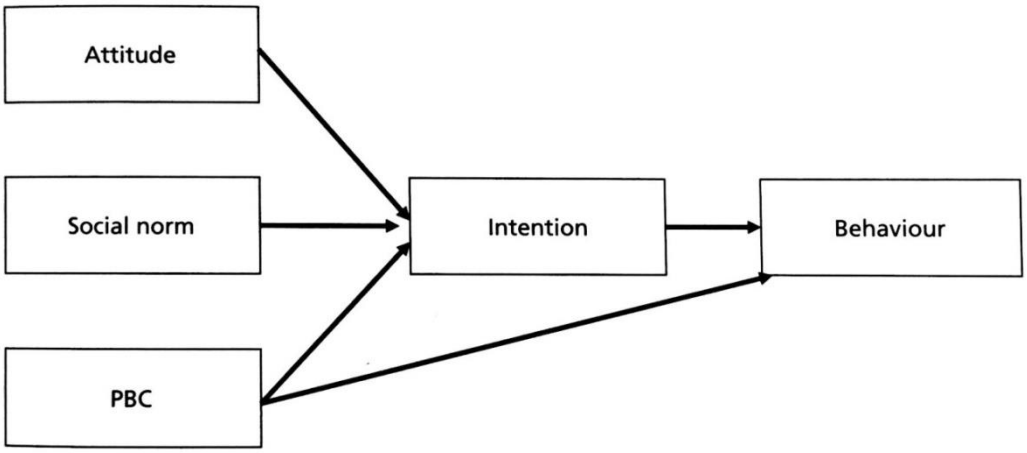
A consumers' willingness to pay is the amount of money a consumer is compliant and comfortable to pay for a given number of units of consumer goods, based on the utility these units of goods can give to the consumer (Ringstad, 2003).

3.3 The theory of consumers planned behavior

The theory of planned behavior (TPB) assumes that consumers make reasoned choices, and that behavior results form an intention to engage in the relevant behavior (Wee et al., 2013). The TPB implies that a consumers' actual behavior is directly influenced by the individual behavioral intention. The consumers' behavior is given by the consumer's intention, which is driven by the factors of attitude, social norm and perceived behavior control (Yoon, 2011).

The TPB assumes that factors such as demographics and general values affect a consumer's behavior indirectly through the different factors of attitude, social norms and perceived behavior control. The extent to which the factors of attitudes, social norm and PBC influence the intention and behavior diverges across different types of behaviors (Wee et al., 2013). The TPB model illustrates that the factors of attitude, social norm and perceived behavioral control are direct determinants of behavioral intentions (Taylor and Todd, 1995). Behavior is then directly affected by behavioral intentions or PBC, or indirectly by the other underlying factors. The following model illustrates the relationship between the concepts (Wee et al., 2013).

Figure 3-4 Theory of planned behavior



3.3.1 Behavior

Behavior within marketing is defined as a specific action directed at specific targeted objects. An action of a specific behavior occurs in situational contexts or in environments at a particular given time (Peter and Olson, 2008).

The theory of planned behavior asserts that behavior (B) is connected as a direct function of behavioral intention (BI) and/ or perceived behavioral control (PBC). The behavioral intention (BI) is created and formed by an individuals' attitude (A), Social Norm (SN) and perceived behavioral control (PBC) (Taylor and Todd, 1995). This indicates that the factor of perceived behavioral control (PBC) can affect behavior (B) directly or indirectly through behavioral intentions (BI) (Ajzen, 2005). The result of behavior is therefore a weighted function of intention and perceived behavioral control. Included in this function is behavioral intention, which is a weighted sum of the components of attitude, social norm and perceived behavioral control (Taylor and Todd, 1995). This can be illustrated through the given function of $\mathbf{B} = \boldsymbol{w_1 BI + w_2 PBC}$

3.3.2 Intention

Intention is a function of the three basic determinants mentioned below. Attitude reflecting the personal nature, social norm reflecting on the social influence affecting the behavior and issues of control through the perceived behavior control (Ajzen, 2005). A behavioral intention can be described as a consumers "plan" to engage in a specified behavior in order to reach a wanted goal (Peter and Olson, 2008). Intention can be described only by two of the

determinants, or all three. For some intentions attitudinal considerations can be of more importance than normative considerations, all depending on the specific situation (Ajzen, 2005).

A consumer intention has the possibility to change over time, like other cognitive factors. The longer the intervening time period is, more uncertainties can be created and unanticipated circumstances can occur (Peter and Olson, 2008). Each of the factors of behavioral intention are determined by underlying belief structures. These belief structures are attitudinal beliefs (bi), normative beliefs (nbj) and control beliefs (cbk) (Ajzen, 2005). This generates the formula: $\boldsymbol{BI = w_3A + w_4SN + w_5PBC}$

3.3.3 Attitude

Attitude is one of the most important concepts that researchers, specially marketers, use to understand consumers and their behavior (Peter and Olson, 2008). The attitude factor reflects on how positively or negatively people evaluate a particular action (Wee et al., 2013), or more precisely an individuals' overall evaluation of a specific concept (Peter and Olson, 2008).

The concept of a consumers' attitude is composed by (1) the cognitive component, the consumer's beliefs about an specific object, (2) the affective component, determining the consumers' feelings or emotional reactions towards an object and (3) the behavioral component, the consumers' have a tendency to respond in a certain manner towards an specific object or activity. Together these three components are consistent with each other, meaning that change in one of the attitude component tends to create related changes in the other components (Hawkins et al., 2004).

An attitude towards an action depends on the importance of the consumers' perspective on a specific behavior. If the consumer believe that the attitude can lead to a particular outcome and how important these outcomes are for the consumer (Wee et al., 2013). If the consumer believes that the outcome of a particular action will create good things for him, the attitude will typically be positive.

The attitude factor illustrates an individual's disposition to respond favorably or unfavorably towards a specific object, person, institution or event (Ajzen, 2005). A consumers' affective system automatically creates affective responses towards these. Affective responses can be emotions, feelings, moods, evaluations and attitudes. These responses are immediate and direct responses to a certain stimuli, and are generated without conscious, cognitive

processing of information about the specific product (Peter and Olson, 2008). This indicates that not only cognitive processing, opinions and external influencers can create the attitude, but in addition the affective system can affect the consumers' attitude.

The strength and evaluations of a consumer' salient beliefs about the functional consequences are combined to form an attitude towards the behavior. This attitude reflect the consumer's overall evaluation of performing a certain behavior (Peter and Olson, 2008). The attitude towards a specific behavior is therefore importantly linked towards the observed and final behavior. Attitude can be perceived as a hypothetical construct that must be inferred from measurable responses, in order to collect reasonable data. The measurement of attitude is usually given as a scale in order to illustrate the positive or negative evaluations from the respondents (Ajzen, 2005).

The component attitude (A) is equated with the underlying belief structure of attitudinal beliefs (b_i) (Ajzen, 2005), illustrating that the sum of performing a behavior will lead to an outcome, weighted by the evaluation of the desirability and connection towards that outcome (e_i) (Taylor and Todd, 1995), giving the function for attitude as $\boldsymbol{A = \sum b_i e_i}$

The attitude towards the specific behavior is determined by the individuals evaluation of the outcomes associated with the behavior and by the strength of these assumptions and associations. The attitude connected to the behavior is determined by accessible beliefs about the consequences of the specific behavior, and the attributes of cost connected to the behavior (Ajzen, 2005).

3.3.4 Social norm

The component of social norm reflects on the consumers' perceptions of how the consumer believe that other individuals want them to behave (Peter and Olson, 2008). The social norm therefore reflect the extent to which the consumer believe and expect that the consumer's "important others" approve or disapprove the particular behavior, and the motivation to comply with these expectations (Wee et al., 2013).

Some particular behaviors are primarily more affected by the factor of social norm than others (Peter and Olson, 2008). This is usually combined with particular situations where the society expects a certain behavior. Generally, a certain perspective on another individuals opinion is affecting to an individual's performing choices (Ajzen, 2005). The factor of social norm is

formulated as the individuals normative belief (nb_j) from a specific individual (Ajzen, 2005), explained as a referent, weighted by the motivation to comply with that referent (mc_j) (Taylor and Todd, 1995), generating the formula: $\boldsymbol{SN = \sum nb_j\, mc_j}$

3.3.5 Perceived behavior control

The perceived behavior control (PBC) reflects the extent to which the consumer thinks he/she is capable of engaging in the relevant behavior. Perceived behavior control as a factor, have the power to influence a specific behavior directly, or indirectly through intentions (Wee et al., 2013).

The theory of planned behavior model is an extension of the theory of reasoned action. The factor separating the models is the construct of perceived behavior control. It is presumed that the factor of perceived behavior control generates a better prediction to illustrate that not all behaviors are completely under the individuals own control (Schiffman et al., 2012), and therefore is a better model to visualize the behavior in the hydrogen market.

The factor of perceived behavioral control is a reflection of an individual' belief regarded the access to the required resources and opportunities to perform a certain behavior. In addition, it can be the reflected as the internal and/ or external factors that can impede the performance of a specific behavior (Taylor and Todd, 1995). Perceived behavioral control can be affected by previous experience of a behavior and influencing second hand information about the specific behavior (Ajzen, 2005). The factor of perceived behavioral control therefore encompasses the following components of facilitating conditions and self-efficacy. Perceived behavioral control is formulated as the sum of the control beliefs (cb_k) weighted by the perceived facilitation (pf_k) of the control belief, in either of the inhibiting or facilitating the behavior (Taylor and Todd, 1995), generating the formula: $\boldsymbol{PBC = \sum cb_k pf_k}$

3.3.6 Factors influencing intention and behavior

As mentioned above, there are factors that can influence in order to either reduce or weaken the relationship between what are measured behavioral intentions and what is later observed as the actual behavior (Peter and Olson, 2008). This indicates that the opinions and perceived behavior illustrated in this thesis can be different from the reality when hydrogen is launched as an adequate compensation to diesel motors. These influencing factors can be intervening time, different levels of specificity, unforeseen environmental event, unforeseen situational

context, degree of voluntary control, stability of intentions and new information (Peter and Olson, 2008).

The factor of intervening time occurs when the time between the measurement of intention and observation of behavior increases. This can lead to other interfering factors such as modification and/or change of the original intention, generating a misleading correlation towards the observed behavior (Peter and Olson, 2008). A change in the surrounding environment can additionally generate a change from the current intention to the observed behavior (Peter and Olson, 2008). Relating to this thesis, such unforeseen environmental event could be if the government chose to focus on another environmental fuel, and the consumers would therefore follow that path. The governmental role is presumed to be of a major importance of affecting the hydrogen market situation. There are possibilities for an unforeseen situational context, where the consumer had another situational context in mind when the intention was measured contra when the behavior is observed (Peter and Olson, 2008). The unforeseen situational context can be close related to the factor of intervening time. Not all behaviors are under complete volitional control, and therefore can complicate the intended behavior (Peter and Olson, 2008). Related to this thesis, this could be a situation where a company intends to buy a hydrogen truck when the oldest truck is discarded. If this occur before a hydrogen truck can be supplied, the intended behavior choice of a hydrogen truck can be obstructed.

Strong intentions are usually quite stable and grounded in the well-developed structure of salient believes for attitude and social norms. Other intentions are only founded on weakly held believes that are easily changeable by other influencing factors. The stability of the intention is therefore a factor that can influence the observed behavior (Peter and Olson, 2008). During a period of evaluation towards a behavior, consumers may realize or be informed about the salient consequences of their intended behavior. This can affect the consumer's beliefs and attitudes toward the potential act or in the social norm of the behavior. Such changes can regenerate the intention towards other behaviors. At that point the original intention is no longer relevant towards the behavior, and doesn't create an accurate prediction to the eventual behavior (Peter and Olson, 2008).

3.4 Stakeholder theory

In order to completely map the potential market for hydrogen fuel, the stakeholders of such a market should be identified. In this theoretical framework all the potential actors of a market is mentioned in order to understand the overall actors in a fully-fledged market. The focus for this thesis is related to the actors that are seen as clearly relevant for mapping the potential market for hydrogen. These are currently perceived as customers, suppliers, the government, political parties and activist groups. These groups are presumed to have a clear opinion and to be majorly affected when introducing a hydrogen market.

A stakeholder is defined as any individual or group of individuals who can affect or is affected by the achievement (Wiig and Brønn, 2002), decision, policy or operation of an organization or projects purpose (Hartman et al., 2014). Further described as an individual or group which the project or organization is directly or indirectly dependent on, likewise depend directly or indirectly on the organization or project (Kjær Hansen et al., 2006).

The primary responsibility of an organization is to encourage as much possible value creation for the stakeholders as attainable (Hartman et al., 2014). The important factor of value creation for a stakeholder is generated in various forms. Stakeholders are not only legally binding parties, but can likewise be other actors holding laws and regulations forced by the society and claiming certain rights (Crane and Matten, 2010). A stakeholders perspective can therefore differ from the project or organization and can support and create more reasonable, accountable and responsible decisions (Hartman et al., 2014).

In order to manage the relationships with the potential stakeholders it is important for the specific project or organization to identify and understand the three levels of stakeholder management. The first level for the organization is to understand from a rational perspective who the stakeholders are and what the perceived stakes are for the stakeholder. Secondly, the organization must understand the circumstances if either the organization processes used to implicitly or explicitly manage its stakeholder relationships, and whether or not this is matched towards the stakeholder map. Finally, the last level is to understand the transactions and bargains and whether or not these fit the stakeholder map (Wiig and Brønn, 2002).

At the rational level of stakeholder theory it is important to identify and create a representation of potential stakeholders for the market. A generic stakeholder map contains partners such a customers, suppliers, employees, owners, environmentalists, consumer advocates, media, government and global competitors (Wiig and Brønn, 2002). Based on Wiig and Brønn (2002) theory for the rational level of stakeholder theory the following generic stakeholder map can be visualized.

Figure 3-5 The generic stakeholder map

A stakeholder chart can further be generated in order to accompany the generic stakeholder map. This is conducted in order to map the specific stakeholders for the project or organization. This chart illustrates more in-depth which actors that can possibly be perceived as a stakeholder (Wiig and Brønn, 2002).

Owners	Financial Community	Activist Groups
Shareowners Bondowners Employees	Analyst Investment banks Commercial banks National banks	Safety and Health groups Environmental groups "Big business" groups Single issue groups
Suppliers	Government	Political Groups
Different firms	Parliament Courts Departments	Political parties County municipality Municipality
Customers	Customer Advocate Groups	Unions
Different segments	Consumers Union Council of Consumers	Workers union Political action committees of unions
Employees	Trade Associations	Competitors
Different segments	Business roundtable Customer Trade org	Domestic competitors Foreign competitors

Figure 3-6 Specific stakeholders

In order to understand the project or organization and how they manage stakeholder relationships it is important to contemplate the standard operating procedures and how these accommodate with the surrounding environment. This usually involve taking complex stakeholder relationships and enrich them with the stakeholder concept, preferably through processes such as portfolio analysis, strategic review process and environmental scanning processes (Wiig and Brønn, 2002).

The transaction level of a stakeholder relations illustrate the number of and especially the quality of the transaction between the organization and the stakeholders (Wiig and Brønn, 2002). The transaction among the organization and the different stakeholders can be of a variety of communication structure. Communication and transaction between governmental institutions is ordinarily of another variant than with potential competitors.

A stakeholder analysis is conducted in order to map all the influencing or influenced parts of a project. The analysis generates an understanding on how to keep the coalition of stakeholders together, likewise provide a basis for objectives (Andersen et al., 2009).

The stakeholder analysis combined with the three levels of stakeholder relationships generates the basis for the pursuing stakeholder interest map. This map is based on van Bree et al. (2010) model on actors in the socio-technical regime of car-based transportation. Their model is based on the link between technology and society through a multi-level perspective.

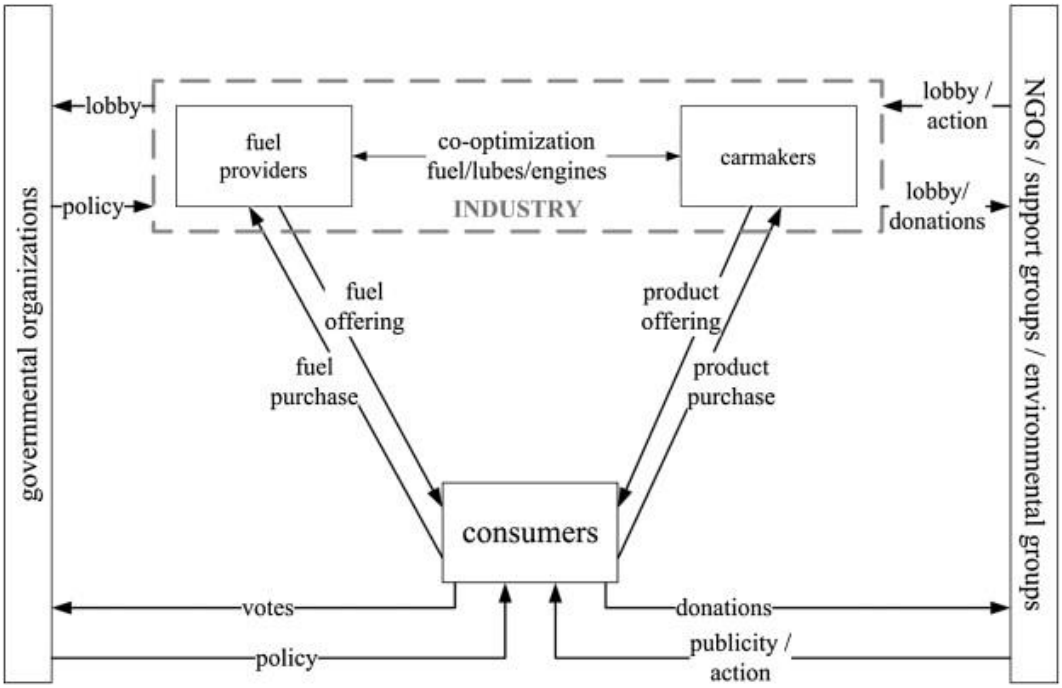


Figure 3-7 Actors in a socio-technical regime

This model is integrated in order to illustrate the relationships and connections between the different actors in a hydrogen market. The arrows symbolize the direction of the information and transaction flow. The relationship is further explained in the stakeholder analysis in section 5.4.8.

3.6 Summary

The theories presented in this thesis are included in order to create a theoretical framework for the research. The theoretical foundations main aim is to build a perspective on the possibilities and current opinions towards a market for hydrogen fuel in Norway.

The microeconomic theory of supply and demand illustrates how a market is dynamically built. As the demander side is the most important for this research, the consumer behavior creates the focus for the further implications of the thesis.

The rational choice theory is based on three steps in order for the consumer to be able to choose the good that is most suitable for his preferences and income. Firstly the consumer defines its own preferences towards its needs. Secondly, the budget constrain is defined in order to understand the purchasing power the consumer have. Based on these two requirements the consumer choice is developed. To illustrate the consumers preferable choice a consumer's preference is mapped and together with a budget constrains the combination illustrates the most preferred and the best affordable good for the consumer.

In order to describe the consumers' intention towards hydrogen the theory of planned behavior is presented. The theory of planned behavior illustrates that intention is built upon three different factors of attitude, social norms and perceived behavioral control. Two of these or all three at the same time can create a basis for an intention, leading to a specific behavior. Attitude is an individuals' overall evaluation of a specific concept, social norm is the consumers' perceptions of what the consumer believe that other individuals want them to do and perceived behavioral control is the extent to which the consumer's think he/she is capable of engaging in the relevant behavior. The intention and observed behavior can be affected by several different factors, where time is the main affecting factor.

Since the consumer is not alone in a market situation the stakeholder theory is included to understand who and how others are affected by the hydrogen market. The stakeholder theory addresses potential actors in a market, and how these can affect or is affected by the market situation.

4 Methodology

The framework for the conducted research of this thesis is presented in this chapter. The first part of the chapter describes the philosophical approach and the choice of research strategy and design. Further on, the decision behind choice of method and data collection is described. At the end of the chapter, ethical issues, validity and reliability is described and discussed. The main aim for this chapter is to illustrate how and why the data for this thesis has been collected and conducted in this methodological manner.

4.1 Philosophical position

Easterby-Smith et al. (2012: 18) describes the concept of ontology as the basic philosophical assumptions which determine the nature of the perceived reality of the world. My ontological perspective as a researcher is perceived to be closely related to relativism, where there are perceived to be many "truths" and that facts only depend on the viewpoint of the observer (Easterby-Smith et al., 2012). The perspective of this research tend to be dragging towards internal realism as well, where the truth is perceived to exist but is obscure, and that facts are concrete, but cannot be accessed directly (Easterby-Smith et al., 2012). Combining these ontologies gives a pragmatic orientation of the paper. The main idea with pragmatism is that any meaning structures have to be created from individuals lived experiences. The pragmatic orientation doesn't accept that there are pre-determined theories or frameworks that shape knowledge or truth, likewise that individuals can't create their own truth without basing it on something (Easterby-Smith et al., 2012).

Epistemology is determined as views and general sets of assumptions on the most appropriate ways of inquiring in to the nature of the world. Epistemology can be divided into several perspectives on a scale from strong positivism to strong constructionist (Easterby-Smith et al., 2012). The pragmatic orientation of the thesis leads to a social constructionism approach towards data collection and analysis for the thesis. Social constructionism is a concept where the "reality" is determined by individuals rather than by objective and external factors. Social constructionism focuses on appreciating the way individuals make sense of their experiences (Easterby-Smith et al., 2012). When using social constructionism as an epistemology the main driver of the science is the individuals' interest. The aim, outcome and explanations from the social constructionism research is to increase the general understanding of a certain situation (Easterby-Smith et al., 2012). For this thesis it is important to understand how the consumer behaves towards using hydrogen, and this research leads to a general understanding of how

parts of the Norwegian transport industry view the situation on changing towards a zero emission product.

Linking the ontology with the epistemology can give implications for the methodical approach for the research. Using relativism ontology in a pragmatic perspective combined with social constructionism gives methodological implications that the aim for the research should be convergence, and that questions should be the starting point of the research. The particular research should be designed as cases or surveys. With the usage of word and numbers as data the analysis and interpretations can be done with triangulation and comparison. The outcome from such a research should be theory generation (Easterby-Smith et al., 2012).

4.2 Research strategy and design

In order to conduct research on the consumer behavior towards a fuel shift the research design should be a mixed method approach based on pragmatism and social constructionism. A mixed method approach focuses on combining qualitative and quantitative methods in order to collect data through the pragmatism ontology and evaluate the data through a social constructionism point of view (Easterby-Smith et al., 2012).

The research design for this thesis uses a dominance of methods, where the quantitative design is predominant for the qualitative design. The predominant design is used in order to build the thesis on the quantitative part, and further use a qualitative data collection through an unstructured interview to corroborate the answers from the quantitative data. This method is by some authors determined as method triangulation, where the qualitative data elaborates and complements the quantitative data (Jacobsen, 2015).

A mixed method approach can increase the confidence and credibility of the results, leading to an increased validity of the results (Easterby-Smith et al., 2012). This is the main reason for using both a quantitative and a qualitative approach in this thesis. The unstructured interview is grounded on results based on a valid, representative group of the population. The strategy for this research process is illustrated in this figure.

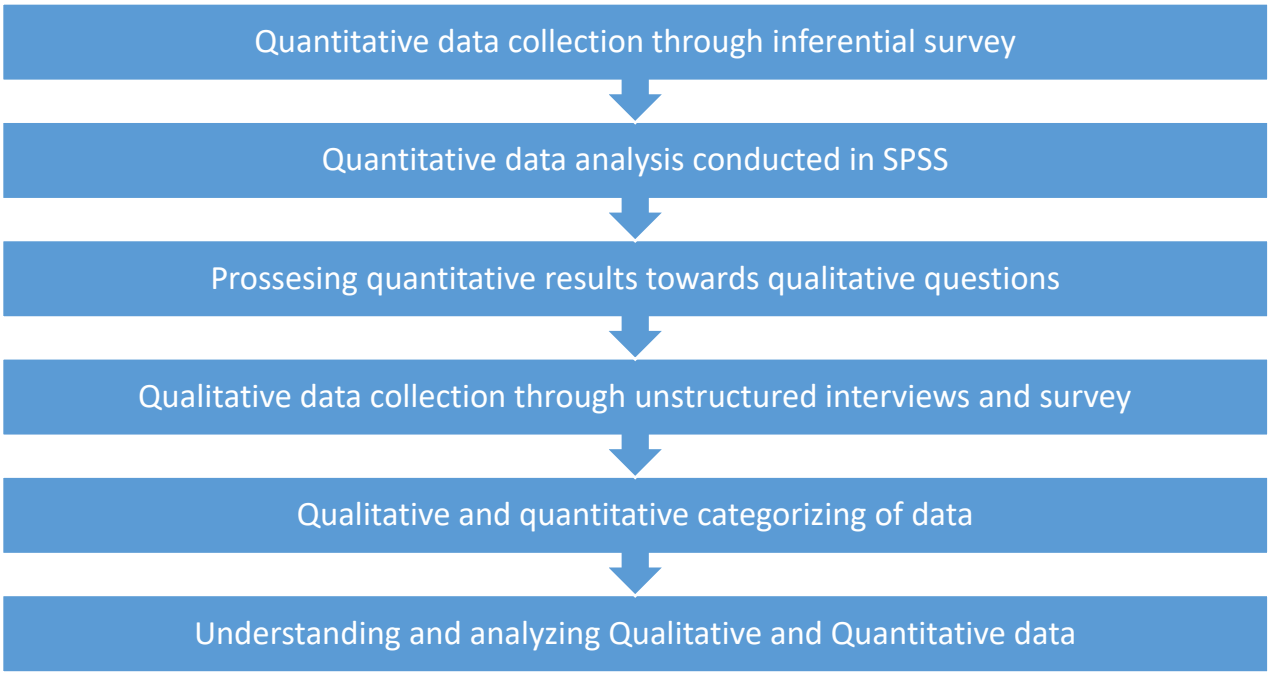


Figure 4-1 Research strategy

4.3 The relationship between the theoretical and empirical framework

When mixing methods, the relationship between the theoretical framework and the empirical framework for the thesis should be enlightened.

The pragmatic approach chosen for this research includes a requisition that the research should be conducted towards either an deductive or inductive approach, depending on the most suitable for the concrete problem statement (Jacobsen, 2005). As the methods of qualitative and quantitative are combined, it is unreasonable to commit to one of the extremities. The combination, focused on the pragmatic approach is called abduction. Initially the abduction approach is grounded on the thought that all scientific, theoretical thinking is introduced by previously empirical observations, evaluating theory. An abductive approach is a combination of deduction and induction. A pragmatic, abductive approach to research attends to explore for the probable descriptions and expectations (Jacobsen, 2015).

For this thesis, the first dominating quantitative part of the data collection led towards a more deductive approach of the research and data collection. A deductive approach is a strategy when the researcher conducts the research based on going from a theoretical perspective towards the empirical findings (Jacobsen, 2005). Conducting a deductive research intentionally means to derive a result from going from the general aspect towards a concrete

aspect (Johannessen et al., 2011). This indicates that the researcher uses the basis of what is already known about a specific field and by the use of theoretical considerations in relation to that domain, creates hypotheses, that later must be subjected to empirical examination (Bryman and Bell, 2007). The process of conducting a deductive research is illustrated in the given model, based on Jacobsen (2015) process of deduction.

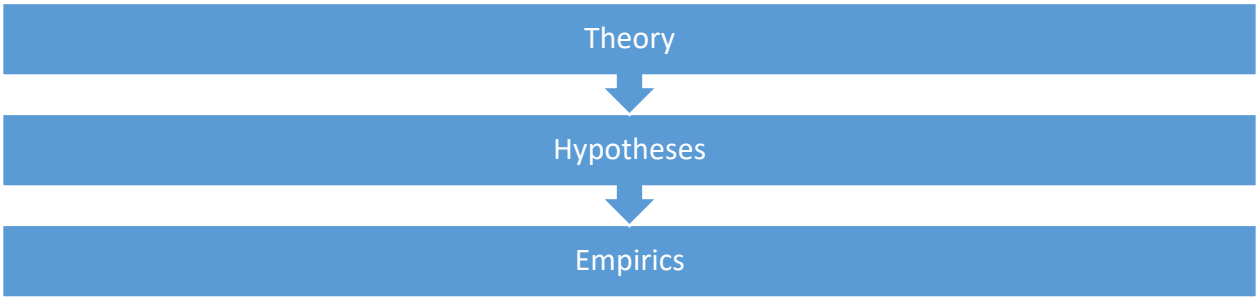


Figure 4-2 The process of deduction

After a deductive approach to the quantitative research, a more induction approach was used as the empirical findings led to new questions for the qualitative part. An inductive approach aims to conduct the research by going from an empirical (reality) observation towards theory. This, on one hand, indicates that all theory should be founded in the current reality (Jacobsen, 2015). Described with other words, the process of induction is when generalizable inferences is drawn out from observations (Bryman and Bell, 2007). Induction was therefore used for the qualitative data in order to underpin the quantitative data. The questions used for the qualitative unstructured interview is grounded in the empirical findings of the quantitative survey, giving the qualitative part of the research an inductive approach. This inductive process is illustrated as follows (Jacobsen, 2015).

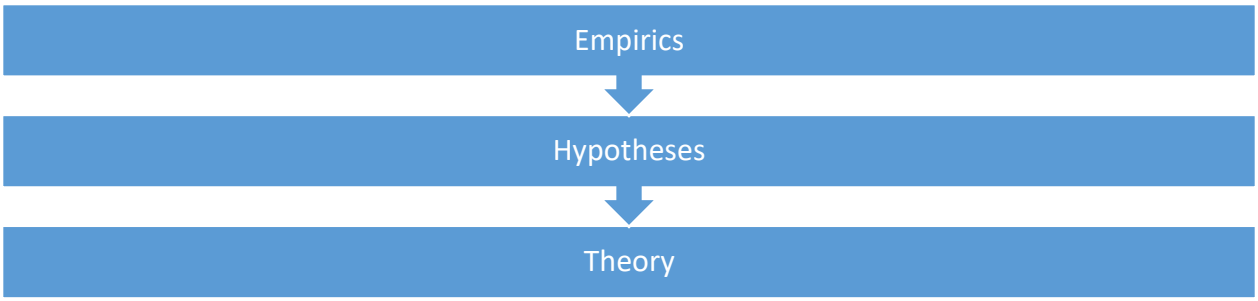


Figure 4-3 The process of induction

Combining deduction and induction gives the abductive approach. In addition, a pragmatic approach to the research determines the usage of abduction (Jacobsen, 2015), when

combining the theoretical and empirical framework of the thesis. The method of abduction generates a continuously problem solving process and is further illustrated (Jacobsen, 2015).

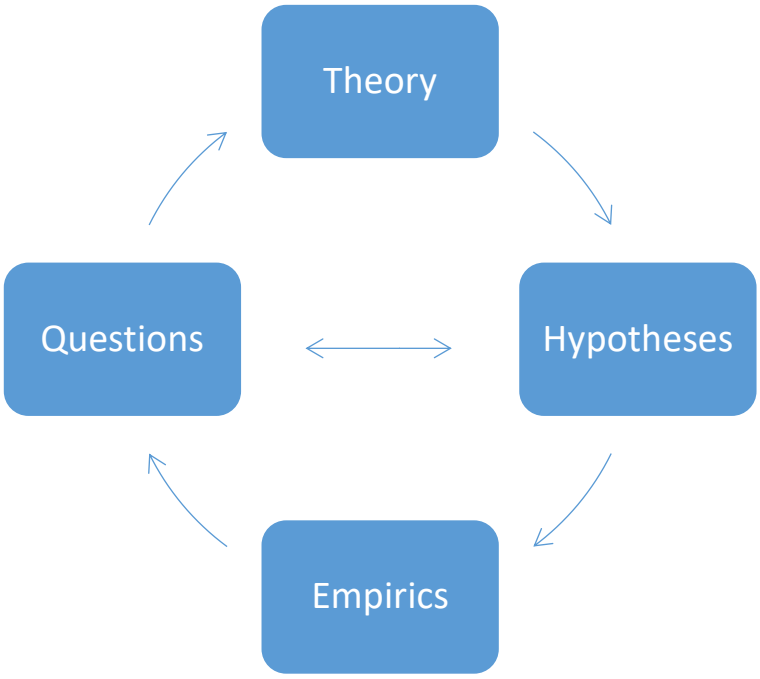


Figure 4-4 The process of abduction

The process of abduction illustrates going from a theoretical framework, such as the theory of planned behavior and the rational choice theory, towards hypotheses about the consumers opinions and behaviors, where the empirical findings from the survey led to new research questions in the qualitative interview, generating a stronger perspective on the values of attitude, social norm and PBC.

4.4 Data collection

Pragmatism as a research perspective acknowledges that a given viewpoint for research requires a pre-experienced situation from an individual. The philosophy originates between the philosophical viewpoint of internal realism and relativism, creating the research data as both words and numbers (Easterby-Smith et al., 2012). Numbers as a value was collected by Likert scales through the respondents' opinions in the conducted quantitative inferential survey. Words were collected through the informants' personal viewpoints and opinions towards hydrogen.

The primary data for this thesis is collected through an inferential survey and interviews. The secondary data is collected through news- and research articles and other confirming sources.

As these methods are so specifically different, they are described in separate subchapters. The data collection for both methods was conducted in the month of March, the year of research.

4.4.1 Sampling design

A sample is the segment of the population that is selected in order to conduct research (Bryman and Bell, 2007). This quantitative research sample aims to make an inference about the stated population of the potential consumers of hydrogen in the Norwegian road transportation industry (Jacobsen, 2015). The research is therefore conducted by testing an existing theory, the theory of planned behavior, towards the potential market consumers. To conduct a viable sample for such theory testing involves using the right individuals for the theory tested, and not trying to replicate a sample for the whole population (Calder et al., 1981).

Quantitative research designs distinguish between probability and non-probability sampling, where the general credibility is reasonably higher for probability sampling (Easterby-Smith et al., 2012). For this research the sample contained potential customers for the hydrogen fuel market. The purposive sample was therefore the most suitable for this research. Purposive sample is a type of non-probability sampling method, where the sampling process involves selecting sample units on the basis on how actual they are for the research. The researcher usually have an idea of what sample units that are needed for the research, and tries to find the right sampling candidates (Bryman and Bell, 2007). The sample for the research was drawn and conducted by introducing the research survey on a conference special for owners and/ or management staff from transportation companies in Norway. This secured that there were only beneficial respondents to the survey.

The generalizability of the research conducted is torn. On one hand the multiple regression analysis conducted in this research have only the minimum amount of participants required in order to generalize the research. 15 participants per independent variable are substantial for a reliable importance (Pallant, 2013). As this research has three independent variables the minimal number of respondents is determined to be 45. This research have 46 respondents to the survey, it is estimated that only the minimum requirements for generalizability is approved. Furthermore the group of respondents is only a small amount of road transportation companies in Norway.

A total of 105 participants attended to the conference, where the data collection was conducted. Almost all companies had two participants attending, making the possible amount of companies participating in the survey at 52 respondents. The total numbers of respondents for the survey was 46 respondents, giving a response rate to 88,5 percent.

The respondents' size of firms ranged between below 20 employees till over 200 employees, giving a broad perspective on the opinions of small, medium sized and big companies. The number of trucks the companies where disposes of, ranged from only 1 till approximately 120 trucks. The sample consisted of companies with residence all over Norway. 17 of the 19 counties of Norway were represented, where the small majority came from the county Sør Trøndelag.

Summating the numbers of trucks the respondents disposes are at a total of 1299 trucks. Statistics from Statens Vegvesen, the Norwegian Public Roads Administration, illustrates that in the end of 2015 there was 67 564 trucks and 8 926 trolleys registered in Norway (Vegdirektoratet, 2016). It is presumed that the research respondents forms a group of different types of transportation companies, with variation in size, number of trucks, location, and most important of all, their opinion.

4.4.2 Quantitative data collection

The quantitative data collection was conducted through an inferential survey. An inferential survey is a survey design predominated in academic management research especially within the fields of marketing and organizational psychology (Easterby-Smith et al., 2012). This makes the design functional for the first step of the data collection, where the market of hydrogen is mapped, and opinions of future customers are valued through Likert scaled numbers.

The questions for the survey was grounded and based on the theory of planned behavior. The factors of attitude, social norm, and perceived behavior control were valuated towards the intention and behavior of the customers, towards hydrogen. In addition, the survey focuses on the environmental aspect and the consumers' environmental perspective.

Using inferential survey as a research design, the first phase of the research is to isolate the factors that seems to be involved, and through a scientific method try to implicate what causes the factor to be relevant for the research (Easterby-Smith et al., 2012). For this research the

theory of planned behavior determined the dependent and independent variables for further research. As relevant factors are determined, the independent and predictor variables should be identified, in order to precede the research, which in this research was identified as attitude, social norm and perceived behavioral control through the TPB (Easterby-Smith et al., 2012). The predictor variables for this conducted research is given as attitude, social norm and perceived behavioral control.

Development of the questionnaire

The survey questions and layout was based on previously and recommended layouts for survey on the theory of planned behavior. Among recommended layouts were the instrument made by Ajzen (2013) called *Theory of Planned Behavior Questionnaire* created intentionally for illustrating how surveys should be constructed when conducting research with the theory of planned behavior as a theoretical framework. The survey was designed with a simple layout together with questions that had a low threshold for the ability to respond. The questions were asked either as pure question or as statements. The opinion answers in the survey were indicated through a five point Likert scale, validating to what extent, attitude and importance of the consumers. A Likert scale gives the answer options a meaning and significance, giving the respondents a greater understanding and extent of the featured options (Johannessen et al., 2011).

Pretesting

A pretest is conducted before the survey is handed out in order to make sure that the survey is understandable (Johannessen et al., 2011), and to control if the different concepts correlate. The pretest could be sent out to other researchers, other professional who knows the field of study or respondents that are similar to the target group that the research is conducted about/ from (Johannessen et al., 2011). A pretest can be conducted in order to ensure that the questions are not leading towards certain answers (Bryman and Bell, 2007). If the results from a pretesting group show similar answers to the survey a control of the questions can be conducted in order to eliminate leading questions.

For this thesis I chose to conduct the pretesting on people that is presumed to have similar expectations towards hydrogen as a fuel as the sample group. The pretest was therefore

conducted on individuals related to the transportation industry. In addition a pretest was conducted on several of my fellow students in order to control the language of the survey, and the level of understanding for the questions. Some of the questions were edited in order to avoid questions leading to certain results. Likewise, were some of the questions created more specific in order to get an answer as close to the reality as possible.

Measurement of the concepts

The data from the survey should potentially create a foundation in order to examine the consumers' intentions and behavior towards changing to hydrogen as a fuel. The survey should in addition examine the different factors of attitude, social norm and perceived behavior control related to hydrogen as a fuel. The survey was designed in order to be fairly easy to conduct, short and convenient to respond to, as the data was collected during a conference. Demographical variables, such as the company's county of residence, number of employees and number of trucks were included in the survey as control variables.

The theoretical framework indicated the basis for conducting the survey. The factors from the theory of planned behavior determine the different concepts for the research for this thesis. A concept is determined as an abstraction or idea based on perceptions of a phenomena (Hair, 2011). The different concepts for the quantitative research are attitude, social norm, perceived behavior control, leading directly and indirectly to intention and behavior.

The concept of attitude reflects on how positive or negative people are towards a specific action. Social norms reflect how the consumer believes that others approve or disapprove the particular behavior. Perceived behavior control reflect to what extent the consumer believe that he is capable of engaging in the particular behavior (Wee et al., 2013). The survey focuses on what the consumers perceive as necessary in order to choose hydrogen as a fuel being subsidizing from the state, the proximity to fuel stations of the product and others.

The measured concepts of intention, attitude, social norm and PBC are presumed to generate an indication and further anticipation of the future behavior of the potential consumers in the Norwegian road transportation industry. The survey and statistics from these measurements is located in the appendices.

Attitude

In order to measure Attitude as a concept there was created several different questions and statements in the survey. The hypothesis which generates the basis for the attitude concept and testing it is as follows: *"There is a positive relationship between the company's attitude towards being environmental friendly and their intention towards changing to hydrogen as a fuel"*. In order to understand the differences in attitude the pursuing questions and statements were asked.

"How important is it for your company to be environmental friendly?"

"For my company the usage of purer fuels is"

For these two questions the five-point Likert scale ranging from "highly important" to "highly unimportant" was used as measurement. In addition the potential consumers attitude were measured through

"How is the opinion of your company towards hydrogen as a fuel to your disponed trucks?"

This attitude were measured on a Likert-scale ranging from "Highly positive" to "Highly negative".

Social norm

Social norm was used to measure how others companies opinions affected the company, and especially how the company perceived others opinions. The hypothesis "*There is a positive relationship between the company's social norm and their intention towards changing to hydrogen as a fuel"* was generated in order to measure the concept of social norm. The hypothesis was measured through the following variable questions.

"To what extent do you think that other companies view your company as environmental friendly?"

"To what extent do you think that other companies view your company as more environmental friendly when using hydrogen?"

These questions were measured on a Likert scale ranging from "very large extent" to "very small extent". Further the following variable question was asked:

"How do you think that other companies in the same field of operation would perceive your company, is your company had changed to hydrogen as a fuel today?"

This variable of social norm were measured on a Likert-scale ranging from “Highly positive” to “Highly negative”.

Perceived behavioral control

The concept of perceived behavioral control was measured on what extent the respondent company perceived their own capacity and behavior control. A hypothesis generated as “*There is a positive relationship between the company’s perceived behavioral control and their intention towards changing to hydrogen as a fuel”*, intended to measure the relationship between the concepts of the model. The variables for perceived behavioral control were generated through these questions:

“To what extent do you believe that your company has the capacity to change to hydrogen vehicles?”

This concept was measured on a Likert scale ranging from “very large extent” to “very small extent”. Perceived behavioral control was in addition measured though an opinion matrix, testing the opinions on the pursuing statements: “If the performance factor on the truck is the same when using hydrogen as with diesel, how is your company’s”:

“Willingness to pay for the fuel in its own”

“Willingness to pay for purchasing the vehicle”

“Willingness to pay for services and controls on the vehicle”

These were measured in a five-point Likert scale with the given options of “significantly higher than diesel”, “some higher than diesel”, “same level as diesel”, some lower than diesel” and “significantly lower than diesel”. As diesel is the current fuel on trucks the year of study, diesel was given as the reference point.

Intention

Intention was used as a measure grounded in the theory of planned behavior, to understand how likely the companies would change towards a hydrogen-driven truck. To measure this concept, the pursuing statements were asked in the survey, based on Ajzen (2013):

“My company expects to be early in the process of using hydrogen vehicles”

“My company wishes to be early in the process of using hydrogen vehicles”

"My company intends to be early in the process of using hydrogen vehicles"

These factors were measured on a five-point Likert scale from "strongly agree" to "strongly disagree".

Control variables

The control variables of location (county residence), size (number of employees), environmental friendly technology and investment size (number of trucks) where included in the research, in order to understand if there were differences between the opinions in the control variable groups. The control variable with highest number of distributed answers between the variables was the variable stating the difference between companies currently using and not using environmental friendly technology. This therefore has the highest focus in the pursuing analysis and is connected to the importance of framework conditions.

4.4.3 Qualitative data collection

The qualitative part of this research was conducted as an unstructured interview in order to get a deeper understanding of the problem statement. A unstructured interview is a type of interview where the researcher has an interview guide with pre-prepared topics for research, but the structuration can vary from interview to interview (Bryman and Bell, 2007).

An interview is an opportunity for the researcher to open dimensions and create new paths of research within a certain research problem (Easterby-Smith et al., 2012). As conducted for this thesis, unstructured interviews are mainly conducted as an informal questioning between the interviewer and the interviewee (Bryman and Bell, 2007). Interviews are an appropriate method for data collection when it is necessary to understand the constructs that the respondents use as a basis for explaining their own individual opinion (Easterby-Smith et al., 2012). As it is done in this thesis when the data collected from the inferential survey is analyzed and used as a basis for creating the questions for the interview guide. A qualitative interview aims to collect information that captures the interpretation of a research phenomenon related to a specific worldview (Kvale, 1996).

Interview can be an ideal method of data collection when the aim is to develop an understanding of the respondents "world". This in order for the researcher to understand how he or she might influence the respondents perspective, either on an independently or a

collaboratively level (Easterby-Smith et al., 2012). In this research the interview was conducted in order to understand the potential market consumers' viewpoint and "worldview" on hydrogen as a fuel.

The potential market consumers' viewpoint was gathered through a qualitative part of the inferential survey. The last part of the survey was an opening so that the company's representatives could express their opinions on the hydrogen fuel theme. The statements given at the survey was used as corroborative facts during the analysis of the thesis. Additionally, the qualitative secondary data confirming and complementing the conducted research was gathered specifically in order to understand the current status of market situation, the potential market stakeholders and further underpin the consumers' intention towards hydrogen.

Measurement of the concepts

The questions for the unstructured interviews were created on the basis of the empirical findings from the quantitative part of the research. The questions for the interview guide focused the attitudes, perspective and opinions of the Norwegian transportation industry. The questions were focused on the opinions stated in the quantitative research and focused on the consumers attitude, social norm and perceived behavioral control.

4.5 Data analysis

In this subchapter the choice of data analysis methods are firmly described, in order to understand the underlying arguments for how and why the research for this thesis is conducted as it is. As this is based on a mixed method approach, the methods are described separately. The first section outlines the quantitative data analysis and the chosen tools and methods for this research. The second section firmly describes the qualitative part of the analysis.

4.5.1 Quantitative data analysis

After the quantitative data was collected through an inferential survey, the collected data were sorted and purified. In the conducted survey, several types of variables and concepts were used. These are classified into different types in order to conduct a proper quantitative data analysis (Bryman and Bell, 2007). The different types of variables used in this inferential

survey were interval/ ratio variables, ordinal variables and nominal variables. In order to perform a reliable data analysis on the collected data from the survey the data was entered into Microsoft Excel and further exported and analyzed in the data analysis tool SPSS (Statistical Package for Social Sciences). An exploratory factor analysis was conducted in order to create a multiple linear regression analysis. The results from the conducted analysis are described in the empirical part and further illustrated in the appendices.

Univariate analysis

A univariate analysis is a type of analysis where one variable is analyzed at a time (Bryman and Bell, 2007). A univariate analysis can be in the form of frequency tables and figures. In addition, it can be statistical goals such as median, average and standard deviation (Johannessen et al., 2011). The results from the univariate analysis were presented in frequency tables, which illustrated the number of informants (n) and the percentage (%) connected to each of the different variable categories (Bryman and Bell, 2007).

Multiple regression analysis

A regression analysis illustrates to what extent one independent variable co-vary with a dependent variable (Johannessen et al., 2011). The multiple regression analysis is a general statistical technique to analyze the relationship between a single dependent variable and several independent variables (Hammervold, 2012). The quality of the total regression analysis is summarized by the correlation variable called squared multiple correlation symbolized as R^2. The value of R^2 have the possibility to vary between 0 and 1, and illustrates how a spread of a single continuous variable score can account the predictors in the given model (Easterby-Smith et al., 2012). The value of F in the regression analysis is the result of comparing the amount of explained variance to the unexplained variance. The larger the value of F is, the more variance of the dependent variable is interpreted by the independent variable (Hair, 2011). The significant test of a linear regression analysis presents that as long as the significance variable is below 0,05 there is an probability lower than 5% that our null hypothesis is valid (Clausen and Eikemo, 2007).

The multiple regression analysis is conducted in this thesis in order to test and illustrate the regression in the theory of planned behavior. The theory states that the dependent concept

intention (Y) initially depends on the changes in the independent concept of attitude (X_1), social norm (X_2) and perceived behavioral control (X_3). A mathematical illustration of a linear regression analysis can be modeled with the given formula:

Equation 4-1 Linear regression

$$\boldsymbol{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3}$$

Y is the dependent concept intention. The symbol β illustrates the standardized beta coefficients that is further estimated. The values of β_1, β_2 and β_3 generates a change in the concepts X_1,X_2 and X_3 when a change of one unit is conducted in the independent variable (Johannessen et al., 2011).

4.5.2 Qualitative data analysis

The qualitative data, including comments and opinions from the conference and comments included in the survey, was categorized and analyzed after the theoretical framework and matched towards the quantitative empirical data. The theoretical categorizing is divided within the market situation, market actors and the customer as an actor and its intention. In addition, an SWOT-analysis was conducted to combine and summarize the theoretical framework, the qualitative and quantitative method to an empirical framework.

Qualitative secondary data was additionally analyzed towards the research conducted in this thesis in order to confirm and complement the data collected. This was conducted in order to gain a perspective of the market situation and further understand the potential behavior of the other actors in the hydrogen market.

SWOT analysis of a future hydrogen market

A SWOT analysis is a tool for analyzing the strength, weakness, opportunities and threats for a specific company, resource or situation (Roos et al., 2010). The SWOT-analysis is included in this research in order to understand the possibilities and challenges potential stakeholders can face in a future hydrogen market.

A SWOT analysis evaluates the internal and controllable factors of strength and weaknesses and the external and uncontrollable factors of opportunities and threats. Strength and weaknesses are “internal” issues and are therefore “controllable” by the organization. They

are termed as controllable because it is presumed that you can act upon your own strength and weaknesses. Opportunities and threats are "external" for the organization, and are therefore harder to act upon and control by the organization itself (Fifield, 2007). The SWOT analysis can therefore act as a connection between the internal and external analysis of the resource (Roos et al., 2010).

SWOT analyses are commonly used for analyzing company's possibilities in a market. The traditional SWOT analysis of a company's performance suggests that the company should be able to improve their performance only when their current strategies exploit new opportunities or neutralizes potential threats (Barney, 1991). In addition a SWOT analysis can lay the basis for performing certain decisions (Johannessen et al., 2011). The SWOT analysis an applicable tool for this thesis since the SWOT tool can be used to understand the factors of the market and further can generate possibilities to develop the market for the different actors. Understanding the different factors of the market can generate a visualization of the status and further give possibilities for actors to survive potential changes in the market (Roos et al., 2010).

For this thesis the analysis focuses on the hydrogen and the potential market situation, and not the company in focus. This mainly to understand the possibilities of the resource combined with its market stakeholders. The SWOT analysis can be used as a resource analysis in order to identify the key factors of the resource (Roos et al., 2010). The SWOT analysis of this thesis is additionally used as a tool in order to summarize the analysis of the empirical findings.

The strength-factor of the SWOT analysis represents the strengths that target customers believes that the resource possibly have (Fifield, 2007). This therefore illustrates the most important factor for the consumers when purchasing the good. The Weakness-factor of the analysis represents the weaknesses that the consumers believe that the resource has (Fifield, 2007). The opportunities a company has are usually external and hard for the producing organization to control. It is therefore one of the factors that its most important that the organization work upon (Fifield, 2007). The threats are in addition a factor that can be hard for the organization to control. External factors, such as threats, should be prioritized in an organization in order to enhance their improvements to a further level (Fifield, 2007).

4.6 Validity and reliability

Using a mixed method approach is presumed to enhance the validity and generalizability of the results from the research (Easterby-Smith et al., 2012). When conducting research, a central question asked is how valid the data is for the conducted research. Validity is described as how good or relevant the data that is conducted reflects and represents the phenomena. Validity is defined based on the three factors of concept validity, internal validity and external validity (Johannessen et al., 2011).

Concept validity is the relationship between the general phenomenon and the concrete data (Johannessen et al., 2011). The question is if the data collected from the research is realistic and valid to use in order to make a conclusion around the phenomena. As for this master thesis it is realistic to believe that the data collected is valid. This because the respondents to the survey are either owners or leaders in transportation companies in Norway and therefore is within the thesis targeted sample group. Their expressed opinions represent the overall viewpoint from the road transportation companies in Norway.

Internal validity determines if the research survey is suited to conduct causal relationships or not. If the survey has high intern validity it is easier to conduct a conclusion based on a influencing factor (Johannessen et al., 2011). The survey for this research had several question variables in order to determine the concepts of intention, attitude, social norm and perceived behavioral control.

Extern validity is determined as the ability to generalize the research results and use them for other situations and research (Johannessen et al., 2011). The data collected in this survey is special for the Norwegian transportation industry, but it is believable that other countries will have the same opinions within usage of hydrogen. On the other hand, as the focus on zero-emissions are especially high in Norway this can create a pressure on Norwegian transportation companies to answer more positively results towards hydrogen vehicles than other country's at a current time.

Reliability is determined as how trustworthy the data collected are. Reliability connects to the accuracy of the survey data, the consistency of research measures (Bryman and Bell, 2007), what data that are used, how they are collected and how they are processed and considered (Johannessen et al., 2011). It is anticipated that the informants and respondents to this research had the basis and knowledge for determining a response to the questions and

statements asked, as their attendance on the conference where the research was conducted determined knowledge about the company's current situation.

There are three prominent factors that illustrates the reliability of a measure, these are stability, internal reliability and inter-observer consistency (Bryman and Bell, 2007). Stability considers whether or not a measure is stable and consistent over time. The easiest way of testing the stability of the specific measure is to conduct a test-retest method. Here the measure of correlation between two variables is essential, because it measures the strength between the two variables (Bryman and Bell, 2007). The pretest conducted for this research tested the stability of the measures through confirmation from the pretesting respondents and conducting a pretest with the tool for analysis. Internal reliability considers whether or not the indicators given in the survey make up the scale are consistent. Internal validity explores the possibilities if the respondents score on one indicator can be matched to their scores in other indicators (Bryman and Bell, 2007). The internal validity was controlled through asking the questions in different variants, in order to confirm the internal validity of the companies. For the concept of intention the variables was asked in the three variants of *"my company (1) expects, (2) wishes* and *(3) intends to be early in the process of using hydrogen vehicles".* Inter-observer consistency involves the validity when more than one researcher/ observer is involved in recording and translation of data into categories. Are there more than one researcher, there is a possibility for deficiency of consistency between the researchers (Bryman and Bell, 2007). For this thesis the accuracy of the survey data should be correct in order that they represent the response for the targeted group. Interpreted by one researcher, the data both qualitative and quantitative, is collected through a conference especially for owners of goods transportation vehicles creating accuracy for the targeted mapping of this thesis.

4.7 Ethical values

Bryman and Bell (2007) outline four main areas within ethical values of research. These are harm to participants, deficiency of informed consent, invasion of privacy and involved deception. To describe these main areas they have been combined with the key principles in research ethics given by Easterby-Smith et al. (2012) and further use these key principles to explain the ethical values of my research. These principles have been central in the conduction of this research.

Harm to participants

Ensuring that no harm comes to participants is the first key principle in Easterby-Smith et al. (2012). This symbolize that an individual should not be affected by either physical harm, harm to the participants development or individual factors such as self-esteem, stress, harm to career prospects or potential future employment (Bryman and Bell, 2007) and/ or inducing subjects to perform reprehensible acts (Diener and Crandall, 1978). This is the second key principle of *respecting the dignity of research participants* (Easterby-Smith et al., 2012). To ensure that the respondents of the research survey are not harmed it is recommended in Bryman and Bell (2007) as to only examine the results of subgroups with ten or more respondents involved. Throughout this research this point has been strictly followed in order to keep the respondents to the survey as anonymous as possible.

The issue of confidentiality and anonymity is important to be aware of when conducting a secondary analysis of qualitative data. Transcripts and field notes should only be presented in a way that will prevent individuals or places from being identified (Bryman and Bell, 2007). Throughout this research there was a complete focus on anonymity and only the researcher had access to the conducted data.

Deficiency of informed consent

The third key principle of Easterby-Smith et al. (2012) is *ensuring a complete informed consent of research participants*. At this point the principle indicates that prospective research participants, the respondents of the quantitative survey, should be properly informed and should be given as much information as needed in order to conduct the decision on whether or not they want to participate in the research. In this research all the participating respondents were informed through a presentation on a conference conducted in March, the year of research. The respondents were encouraged to participate, on voluntarily basis. They had likewise the opportunity to not be a part of the survey, as it was voluntary, even though they were encouraged by the organizers of the conference to participate. They were furthermore informed about full anonymity bout verbally and in the survey.

Invasion of privacy

One of the most important factors within ethics and research is the concept of privacy. The

fourth key principle of Easterby-Smith et al. (2012) is *protecting the privacy of research subjects*. The right to privacy is a principle that many holds valuable (Bryman and Bell, 2007), and is important that is not transcend when conducting research. It is therefore important that the researcher follows the fifth key principle of Easterby-Smith et al. (2012) and *ensures the confidentiality of research data.* As well as ensuring the confidentiality of the data it is important to *protect the anonymity of individuals or organizations* which is the sixth principle of (Easterby-Smith et al., 2012). The right to privacy is strongly connected to the notion of informed consent of the research. It is strongly presumed that if the participants are completely informed and have a detailed understanding of their involvement in the research and what it entails, the participial should be able to acknowledge its role towards privacy of the research (Bryman and Bell, 2007). The participants of the research were ensured full anonymity towards the firm and as individuals. The respondents used only the company name when responding, and not their own individual names.

Involved deception

Deception is a phenomenon that occurs when the researcher represent the research conducted as something other than it actually is. Leading to key principle number seven, *avoiding deception about the nature or aims of the research* (Easterby-Smith et al., 2012). Deception can occur in various degrees within research, mostly because researchers want to limit the participators understanding and knowledge of the research (Bryman and Bell, 2007). The main aim for this research is to generate an understanding and further clarify the possibilities of a hydrogen fuel market and understand the future behavior of consumers towards hydrogen.

Other ethical considerations

In addition to the four main ethical principles identified in Bryman and Bell (2007), there are other ethical considerations that need to be taken in to account when conducting a research project. One of them is Easterby-Smith et al. (2012) principle number eight, *declaration of affiliations, funding sources and conflicts of interest.* Making sure and considering the potential affiliations and conflicts of interests that can occur when conducting the specific research. Affiliations related to funding have the potential to influence the way the research is conducted and how the findings are presented (Bryman and Bell, 2007). *Honesty and*

transparency in communicating about research is key principle number nine and is important to obtain when conducting the research, as honesty is the best policy. The final and tenth key principle is *avoidance of any misleading or false reporting of research findings* (Easterby-Smith et al., 2012). This is probably the most important for the research itself that the findings given in the thesis matches the research conducted.

4.7.1 Strengths and weaknesses with this research

There are several positive and negative arguments for choosing a mixed method approach. Using mixed method approach has the ability to increase the validity, confidence and credibility of the results conducted in the research (Easterby-Smith et al., 2012). In this thesis the qualitative data is included in order to confirm and explain the quantitative data collected. A weakness to this research is that the market is continuously changing as the technology is developed. This indicates that the research conducted and the results generated are only valid for a certain period of time. In addition, the research is focused on the Norwegian transportation industry and mainly the transportation on road, and the possibilities for a hydrogen market in Norway. The low prices for hydropower have the possibilities to generate a low cost for producing hydrogen in Norway.

5 Empirical findings and analysis

In this chapter the empirical findings are analyzed towards the theoretical framework introduced in this thesis, the previous conducted research and the current hydrogen market situation. The analysis is systematically divided between the research concepts in order to generate a better understanding and respond to the problem statement.

5.1 The current market situation

In order to create an illustration of the hydrogen market, the theory of supply and demand is used as a theoretical framework. Further theoretical viewpoints are located in section 3.1.

5.1.1 The supply side

For illustrating the producers' side in the hydrogen market, Østfold Energi is used as a reference point for further discussion.

As the different producers are planning to develop their facilities it is of substantial importance that producers know how much they can offer as a supplier to the market. Their aim and responsibility is to estimate how much kilogram hydrogen they have the ability produce within a given timeframe, with the planned facility. These estimations include the upper bound production capacity of the facility over a given period, calculation of the level of inbound hydropower to the production, estimation of other producers' production level and estimation of how the future price level of hydrogen will be. The future price level is of significant importance as the electricity price level can determine the future of hydrogen production. The factor of the upper bound of the production depends on the preinstalled maximum production capacity of the facility. The hydrogen project that Østfold Energi aims to develop demands an estimated turnover for 333 kg hydrogen per day, with a current investment cost at 50 million NOK (Fimreite, 2017).

The level of inbound energy source of hydropower to the production facility would strongly depend on the connected hydropower plant in Naddvik. Their yearly average power capacity is currently at 437 GWh, which is regulated by the level of the connected water reservoirs, how much is used within a given period and the anticipated level of precipitation, filling the connected reservoirs (Ostfoldenergi.no, 2015b). As a reference point for further discussion, a 50 MW hydrogen producing electrolysis plant need an yearly average power capacity at 438 GWh (Hirth, 2016).

At this current point the market for hydrogen is developing day by day. Østfold Energi will within a short period of time face competition from other producers desiring to generate hydrogen from renewable energy sources. Currently hydrogen fuel produced by a renewable energy source is assumed to be the new revolution within emission reduction technology in the transportation industry. The main competitive advantage Østfold Energi holds at the current stage is that they own the hydropower plant that is intended to generate the electricity for the production plant. The fact that the producer of hydrogen is involved in several stages of the value chain can be an advantageously step in the market introduction process. One of the major competitive advantage the producer faces when he manages the inbound energy source and the electrolysis production facility for hydrogen is the reduction of estimated total costs. Managing both the energy and production level of the supply chain eliminates the extra costs of grid tariff, electricity taxes and the cost of certification (Ramstad, 2016). The costs, delivery and flexibility are competitive advantages connected to managing several levels in the supply chain (Li et al., 2006). For a company involved in several steps of the value chain can be affecting the hydrogen production. A situation of high electricity prices in Norway would make hydrogen production unattractive, as the hydrogen production is costly in itself. At a high price level it is presumed that the suppliers would preferably only produce and supply high cost electricity to the market, and not use it for generating hydrogen production. A high electricity price could therefore generate an alternative processing of the hydropower. The energy generated from hydropower is additionally an competitive and solid source of energy due a relatively low manufacturing loss, where approximately 90 percent of the water is generated to pure electricity (Hauge et al., 2015).Hydrogen electrolysis production generated from hydropower is presumably a profitable hydrogen production. For the supplier the profitability would depend on factors such as electricity price and water flow, the hydrogen demand, contracts with filling stations and coordinating of engineering and administrating the production (Ramstad, 2016).

In addition, the estimated price of the product represents a major part on the supply side. It is of substantial importance that the estimated price for the hydrogen covers all total expenses for the production. Some of the total expenses for the hydrogen production are presumably cost related to electricity-prices, taxes, transportation, production investment costs and so on.

The supplied price for hydrogen is, the year of study, at a level of 90 NOK per kilo hydrogen sold (Norskhydrogenforum, 2016) and it is assumable that this is an applicable market introduction price, as this is a price that is reconciled at the current market. The Nikola one

hydrogen truck is estimated to use approximately 0,46 kg per mile driven (Dalløkken, 2016), giving an approximately cost of 41,4 NOK per mile. This cost represents the estimated consumption of a hydrogen vehicle with the specific features stated in section number 2.3.7.

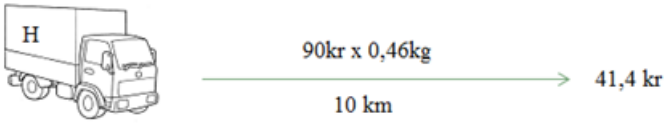


Figure 5-1 Hydrogen consumption

The cost of consumption, price of hydrogen and the other mentioned theoretical factors for developing a supply curve can combined with the factors representative for the renewable energy producing hydrogen industry in this research generate the following supply curve.

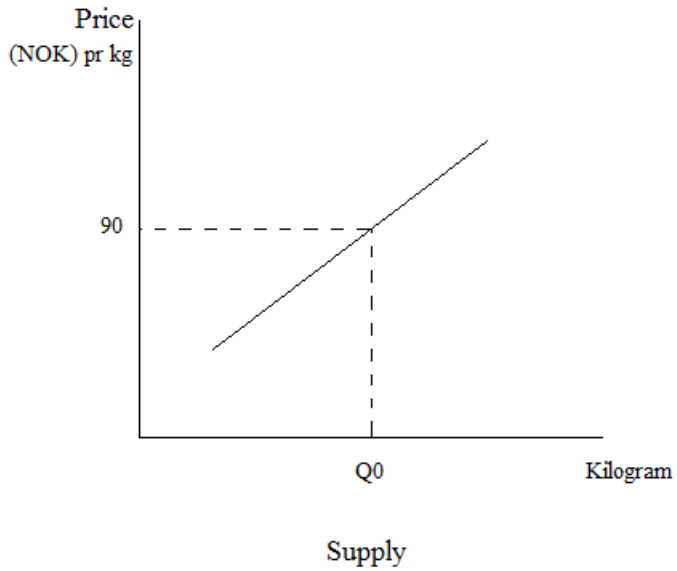


Figure 5-2 Market related supply curve

The current status of consumption per kilometers gives an intersection point on the demand curve at the price of 90 NOK per kilo hydrogen purchased.

5.1.2 The demand side

On the demand side of the market there are several factors that are anticipated to influent the total market situation. Most important for the producers of hydrogen is to find the potential

demanders, and develop a supply and demand relationship. It is anticipated that the demanders of hydrogen would affect the market situation by influencing factors as the price per kg hydrogen, the hydrogen availability, the truck/engine replacement-cost, state subsidies and number of stable suppliers.

A factor which is of high importance for the demanders of hydrogen is how easily accessible the fuel is in Norway. The respondents to the survey expressed that the access of hydrogen at ordinary filling stations was of importance for them in order to perform a hydrogen fuel shift. On average, the accessibility to hydrogen at ordinary stations was the most important factor for changing towards hydrogen, see section 5.5 about the political and environmental framework requirements. Several respondents at the conference agreed to the statement that hydrogen accessibility was the major factor of importance when introducing a new fuel to the market. The hydrogen fuel market faces a "chicken and egg" problem if the infrastructure isn't developed fully when the vehicles are introduced. This is due to the fact that consumers would not invest in hydrogen vehicles if the fuel infrastructure isn't fully developed. Furthermore, the filling infrastructure wouldn't be fully developed before there are vehicles demanding the fuel. As hydrogen is predicted to be the new solution to the emission reduction process of the transportation industry, the solution for generating a fully-fledged hydrogen market is to develop a stable hydrogen filling infrastructure.

From the supply and demand theory, it is stated that a shift in the supply or demand curve, based on its factors, would generate a change in the variables of the hydrogen volume produced and price. A higher price from the suppliers would from theoretical aspects mean that the demand would be reduced, and vice versa. As the price for hydrogen is at approximately the same level as diesel, but with a lower cost per mile driven, the demanders would have the opportunity to control the price of the product. This due to the fact that low prices presumably generates a higher purchase rate of more hydrogen technology, generating a higher demand for hydrogen.

The results from the conducted survey indicate that a low majority of potential consumers' willingness to pay for the hydrogen is at the same level as the price of diesel today. This is an indicator presuming that the potential consumer group have a neutral to positive attitude towards the price level of hydrogen, as hydrogen is expected to be lowered in the future as the demand increases (Norskhydrogenforum, 2016). The price for diesel is, the year of study, at a level of approximately 13 NOK per liter diesel sold, inclusive taxes, (YX.no, 2017) listed in

appendix 1. With an estimation of a fuel consumption about 4,5 liters per mile (Simonsen, 2012), the cost will be approximately 58,5 per mile. The calculations for the diesel consumption are conducted inclusive taxes.

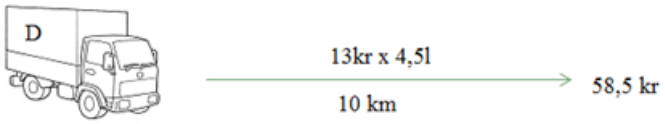


Figure 5-3 Diesel consumption

Therefore with the mentioned theoretical factors for developing a demand curve for the potential consumers of the hydrogen industry combined with the factors representative for the hydrogen industry in this research, the following demand curve can be visualized:

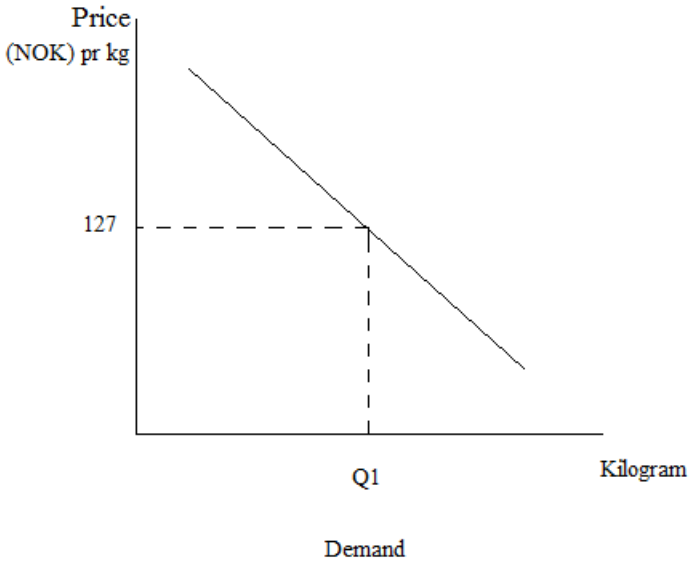


Figure 5-4 Market related demand curve

As the consumers' willingness to pay is equal to the current diesel price, it is assumable that they would demand a price at the level of the diesel price of today (appendix 5). Hydrogen and diesel are not given in the same units of measurements, as hydrogen is measured in kilograms and diesel in liters. The consumers' willingness to pay for hydrogen would be at a price of 127 NOK per kilogram hydrogen. The calculation is based on the consumption level

for diesel at 58,5 NOK divided on the hydrogen vehicle consumption of 0,46 kilograms per mile. This given calculation estimates that the current price matches the consumers' willingness to pay determined in kilograms.

5.1.3 The market mechanism

Combining the producers willing to supply hydrogen to the market, their capabilities and power to develop a market together with demanders willing to invest in hydrogen technology, their attitudes and risk management, generates the market structure of the hydrogen fuel market.

The market mechanism depends on the price comparison between hydrogen and diesel, as the price for hydrogen generates the producers willingness to supply and the price of diesel determines the foundation for the consumers' willingness to demand. Hydrogen is determined to be a comparable fuel to conventional fuels as diesel in this analysis, as the current crude oil price, the time of research, is close to and above $50 per barrel produced (appendix 1). As for both of the fuels types there are several factors that can affect the estimation. The driving range per unit of fuel is dependent on external variables such as the driving temperature, the amount of electricity used in the vehicle and the driving style (Norskhydrogenforum, 2016). These variables are not taken in to account in the following fuel consumption comparison.

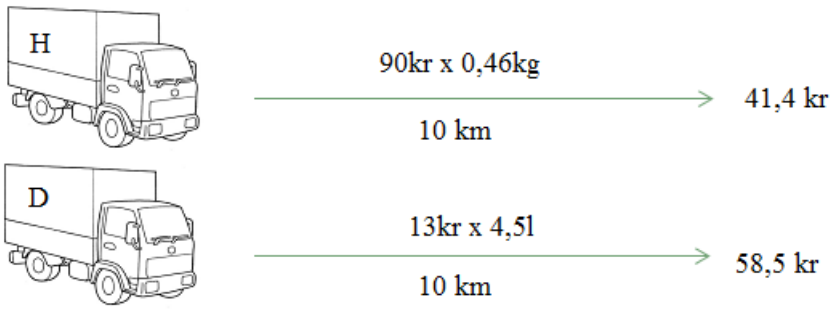


Figure 5-5 Price comparison

This comparison of the fuels illustrates that the producers in the current hydrogen market are able to supply hydrogen at a lower price level than the consumers demand at the current stage. This can therefore generate an assumption that if hydrogen is introduced with the same specifics as given in this thesis, there are going to be a significant high level of demanders in

the introduction phase of the hydrogen fuel market. In general, low prices generate higher demand for a good.

Based on this, a graphical illustration of the market mechanism and situation can be generated. This involves combining the supply curve, the demand curve and the estimated levels of price and quantities.

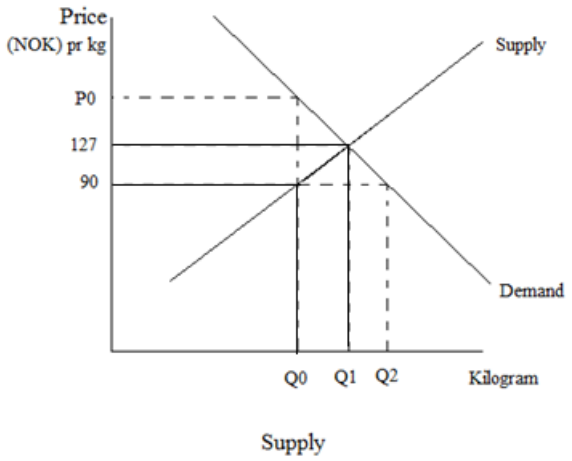


Figure 5-6 Market mechanism

The graphical illustration visualizes the market levels of price and quantity given the current estimations. The demanders have a willingness to pay at a level of 127 NOK per kilogram hydrogen, whereas the currently supplied price level is at 90 NOK per kilogram hydrogen. The graph illustrates the possibility to generate a higher market price (P0) if the quantum demanded is lower than the supplied quantum. The same accounts for the quantum, as a new quantum (Q2) can be demanded at the same level as the current market price. This situation can generate a market shortage, where the consumers realize the effectiveness and cost reduction of changing towards hydrogen, generating a higher demand than the producers are able to supply to the market. On the one hand it is anticipated that the market would be in equilibrium at this price and quantum in the introduction phase of the market, as the market seeks demanders of hydrogen technology in order to be conducted. Suppliers already produce hydrogen to a price of 90 NOK per liter, an increase in price from the suppliers' side is not presumed to be functionalizing in an introducing phase of the market. A producer of hydrogen will, according to the theory of supply and demand, always aim to enhance it production towards a potential surplus, where the quantity of hydrogen supplied exceed the quantity of hydrogen demanded from the consumers On the other hand as the consumers' willingness to

pay is at a higher than the current level, the producers have the ability to supply the market at a higher introduction price. The price level will either ways be the major important factor for generating a fully-fledged market as low prices tends to generate higher level of demand. The mechanism of the hydrogen market illustrates that when the price of hydrogen is lowered in the market the demand from consumers will increase and from this a new market equilibrium will occur.

The current status illustrates that the market can face a possible shortage, due to the fact that the consumers have a higher willingness to pay for the fuel. This market displacement is at a point where the consumers are willing to pay more than the current market price. This situation can possibly develop to a phase where the suppliers don't have the ability to comply the demand from the consumers. It is therefore substantial to state the importance of the actors in the market, and as illustrated later in the thesis, the importance of governmental support in this type of market situation.

5.2 The consumers rational choice

The consumer choice is defined by the two factors of consumers' preferences and budget constraints. Together these illustrate that a consumers' choice is determined to give the maximal satisfaction possible for the consumer in the market, given the limited budget available (Pindyck and Rubinfeld, 2013). Furthermore, the consumers' preference is grounded in the three assumptions of completeness, transitivity and non-satiation.

For this research it is presumed that the respondents and informants have the complete ability to compare between the choice of using hydrogen, diesel or any other type of fuel as a source of fuel for their vehicles. The respondents and informants for the research are either owners or members of the management in their respective companies. It is therefore presumed that these individuals have the ability to compare and rank the different technologies if the complete information is given. The leadership and management of a company are expected to have information about the company's perceived environmental perspective, budget constraints and market position. This gives a further implication that the respondents involved in the research is viable for the first assumption of completeness.

The results from the survey illustrated the consumers' ability to compare and evaluate the different fuels and technologies towards each other. The respondents gave indicating answers about their current attitude towards hydrogen, whereas nearly 48 percent (n=22) indicated a

positive attitude (appendix 3). Moreover they illustrated what factors that was of highest importance for them in order to perform a change from diesel to hydrogen. The research shows that the consumer's attitude towards hydrogen is transitive to other fuels as well. Illustrating the fact that the consumers that prefer to change to hydrogen as a fuel would additionally prefer hydrogen before other fuel technologies. This gives an important implication for the suppliers as a number of respondents would prefer hydrogen compared to the current technology. This indicates the fact that the competition from other low emission fuel types such as biodiesel and fully fledged electrical vehicles is determined to be at a low level.

For this research it is assumable that the consumers complete the assumption of non-satiation. As for any other industry it is assumable that the consumer would prefer to have more of a good, than less of a good. Moreover it is assumable that the consumers prefer the best variant of the good, matching their preferences. Many of the informants expressed their wish, through the unstructured interviews, to always be in possession of the latest technology available on the market. From the survey, all the respondents that implied that they had vehicles with low-emission technology, expressed that they had engines complying with the European Union EURO VI requirements. This is currently the technology with highest emission reducing requirements in Europe, and were published in 2009 as a part of the Commission Regulation No 595/2009 from the European Union (ec.europa.eu, 2016). This therefore implies that the vehicles used in the current market are less than eight years old.

The budget constrains for hydrogen illustrates the consumers possible combinations of the good, given the consumers income and price of the good. The consumers' willingness to pay therefore determines the level of budget constraints for the consumers of hydrogen. The respondents expressed that for the price of buying a hydrogen vehicle, over 60 percent indicated that they were willing to pay the same amount for a hydrogen vehicle, as for a diesel vehicle (appendix 3). This therefore gives the basis for stating that the consumers' willingness to pay and budget constrains are equal and on the same level as the current existing technology.

For the cost of purchasing the fuel 65 percent stated that they were willing to purchase hydrogen at the same price level as for diesel (appendix 3). Even though hydrogen and diesel are not determined at the same unit of measurement, the calculations conducted in this research shows that the prices for hydrogen are at a lower level than diesel. These calculations

consider the current consumption level for the technology and the price per unit. This therefore determines the assumption that the consumers have a higher willingness to pay for the product than the supplied price for the fuel is today.

The consumers' budget constraints for performing services and maintenance on the vehicles are at the same level as diesel. At this factor even more respondents expressed their willingness to pay to be at the same level as current prices for diesel vehicles (Appendix 5). Nikola Motors as a producer of hydrogen vehicles stated by current estimation a halving of the price level on the maintenance cost per month (Nikolamotor.com, 2016). This therefore generates the assumption that the consumers have a higher willingness to pay than the stated supply price for maintenance on the current technology available on the market, the Nikola One.

With the given limitations for the consumer preferences and the budget constrains the consumers optimal combination of goods can be generated. Combining the consumer preference, which illustrates the consumers ranking of the goods after own preferences, and the budget constrain, which gives an prediction on which goods are affordable for the consumer, the consumers should be able to choose the best feasible fuel technology from the visualizing of the consumers choice. Hydrogen is presumably the best feasible fuel technology for the road transportation industry, if the requirements in this thesis are held. The hydrogen vehicles are determined to have improving features than current diesel technology. Important factors such as cost reduction, range extender, acceleration and top speed up hills make it reasonable to determine hydrogen as a preferable technology.

5.3 The consumers planned behavior

The theory of planned behavior determines that there should be a substantial relationship between the given concepts of the model. The model is illustrated in the theoretical section 3.3.This visualizes a regression between the dependent concept intention and the independent concept of attitude, social norm and perceived behavioral control. A multiple linear regression analysis was carried out in order to test the model for the theory of planned behavior. This analysis was conducted in order to understand the relationship between the concepts in a combined picture.

The ANOVA (analysis of variance) is a type of hypothesis testing, where two or more concepts or variables can be classified on the basis of other concepts or variables (Easterby-

Smith et al., 2012). The table illustrates that the complete model of the theory of planned behavior is statistically significant, with a significance value as p=0,000. The results from the multiple regression analysis are illustrated in table 5-1.

Table 5-1 Multiple regression estimates

Concepts	**Coefficient β**	**T – values**	**P – values**
Attitude (β_1)	0,541	4,051	0,000
Social norm (β_2)	0,109	0,845	0,403
PBC (β_3)	0,233	2,026	0,049
Summary statistics			
N	46		
R^2	0,516		
F	16,981		

The multiple correlation coefficient given as adjusted R^2 illustrates how large part of the variation in the dependent concept originates from variation in the independent variables (Johannessen, 2009), and is adjusted by the number of independent variables the model contains (Pallant, 2013). This coefficient is of the highest focus, as the number of independent concepts is low in this conducted research. The adjusted R^2=0,516 value illustrates that 51 percent of measured variance of a consumers intention can be explained by the consumers attitude, social norm and perceived behavioral control. The value of F is given at 16, 981 which is a high value, indicating that the variance of the intention is interpreted by the independent variables.

The results from the regression analysis illustrates that a consumers attitude towards hydrogen is the most important concept for a consumer, in order for the consumer to have a distinct intention towards purchasing hydrogen technology. This was illustrated with the beta coefficient of the regression analysis. The coefficient illustrated than an increase in one unit of attitude (β=0,541) will generate an increase of intention with 0, 54 units. This is the relationship with the highest beta value among the concepts which indicates that attitude is the concept that gives the strongest unique contribution in order to explain a consumers' intention (Pallant, 2013). This confirms and supports the first hypothesis which states a positive relationship between the companies' attitude and their intention towards changing to

hydrogen as a fuel. The level of significance in the regression analysis performed for this thesis presented a significance level of 0,000 between the concept of attitude and intention. This illustrates that there are more than 95 percent probability that there is a distinct regression between the concepts of attitude and intention, confirming the relationship between the concepts. This is further underpinned by the high t-value (t=4,051). It is therefore a reason to assume that the consumers' intention towards hydrogen fuel and technology depends majorly on the consumers' attitude towards hydrogen. This implies that a positivistic attitude would generate the intention to purchase a hydrogen vehicle. It is presumed that the consumers' positive attitude is a stable and grounded in the consumers salient believes, due to the power of affection. The stability and importance of attitude generating an intention is an influencing factor for the observed behavior. The positive attitude therefore presumes a positive observed behavior towards hydrogen in the future.

The significance level for the concept of social norm in relationship with intention illustrates the probability for confirming the significant level of the hypothesis is lower than 95 percent, giving the basis to state that the null hypothesis is confirmable. In other words this indicates that the concept of social norm doesn't make a significant unique contribution to the prediction of intention (Pallant, 2013). This is further underpinned by the low t-value (t=0,845). In addition, the level of the beta coefficient is low, stating that a change in social norm only affects intention with 0,01 units. This gives the reason to state that in this conducted research the null hypothesis is confirmed stating that there are no substantial relationship between social norm and intention in the given model. This intentionally indicates that the road transportation companies' decision towards hydrogen and a fuel change doesn't depend majorly on the companies in the same industry.

The significance level for the concept of perceived behavioral control in relationship with intention gave a value of 0,049, which is a limit value for stating that we have a 95 percent probability for confirming a significant level between the two concepts (Easterby-Smith et al., 2012). For this research the consumers perceived behavioral control have an impact on their intention towards purchasing hydrogen technology. The relationship between perceived behavioral control and intention is illustrated as distinct, where a the positive beta coefficient of 0,233 demonstrates that an increase of perceived behavioral control with one unit would lead to an increase in the concept of intention with 0,23 units. This is further underpinned by the high t-value (t=2,026). This confirms the third hypothesis which states a positive relationship between the companies' perceived behavioral control and their intention towards

changing to hydrogen as a fuel. The concept of perceived behavioral control therefore illustrates a significant impact on how the consumers' behavioral intention is towards hydrogen. The consumers perceived purchase capacity and willingness to pay is in this thesis is more important for the consumer, than the perceived social norm.

The concepts are further exploited separately in order to understand the consumers' attitude towards hydrogen, how they perceive other companies opinions through social norm and moreover understand the company's perceived capacity through the concept of perceived behavioral control. Additionally is the consumers' intention towards being a part of the introduction process of hydrogen is enlightened.

5.3.1 The consumers attitude

In the qualitative part of the survey, the informants had the ability to express their attitude towards hydrogen with using just one word. There were 35 informants to this question, whereas 14 of these expressed a clear positive attitude towards hydrogen. The positive attitude was confirmed several times at the conference as the transportation companies are interested in new environmental friendly technology.

One of the informants expressed that they are willing to try the technology in the harsh arctic climate. "*Our company wants to participate in a potential (hydrogen) project on how this could work in arctic conditions. Our company is surrounded by bitterly cold and shifting weather conditions"* This statement emphasizes the consumers' positivity, but with a focus on the insecurity for the harsh climate that can occur in Norway. The insecurity of introducing new technology to the Norwegian climate was confirmed with several of the informants, as this is of major importance for the companies.

One of the informants expressed a risk factor related to the cold winters in Norway, and how *the hydrogen fuel act in relation with temperature, with a special focus on Norwegian winter convoys.* In Norway winter convoys are commonly used crossing harsh conditioned mountains in order to transport goods and people across the country. A winter convoy involves harsh weather conditions. It is therefore of substantial importance that the vehicles are able to handle cold weather conditions, with low temperatures for a longer period of time. The current developed technology of hydrogen vehicles are presumed to be as trustworthy as any other fueled vehicles, as they are able to start in minus 30 degrees (Norskhydrogenforum, 2016). The newly developed vehicle technology has to be approved through standard

requirements set by the European Union. It is therefore assumable that the vehicles would be as suitable for winter convoys, as any other fueled vehicle.

In order to understand the respondents' attitudes towards hydrogen, the aspect was combined with the consumers climate and environment focus through the question of *"How important is it for your company to be environmental friendly?"* As much as 87 percent of the respondent companies stated their importance of being environmental friendly (Appendix 3). This can be connected to social norm, as the climate and environmental friendly focus has increased drastically the latest years. It is assumable that the Norwegian governmental directions and requirements have generated a more environmental friendly perspective for companies in the transportation industry in Norway. The government has generated a behavioral intention among companies mainly based on strengthening the positive attitude towards an environmental friendly focus. The importance of the environmental focus is presumably generated by the government through laws and regulations, specific requirements and solicitations.

Hydrogen is seen as an environmental friendly fuel by itself, but has earlier been produced by methods with low resource utilization and has been highly polluting. As long as it is produced with a renewable energy source the hydrogen fuel value chain can be perceived as environmental friendly. In order to enlighten and connect the environmental perspective towards the consumers' attitude the following question was asked in order to illustrate the consumers' willingness to use hydrogen on their own vehicle. Through the question *"How is your company's position in usage of hydrogen fuel on your disposed vehicles?"* the companies attitude where illustrated. From this question 22 of the companies asked, implied a positive attitude towards using hydrogen on their own vehicles (appendix 3). This positive attitude can be connected to the fact that if a consumer believes that the consequences of a specific behavior will generate good things, the attitude is generally positive. As much as 19 companies indicated that they had a neither positive nor negative attitude towards hydrogen fueled vehicles. Only 5 of the companies asked where negative towards using hydrogen on their vehicles today (appendix 3).

A statement was asked in order to understand the companies' attitude towards usage of clean fuels, perceived as climate and environmental friendly fuels. The answers from the statement *"For my company the usage of clean fuel is..?"* over 80 percent of the companies asked stated that the usage of clean fuels are important for their company, while only 1 company stated

that this was an unimportant factor. These results implies that the majority (n=37) of companies asked believes that it is of importance to use clean fuel in their industry (appendix 3). This can be confirmed with the fact that all respondents that use environmental friendly technology in their company use the EURO VI standard approved by the European Union.

5.3.2 The consumers social norm

In the regression analysis of the theory of planned behavior the concept of consumers' social norm indicated to be of a low impacting factor on intention. The given variables for social norm in this research focused on how the companies presumed that other companies in the same industry perceived them.

The first variable question for the context of social norm was the question *"To what extent do you believe that other perceive your company as environmental friendly?"* To this question a large number of the companies asked presumed that other companies in the same industry perceive them as an environmental friendly company. This is presumably closely related to the environmental requirements given from the government in Norway. It is presumed that the government has a substantial influencing statement voice since only 10 percent (n=5) of the respondents expressed a small extent of perceived environmental friendliness (appendix 3).

What is interesting to see is the fact that as much as 50 percent of all companies asked believe that other companies perceive them as to a neither large nor small extent as environmental friendly, but when the company is asked how their attitude and importance of being environmental friendly over 87 percent illustrated their own importance of environmental friendliness (appendix 3). This can be connected to the relationships between the companies, and the social norm. From this research it is assumable that the companies don't feel affected by the other companies' opinion towards environmental friendliness. Social norm is estimated to be the factor of least importance for generating a behavioral intention towards attitude. This can therefore be one of the reasons that the companies perceive others companies perspective towards being environmental friendly as to a neither large nor small extent of importance.

Following, the question was asked *"How do you believe other companies in the same industry as you would perceive your company if you had changed to hydrogen fuel today?"* The results from this question clearly indicated that there is a positive attitude towards hydrogen as a fuel in the transportation industry. This argument is grounded in the fact that 60,9 percent believe that other companies would perceive their action of using hydrogen as positive, and that only

4,3 percent believe that introducing hydrogen is an negative factor for the company (appendix 3). This gives positive implications for introducing hydrogen to the fuel market, as companies clearly states the environmental importance of hydrogen.

The environmental importance of hydrogen was further indicated as the question *"To what extent do you believe that other perceive your company as environmental friendly with the usage of hydrogen?"* was asked. For this question the companies asked stated that they perceive hydrogen as an environmental friendly fuel, as much as 65 percent believe that they would be perceived as more environmental friendly if they changed to hydrogen vehicles (appendix 3). It is assumable that the transportation industry focuses on being environmental friendly and using the latest environmental friendly technology available on the market. Currently the most environmental friendly fully-fledged engine technology used in the road transportation industry is EURO VI diesel engines. As long as the hydrogen technology is comparable, either on the same level or better, the hydrogen has the possibilities to substitute a substantial amount of diesel trucks.

For the question asked in the survey *"Do you dispose any vehicles with zero-emission technology today?",* the ones that stated that they do, answered to the next question *"if yes, which kind?"* that they used the EURO VI engine, after the European standards. The EURO VI is the current standard, the year of research, for heavy duty vehicles. This is a standard for emission regulations that are created and adopted as a part of the European Union framework (ec.europa.eu, 2016). In the research report conducted by Weber and Amundsen (2016) the results states that the busses that meet the EURO VI- requirements have an thirty times lower emission value of NO_X than the last generation of busses. This intentionally indicates that the focus towards lower emissions is sharpened, both from the governmental requirements, but additionally the fact that the truck companies have invested in this technology shows an environmental friendly focus.

5.3.3 The consumers perceived behavioral control

The consumer perceived behavioral control is an important factor in determining the outcome from a development of a new market. If the consumers believe that they don't have the funds or capacity to change to hydrogen fueled vehicles, the market would face a lower fuel demand. In order to understand the perceived behavioral control, the companies were asked about their willingness to pay, funds and capacity.

The first question connected to the consumers perceived behavioral control was *"To what extent do you believe that your company has the funds and capacity to change to hydrogen fueled vehicles?"* The results expressed that a small overweight of 20 consumers believe that they have a small extent of funds and capacity to change to hydrogen fueled vehicles (appendix 3). This is supported by the following informants' company statement on capacity "*A small firm like mine doesn't have the economical muscles to be a "testing unit" for introducing hydrogen".* This is presumably because the consumers perceive the investment cost as higher than to proceed the usage of their current vehicles.

Only 23 percent (n=11) of the companies asked presumed that the company to a large extent have the funds and capacity to change to hydrogen fueled vehicles, while 15 companies implied that they had an neither large nor small extent to perform a fuel shift (appendix 3). Changing towards hydrogen technology and fuel are determined to be a cost effective solution if the comparison of the vehicles and prices conducted in this thesis are reliable. There are several risks connected to changing fuel technology. In addition, risks are usually strongly connected to higher costs. Risks are perceived as an important factor for the companies asked. Their perception of risks is related to the purchase cost of the vehicle and further subsequent cost connected to the vehicle technology. These are of substantial importance if the companies already perceive their purchasing capacity as limited.

Several questions were asked towards the consumers' willingness to pay for hydrogen in order to understand the company's perceived behavioral control. The willingness to pay was measured through the factors of purchasing the vehicle, the price of the hydrogen fuel and the price for services and maintenance on the vehicle. The statement of *"How is your company's willingness to pay for hydrogen fuel?"* was asked and the results indicated that most companies are willing to pay the same amount for hydrogen as for diesel, as long as the vehicle capabilities and performance is the same for both options. For the price of buying hydrogen fuel, 65 percent stated that they were willing to purchase hydrogen at the same level as the price for diesel (appendix 3). As of the prices today, and the calculation conducted in this thesis, the estimations determine a reasonable price level for the consumers to purchase hydrogen.

A consumers' willingness to pay for the fuel depends on the vehicle used. Therefore the pursuing question relates to the purchasing price of the vehicle. The answer from the statement "How is *your company's willingness to pay for a hydrogen vehicle?"* Indicated that

for the price of buying the vehicle, over 60 percent of the respondent illustrated that they were willing to pay the same amount for a hydrogen vehicle, as for a diesel vehicle, making the willingness to pay equal to the existing technology. This willingness to pay is presumably related to estimated budgeted cost and the company's previously purchasing experience.

In addition the consumers' willingness to pay for service and maintenance was measured. This was conducted through the question *"How is your company's willingness to pay for a hydrogen vehicles service and maintenance?"* In accordance with service and maintenance on the vehicle, the total of 67 percent stated that they were willing to pay the same amount for the service and maintenance on a hydrogen truck, as they do on a diesel truck today (Appendix 3). Nikola Motor Company has estimated the monthly price for service and maintenance on their trucks to be at a level of $0.06 per mile while diesel trucks are estimated to be at a level of $0.12 per mile per month (Nikolamotor.com, 2016). This remarkable difference is of substantial impact for the companies as the cost of service and maintenance can be halved. The consumers' willingness to pay the same amount as diesel was not revolutionary findings, as companies already has budgets matching the diesel prices of current level.

5.3.4 The consumers intention

The concepts of attitude, social norm and perceived behavioral control create the basis for the dependent concept intention. To fully understand the respondents' intention the statements asked is connected to persistence of intention. They are therefore asked as variables in a matrix with a slightly difference between the statements.

Based on the statement *"My Company expects to be early in the process of using hydrogen vehicles"* the majority (n=28) of the respondents illustrated that they neither agree nor disagree. The 11 positive actors agreed to the fact that their company expects to be early in the process of using hydrogen vehicles, while only 7 companies disagreed (Appendix 3). It is presumable to believe that the majority of the respondents haven't created an opinion or stated a clear intention towards the company expecting to be early in the hydrogen process. This is additionally a factor that is presumed to be affected by the factor of intervening time. This is a situation where the time between the research conducted and the actual behavior occurs is substantial.

Following, the statement is formulated with the focus on the company's wish, and the results of the statement *"My Company wishes to be early in the process of using hydrogen vehicles"* are stated. This statement shows that there are slightly more respondents (n=18) that wish to be a part of the introduction process of hydrogen, than the groups that expect to be a part of the process. Half of the companies asked (n=23) stated that they neither agree nor disagree to the fact that their company wishes to be a part of the early process of introducing hydrogen vehicles to the market (appendix 3). The fact that the consumers neither agree nor disagree to being a part of the introduction phase is presumably connected to their concerns of introducing a new fuel and technology. This insecurity is confirmable from one of the informants stating that *"Currently we need to be technology neutral. We are going to use what in the future shows to be the best alternative for both climate and economy".* Implying that their company will wait to perform a technology change until the best technology for emission reduction is proven through testing and trial periods in the Norwegian climate and environment.

Based on the last statement connected to intention the pursuing results were given from the statement *"My Company intends to be early in the process of using hydrogen vehicles".* Fourteen of the companies asked indicated that they agree to the statement that they intend to be early in the process of using hydrogen vehicles in the Norwegian hydrogen market. Overall, the results generates the main assumption that the respondents indicate a neutral intention (n=24) towards participating in the early process of using hydrogen vehicles (appendix 3). Despite their intention to participate early in the process the respondents and informants shows a positivistic attitude towards using hydrogen as a fuel, and that their clear intention will come on a later perspective when the technology is fully introduced to the market. This assumption is founded in company's attitude towards risks that can occur with the technology and in the market. The assumption relates to the fact that even though the respondents express their positivity, there are still many of the respondents that express their insecurity towards the risks in introducing a new technology. There are several risks connected to an introduction of a new technology in every market, and especially in the transportation industry. The risks indicated by the informants are connected to the *Safety for the driver* and possible *fire hazard, when a hydrogen vehicle is involved in accidents.* Hydrogen, as all types of fuel should be treated carefully, as the fuel has a fire and explosion hazard. The vehicles produced today are required to follow several standards in order to

reduce the risks for the driver. The hydrogen vehicles produced has a high safety level and is considered to be as safe as a fossil fueled vehicle (Norskhydrogenforum, 2016).

In addition, the transportation companies express insecurity to goods that hydrogen vehicles are able to transport, as of how hydrogen will act when *the freight of hazardous good* is *combined with hydrogen in an accident.* A hydrogen vehicle is as safe as driving any other fueled vehicles. The technology introduced to the market today follows the safety standards and measures set by governments. The hydrogen fuel tank is especially protected in case of an accident, and safety valves secure the hydrogen from ignition (Norskhydrogenforum, 2016). This indicates the fact that hydrogen vehicles are as safe as any other fueled vehicles.

The consumers questioned and stated the importance of the hydrogen vehicles *weight problems and loading capacity*. This is expressed because the companies don't want the loading capacity of the vehicles to be receded. A receded loading capacity for the vehicles generates economic problems as the vehicle is not able to transport as much goods as intended. The Nikola One is estimated to have a payload capacity of 29, 4 ton (Nikolamotor.com, 2016), which is 19 ton more than the average truck distributes daily in Norway (Stølen, 2016).

The positive attitude, the consumers' relative high willingness to pay for hydrogen fuel and their perceived environmental aspect of hydrogen indicates that the consumers are willing to purchase hydrogen vehicles when they are launched to the market. It is therefore reasonably to interpret that the HyWays-rapport, which stated the estimation that approximately half of the transport sector is in the future expected to perform a shift towards hydrogen vehicles, is correct.

5.4 The market stakeholders

This stakeholder analysis bases its analytical framework on the producers of hydrogen and its related stakeholders. The producer of hydrogen is the closest stakeholder to the resource and determines the production, giving the predictions for this stakeholder analysis. This is because it is presumed that the stakeholders of a company have the possibilities to affect and be affected by the production of the product. For hydrogen as a finished product and fuel, several stakeholders have the opportunity to positively or negatively affect or be affected by the production.

The hydrogen fuel market has at this stage a number of current stakeholders, without being a fully-fledged operative market. The government, producers of hydrogen and its competitors together with the demanders are considered to be the most important stakeholders in this analysis. There are several factors that the hydrogen fuel market depends on in order to be a fully-fledged competitive market. These factors are controllable by the different stakeholders in the market and therefore generate the importance for incorporating a stakeholder analysis. The stakeholders mentioned further in the analysis are actors that is presumed to have a special importance in the developing- and introduction phase in a hydrogen fuel market.

5.4.1 The government

The government holds a great amount of power and control when it comes to developing a hydrogen fuel market. This is mainly because the government has the power to adjust the market methods and instruments. The government of Norway, and the ministry of climate and environment, has currently very consumer-beneficial subsidies for electrical vehicles, which are applicable regulations for hydrogen-consuming vehicles. These subsidies are affecting factors such as lower vehicle purchasing cost, lower ferry taxes, toll taxes, annual vehicle fee etc (Klima- og miljødepartementet, 2016).

The group aligned by the Norwegian ministry of transportation and communication stated in 2003 that at a stage where hydrogen-fueled vehicles are available to the Norwegian market, tax incentives or other preferential measured should be applied (Regjeringen.no, 2004). In the governmental proposal for 2017 it is proposed a budget for subsidies and support for national and international environmental projects to 59 million NOK (Klima- og miljødepartementet, 2016). Tariffs, subsidies and quotas stated by the government have the opportunity to insulate a domestic market from international trade and support the domestic firms to compete against foreign rivals (Carlton and Perloff, 2005).

The importance of the governmental role was expressed by one of the informants through the statement *"It is important, once and for all, to try to include the whole country by introducing the product widely, when the government is sure that this is the "future commitment".* This clearly indicates that the companies depend on subsidizing from the government. Subsidizing from the government is perceived as an important economical supplements for companies in order for the companies to follow the required targets set by the government.

The role of the government is predicted to be central in the completion of a fully-fledged hydrogen fuel market in Norway. This on one hand is because potential consumers of the transportation industry have stated the importance of support from the Norwegian government in order to adopt hydrogen as a fuel in their sector. On the other hand an expert group from the Norwegian government stated the importance of hydrogen development already back in 2003. At that time they determined a suggestion that the government should provide investment support or direct project financing as public support for hydrogen usage at an early market stage. Furthermore, in the same rapport the expert group suggested that when the market reaches a level where hydrogen-fueled vehicles are available for consumers, tax incentives or other preferential measures should be applied by the government in order to assist and support initial market penetration for hydrogen vehicles (Regjeringen.no, 2004).

Andreas Wessel, owner of a small hydropower plant in Norway commented in an article on the future of hydropower sourced hydrogen productions that *"if investments in hydrogen production should be executed, our company would be dependent on support from the government in an market introduction phase"* (Ramstad, 2016). This statement underpins the importance of the governmental role in the introduction phase of hydrogen. The companies expressed that their perceived behavioral control towards hydrogen at a low level, which indicates that governmental support will be of substantial importance in order to generate a fully-fledged hydrogen market in Norway.

The governmental support is determined to be highly important in order for hydrogen fuel to become fully-fledged in the market. If the government aims to reach their targeted climate and environmental goals their subsidizing support to the market will be of substantial importance. The governmental NTP goal states that *"by 2030, new heavy vans, 75% of long distance busses an 50% of new lorries are to be zero-emission vehicles"* In order to reach this goal there is a substantial importance of governmental support. It is important than new zero-emission technology such as hydrogen gets the opportunity to substitute other pollutant solutions. As one of the respondents stated, "*We are a small company and therefore the government should participate by giving subsidies and guarantees to all existing transportation companies in Norway".* Based on this statement the potential consumers assign the importance of the governmental support and are seen as one of the most important actors in a potential hydrogen market. The substantial impact the government can generate is essential if the targeted statements of emission reduction should be achieved.

The government will have a substantial role in the introduction phase of hydrogen, in order to gain a group of demanders. As the estimations of the market situation indicates a potential market shortage the governmental role is still of a significant factor in order to create and develop a market. Without the governmental support, there is a lower probability for generating a fully-fledged market.

5.4.2 Political groups

The county-municipality of Sogn og Fjordane in Norway has started an Hydrogen project in order to become a leading Hydrogen region in Norway. The project is a commitment between the county municipality and five local municipalities of the county. The main aim of the project is to map the opportunities and challenges the municipalities possibly could face within the fields of production, distribution and usage of hydrogen. In addition the project aims to explore the future possibilities to cooperate with the business society and create competence strategies with the local research institutions (Helgheim, 2016). The year of research the actors in the hydrogen market have the possibilities to apply for funds in order to finance preliminary projects that overall contribute to the future development of hydrogen-based value chains in the region of Sogn og Fjordane country (sfj.no, 2017).

Several municipalities in Norway have additionally expressed their positive gratitude towards introducing hydrogen in their region. The municipality of Bodø has emphasized their wish to become the hydrogen-capital of Norway. In order to reach this goal, the municipality has together with local actors such as the local business community, the county municipality Nordland and the local personal transportation company Nordlandsbuss in order to be the leaders of hydrogen technology in Norway (Jensen, 2016). The positivistic attitude form the political groups indicates that hydrogen have the potential to be an important part of the environmental future.

5.4.3 Activist groups

At the current stage there is not to be found any specific activist groups protesting against hydrogen. On the other hand, there are activist groups supporting hydrogen development in Norway. Bellona is an environmental activist foundation which through identification of sustainable climate solutions work towards changing the environmental and climate

challenges (Bellona, 2016). Bellona published already back in 2002 a positive report about hydrogen and how hydrogen can contribute to an emission free society (Buch, 2002).

5.4.4 Customers

There are several potential customers to the hydrogen market industry. The thesis focuses mainly on the road transportation industry in Norway, but there are several other customer groups to the field of hydrogen.

The rapport generated for the European HyWays project stated that the main market for end-use hydrogen customers are within the transportation industry, preferably within the segments of passenger transportation, light duty vehicles and city busses (HyWays, 2007). Hydrogen fueled busses has been tested in Norway the past few years, as a pilot project. In 2012 the first hydrogen city busses was launched in Oslo as a pilot connected to the HyNor project, subordinate to the CHIC-project. The purpose of the project was to firstly test out then further fully commercialize and integrate hydrogen as a fuel in the public transportation systems in Europe. One of the main aims with the project was to consider the environmental, economic and social benefitting results of using hydrogen city busses (NHO transport, 2012). In January 2017 the project decided to invest 39 million NOK in order to keep the city busses rolling for five more years. The report from the superior CHIC-project indicates that the fuel consumption has been of high cost-effectiveness as the consumption has been 26 percent more effective than the comparable diesel busses. The rapports state a CO_2 emission reduction of 85 percent by using hydrogen instead of diesel fueled busses (Dalløkken, 2017). This CO_2 reduction is of substantial importance in order for the Norwegian government to meet their targeted goals. In addition, the usage of public transportation vehicles is one of the Norwegian government's focus points of reducing the GHG emissions, as they change to more environmental friendly ways of transportation (Regjeringen.no, 2014b).

The governmental regulations state a reduction of emissions throughout the whole transportation industry, which in addition includes the transportation by sea. In Norway there are 138 operative ferry connections within the country, with a respective amount of ferries (vegvesen, 2017). Statens Vegvesen (the Norwegian Public Roads Administration) has now published a bidding process for a development contract for a hydrogen-electrical driven ferry to be used on the connection between the distance of Hjelmeland and Nesvik. Hydrogen is

preferred for this distance due to the capabilities, such as the range extend, that hydrogen provides, contra a pure electrical ferry (vegvesen.no, 2017).

Hydrogen is in addition attractive for private consumers, as new hydrogen cars are launched to the market. Several of the largest car producers are launching their hydrogen versions to the market, creating a demand for hydrogen. The market for private vehicles are not currently predicted to be large, as the electrical vehicles still controls a substantial part of the environmental vehicle market. Hydrogen is a positive development introduced to this market due to special features such as the range extender, compared to fully electrical vehicles.

In 2014 the executive director of Alstom AS Carl Åge Bjørgan expressed in an input to the governmental energy statement that he believed that hydrogen can replace diesel within the Norwegian railway industry (Bjørgan, 2014). Today there are diesel locomotives between the distance of Steinkjer and Bodø. Performing a fuel change towards either battery or hydrogen on this distance is estimated to decrease the total costs with 300 million NOK on a yearly basis (Tønseth, 2016). Preferring a hydrogen solution to this railway would not only be cost effective, but additionally have a substantial impact on the governments targeted emission reductions.

Hydrogen has additionally the possibilities to be used in other businesses than the transportation industry. In Norway the telecommunication network and the electricity grid is vulnerable towards storms or other disorders. There are therefore possibilities for using hydrogen in a reserve power system for base stations such as hospitals. This would generate a more environmental and climate friendly system than the diesel aggregates used today (Vätgas Sverige et al., 2013). This clearly illustrates that the market is ready for hydrogen, and the producers can expect demand from several different customer groups within the transportation sector.

There are several projects currently in development. The smelting enterprise Tizir in Tyssedal has signed a contract with the companies Greenstat and Sunnhordaland Kraftlag (Power Company), in order to create a full scale production plant in the municipality. Their aim is to produce 30 ton hydrogen each day from 2019 (Hirth, 2016). This illustrates that hydrogen have several application areas. The hydrogen is in this case determined to be used as an energy source in the smelting enterprise.

5.4.5 Producers

As this thesis is written on request from the company Østfold Energi, the company is used as a reference point in order to describe the producers of hydrogen.

Østfold Energi is as a growth-oriented energy producer which is continuously striving to develop their activities within the segment of renewable energy. The recent years the company has conducted several investments in other renewable-focused companies. These investments are in order to increase their total production of renewable energy. Their main focus areas within the segment of renewable energy are hydropower, wind power and district heating. The company currently own and operates hydropower plants in the counties Sogn og Fjordane and Østfold (Ostfoldenergi.no, 2015a). The company has a highly focus on renewable energy and has set an specific internal goal for the company, in order to become entirely climate neutral within 2020 (Ostfoldenergi.no, 2017). The company is always exploring for new ways to develop their energy. With their renewable energy perspective in mind they are aiming to create a hydrogen factory in the western part of Norway. In this area, Østfold Energi owns a hydropower station and a share of a line network towards the local community of Årdal. In Årdal, there are production facilities ready for Østfold Energi to use in order to start a production for hydrogen at a small scale plant (Brugrand O.H. and Grimeland P.K., 2016).

The current project plan, the year of research, is to use power from their own hydropower station to generate power in order to create hydrogen with the use of electrolysis production (Brugrand O.H. and Grimeland P.K., 2016). At this stage of the process, the current plan is to have a pilot plant working from the end of year 2017, and later develop it in to a small scale production plant (Sylvarnes, 2016).

5.4.6 Competitors

There are several actors attempting to be producers in a competitive hydrogen market. The methods for preparation of hydrogen renewably are diverse. The current status illustrates that electrolysis is the favorable method for manufacturing hydrogen, and that the difference in production of hydrogen will differ mainly in the source of energy. There are several hydrogen projects currently at the drawing table in Norway. Several of the interested producers presume that hydrogen is the future solution and rescue for the transportation industry in order to comprehend with the emission reduction targets.

The currently largest hydrogen project with Norwegian actors today is the Hyper project which is led by the research institute Sintef Energi. They are partners with the national and international companies NEL, Statoil, Linde Kryotechnik, Mitsubishi Corporation, Kawasaki Heavy Industries, Shell, NTNU and the Japanese Institute of Applied Energy. Together these companies seek to find the best production method in order to generate hydrogen for the Norwegian market. NEL, one of the partners involved in the project has a vision of developing a production plant in Norway with a production capacity of 225 000 ton hydrogen produced on a yearly basis (Hirth, 2016).

A commitment to hydrogen fuel and technologies has the ability to generate technology-based business development and value creation for the Norwegian society. Norway has today a substantial amount of specific knowledge and focus on production of hydrogen, shipment technologies, electrolysis production and fuel cell technology. Hydrogen fuel and technology have therefore the ability to generate an increased employment rate in Norway (Forskningsraadet.no, 2006). Technology development and further research will be of substantial importance for generating employment and further research and development of the technology.

5.4.7 Suppliers

In order to produce hydrogen a additional energy source is necessary. For Østfold Energi as an energy producer with owner shares in hydropower stations the source of energy is supplied internally within the company. For other companies the production can require a supply of a separate energy source from an extern supplier. Knut Olav Tveit, the Executive Director for Småkraftnæringa (the association for small power companies in Norway) has expressed to an article that production of hydrogen has the ability to strengthen the operation of small power stations in Norway (Lie, 2013). A development like a hydrogen production plant can lead to increased employment within the hydropower industry and additionally an extended utilization of the hydropower resource.

5.4.8 The stakeholder relations

Hydrogen is definitely the current fuel of interest in the energy market and several stakeholders explores the opportunities to be a part of this development. The van Bree et al. (2010) illustration of the actors in the multilevel perspective of introducing hydrogen vehicles, gives an visualization of the relationship between the actors in a hydrogen fuel market.

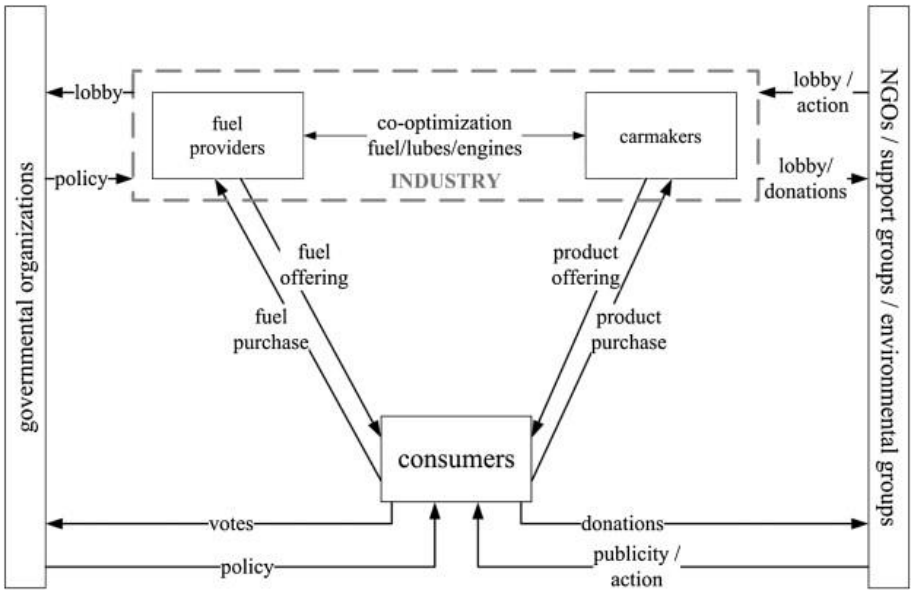


Figure 5-7 The actors in a hydrogen fuel market

This model illustrates the relationship and dynamics between the different actors of a hydrogen fuel market. The government is strongly connected with the consumers where votes given from the consumers reflect and generates policies for the consumers to follow. The government additionally affects the fuel providers and vehicle producers through policies, and opposite through lobbying. The consumers additionally affect and are affected by the hydrogen fuel providers through their supply and demand relationship. The market mechanism is affected by the changes in their relationships. Additionally the same accounts for the vehicle producers. The suppliers and demanders affect each other through their relationships. Consumers affect the environmental groups and national governmental organizations through donations in order to generate publicity and actions in the market. Further the governmental organizations and environmental groups can affect or be affected by the production industry through lobbying. All the actors have an important role in the market in order to affect each other through factors such as production level, price level and market ownership and shares.

5.5 The political and environmental framework conditions of the hydrogen market

There are several benefits of changing to hydrogen fuel and technology in the transportation industry. Former conducted research illustrates that there is a highly importance connected to the environmental aspect and how the politicians and government affect the attitude towards environmental friendly technology. The conducted survey for this research therefore considered the possible factors that where of substantial importance for the process of changing to hydrogen as a fuel. The factors included in the analysis are factors that are based on affecting factors of previous introduction of electrical vehicles to the market and are presumed to influence a consumer's behavior towards a new technology. These factors have been of great success to the subsidized factors for increasing the demand for electrical vehicles, which represented a major difference for developing the fully-fledged market for electrical vehicles as currently known.

The pursuing analysis desires an understanding of the differences between the groups that already have environmental friendly technology in their vehicles contra the group that currently doesn't have emission reducing technology. Following is a summary statistics of the relationship between the use of environmental friendly technology and the importance of the depending factors. The first factors of the analysis are cost related factors, while the rest are more related to the overall framework required.

Table 5-2 Summary statistics of importance factors

Variable name	Definition	Mean	Std. dev.	Min	Max
Annual fee	Importance of annual fee	2,02 (2,33) [1,87]	0,93 (1,17) [0,76]	1 (1) [1]	5 (5) [3]
Toll fee	Importance of toll fee	1,80 (1,80) [1,80]	0,90 (1,14) [0,79]	1 (1) [1]	5 (5) [3]
Ferry fee	Importance of ferry fee	2,10 (2,06) [2,12]	1,03 (1,22) [0,95]	1 (1) [1]	5 (5) [4]
Purchase fee	Importance of purchase fee	2,02 (2,20) [1,93]	1,08 (1,14) [1,06]	1 (1) [1]	5 (5) [5]
Special rights	Importance of special rights	3,1 (3,06) [3,12]	1,05 (1,22) [0,99]	1 (1) [1]	5 (5) [5]

Own filling station	Importance of own filling station	2,56 (2,33) [2,67]	1,12 (1,39) [0,97]	1 (1) [1]	5 (5) [5]
Ordinary filling stations	Importance of ordinary filling stations	1,63 (1,66) [1,61]	0,87 (1,17) [0,71]	1 (1) [1]	5 (5) [3]
Dieselprice	Importance of the diesel price	2,73 (2,53) [2,83]	0,93 (0,91) [0.94]	1 (1) [1]	5 (4) [5]
Required usage	Importance of required usage in tenders	2,13 (1,93) [2,22]	1,02 (1,09) [0,99]	1 (1) [1]	5 (5) [4]
Required emission reduction	Importance of required emission reduction	2,06 (2,26) [1,96]	0,95 (1,09) [0,87]	1 (1) [1]	5 (5) [4]

1=highly important, 5=highly unimportant.
Values presented normally are for all the respondents. Values in parentheses () are for the consumers with environmental friendly technology. Values in brackets are for the consumers without environmental friendly technology.

The results from the analysis show that the average opinion for all respondents asked is that a reduction of the weight annual fee for the vehicle is of importance for investing in hydrogen technology. In Norway, owners of vehicles pay an annual fee to the government. Vehicles over 7500 kg, the category related to this thesis, pay a weight annual fee in order to drive on Norwegian roads. The weight annual fee payment depends on the vehicle weight, number of axels and suspension system (Skatteetaten, 2017). An interesting observation from this result is the fact that the importance of the annual fee is higher for consumers that doesn't have vehicles with emission reducing technology.

The toll fee has a relatively high importance level for all respondents asked in this research. This finding is presumed to be closely related to the political and governmental aspect in Norway. The road infrastructure developments have always been mainly financed by the toll fee income, leading to high payments for all passing vehicles (Regjeringen.no, 2016). The importance of the toll fee for the transportation industry is understandable as this industry has vehicles that have a substantial amount of toll passing throughout a month. The government of Norway has stated that through the new national transportation plan (NTP 2018-2029) the investment pattern is changed, with more governmental grants than previously (Samferdselsdepartementet, 2017). The government has invested 500 million NOK in order to

reduce the current complexity aiming to further reduce the current operating costs and increase the user-friendliness of the toll fee collection (Regjeringen.no, 2016). Nevertheless, the toll fee is stated as an important factor for consumers in order to perform an investment of a hydrogen vehicle. This is grounded in the fact that the industry perceive the toll cost as a high budget cost, and would aim to reduce all potential costs.

The ferry fee as a cost factor impacts the attitude towards the consumers' behavior of purchasing hydrogen technology. The respondents indicated an importance, but at a slightly lower level than the toll fee. Both the toll fee and the ferry fee are related to the cost of purchasing transportation access and are closely connected to the national transportation plan. This is assumable the fee that would not be approved by the government as cost reduction to driving a hydrogen vehicle, despite the success from electrical vehicles. The year of research several instances has expressed that electrical vehicles should pay the ferry fee, and presumably this will be the future solution. Drivers of electrical vehicles have had the exemption from the ferry fee the latter years. This exemption has been one of the affecting governmental subsidizations that have generated a higher purchase of electrical vehicles and especially in areas with ferries (Valgermo and Kjølås, 2017).

The results from the analysis illustrates that the companies that doesn't have low emission technology wants the purchasing fee for the vehicles to be reduced in order to perform a change to hydrogen vehicles. The difference between the groups is small since both parts perceive the purchasing fee as an important factor of investment. The group that doesn't have emission reducing technology indicates a higher rate of importance than those who currently has technology for emission reduction.

The results indicates that the factor of special rights for companies that drives hydrogen vehicle is less of an importance for both the group that have emission reducing technology and the group that doesn't. This is presumably because the consumers perceive it as more important to prioritize governmental funding and subsidies than to develop special rights such as parking facilities for hydrogen vehicles.

The factor of highest importance in the analysis for both the respondent groups that have emission reducing technology and the respondents that doesn't, is the factor of having the filling station on ordinary filling facilities. The network and fuel station infrastructure of Norway are currently thoroughly developed and probably the main reason for wishing to have the opportunity to fill hydrogen there, and not having special fuel stations for hydrogen. One

of the informants confirmed this with stating "*it is of highly importance that the focus in on development of fuel stations and infrastructure"* in order for hydrogen to be a realistic competitive fuel. Additionally, the importance of the fuel infrastructure in the introduction phase was determined in the HyWays project report when stating *"in order to develop hydrogen to be an attractive fuel and facilitate its deployment among users it is necessary to supply hydrogen along the road network"* (HyWays, 2007).

The importance of having a fully-fledged infrastructure for filling stations before introducing hydrogen was implied by an informant company. They stated "*Before this is a relevant topic, there is a must for creating fuel points. Our company drives the distance from Kristiansand to Alta, where several fuel points are substantial. Without planned and established infrastructure, this isn't a topic for us".*

The price difference between hydrogen and diesel has been one of the focusing factors in the analysis as price reflects a company's perceived behavioral control. From the analysis the fluctuation and level of the diesel price is of importance, but to a lower level than the other factors. Hydrogen is determined to have a lower price per mile driven than diesel. This factor just confirms the previously stated results. The consumers' willingness to pay for hydrogen is equal to the current price level of diesel.

The factor of required usage in tenders and procurements was included in the research in order to understand if this is an important factor for changing technology. For the respondents with emission reduction technology this appears as more important than for the other respondent group. In 2001 the law of public procurement was introduced by the Norwegian government. This law discloses, among others, regulations towards environmental friendly procurement. The law of public procurement demands that during the process of planning a purchase the focus of the procurement should be of substantial environmental consideration (Miljøverdepartementet et al., 2007). This indicates that for any public procurement hydrogen vehicles would be a beneficial and preferable variant. This could further indicate that there is a potential market for procurement of garbage trucks within the public sector.

The government has set strict goals in the emission policy for the transportation sector in Norway. The respondents that don't have emission reducing technology today expresses that the factor of legally required emission reduction is a factor of importance for their group, in order to perform a fuel shift. This is to a greater extent than the ones that already have emission reducing technology. A possible reason for this is that the ones that don't have

technology for emission reduction probably don't perceive the importance of using such technology. A requirement would therefore be of a substantial importance for these companies in order to perform a fuel shift. Overall the standard deviation of this model illustrates that the opinions and viewpoints are gathered, and further implies a low diversification.

5.6 The hydrogen market situation

The SWOT analysis is included in order to fully summarize the current hydrogen market situation and this empirical analysis. The SWOT aims to visualize the different strengths, weaknesses, opportunities and threats in the current Norwegian hydrogen market.

5.6.1 Market strengths

The main strength that hydrogen contains compared to other fuels in the market is the level of climate and environmental friendliness. Hydrogen is determined to generate a great extent of emission reduction, and is presumed to be the preferable solution for the Norwegian government, in order to achieve their targeted emission goals.

As illustrated in this thesis is hydrogen fuel presumed to be a cost effective alternative to diesel. The consumers' willingness to pay is at a higher level than the current market price for hydrogen. This higher willingness to pay can potentially generate a higher demand than expected for the fuel when the vehicles are introduced, as consumers would observe and understand the beneficial factors of using hydrogen contra other fuel sources.

Producing hydrogen from hydropower would lead to increased utilization of the resource and the supplying resources. The abilities for generating more hydropower and exploiting this resource could lead to further development of power stations in Norway. As hydropower is an energy source generated naturally through the great waterfalls in Norway, exploiting it would only generate positive effects for the society, such as increased employment.

Introducing hydrogen to the Norwegian market will generate an increased interest within the fields of research and development, stimulating the scientific environment in Norway. This would additionally lead to increased employment within research and development.

5.6.2 Market weaknesses

There are always certain risks when introducing a new technology to the market. New technology usually face "childhood diseases" and consumers usually express uncertainties towards new products. The potential consumers expressed uncertainties and dread towards introducing hydrogen to the Norwegian market. This fear was mainly connected to how hydrogen fueled vehicles would act in cold and harsh Norwegian environment and with hazardous goods. Hydrogen vehicles estimated to have the same features as diesel vehicles, and have the possibility to start at a level of minus thirty degrees Celsius.

5.6.3 Market opportunities

A newly introduced market for hydrogen fuel will lead to a great number of opportunities. Renewable hydrogen will have the opportunity to expand to other market segments than the heavy duty transportation industry. The emission reducing success of the city busses connected to HyNor project indicates that expanding hydrogen to busses all over the country would lead to a greater amount of emission reduction within the transportation industry, making the ability to target the eccentric future goals.

The sea transport in Norway is additionally perceived as a potential fuel market. Hydrogen ferries are estimated to have a longer range than the battery and gas ferries used today, and have a substantial lower emission than other commercial ferries.

Additionally, the technology for developing hydrogen is not a new phenomenon, but generating hydrogen from renewable energy sources makes the hydrogen fuel to a clean fuel. Further technological research development on hydrogen fuel would possibly lead to a higher utilization of the fuel. Using hydrogen to secure and stabilize the safety of the Norwegian grid of electricity is substantial and a remarkable technology development.

5.6.4 Market threats

Possible threats in the hydrogen market can be competition from other substituting fuel sources. As hydrogen is introduced as a substituting fuel for diesel, this can create competition between the technologies. Increased competition can release threats towards the hydrogen technology and fuel. The opinions from the consumers indicate that hydrogen would be a preferable fuel if it holds it comparable features and capabilities towards diesel. Hydrogen has presumably a longer range, to a lower costs, with faster acceleration and higher

up hills top speed. These factors are determined to be of essential importance for the transportation industry.

A possible threat to the hydrogen market can be deficiency of investors. In order to create a full-fledged market the demand for stable investors willing to invest in the technology, the fuel and its infrastructure is of major importance. Developing the fuel infrastructure and including hydrogen as a fuel to the existing filling stations is the most important framework condition for the potential consumers. If there are deficiency of investors and contracts with fuel stations the value of the hydrogen market would fall drastically.

The higher willingness to pay for the consumers can lead to a demand higher than presumed. The deficiency of suppliers can therefore be a substantial threat for the industry and the market displacement. If the energy source is supplied at a lower level than the production and the consumers demand, this is potentially a substantial threat for the market. The same accounts the other way, if there is substantial investment to hydrogen fuel development and the amount of consumers are at a lower level than estimated; this can generate a possible threat for developing a fully-fledged market. The existing fuel technologies are systematically integrated in the society and are easy to go back to if hydrogen is a failure. It is therefore of substantial importance that the hydrogen fuel and vehicles are introduced perfectly when it is firstly introduced.

Combining and summarizing all the factors mentioned the illustration of the SWOT- analysis can be visualized as Table 5-3.

Table 5-3 SWOT analysis

Strength	Weaknesses
Environmental friendly Cost effective Increased resource utilization Increased employment Increased research and development	Introduction risks Insecurity towards new product
Opportunities	**Threats**
Expanding to other markets Further technological development Generates security of supply	Substituting products Deficiency of investors Deficiency of suppliers Deficiency of demanders

6 Conclusion

In this chapter a conclusion is drawn based on the specific research problem statement and its accompanying research questions. The conclusion focuses on the three different levels of research conducted in this thesis, the market level, the stakeholder level and the consumers' behavioral intention level. The problem statement generating this thesis is:

"Hydrogen produced by renewables - Is the Norwegian transport industry ready for a fuel shift?"

This problem statement is connected with the research questions focusing on the different aspects of the problem statement. The research questions address the current market situation and potential actors, the consumers' intentions towards hydrogen and the kind of framework conditions that is important for the consumer. These research questions are created in order to get a perspective and overview of current situation and answer the problem statement firmly.

- *How is the current market situation for developing a hydrogen market in Norway, and which actors are possibly affected by such development today?*
- *How is the potential consumers' current intention towards a hydrogen fuel shift?*
- *What kind of framework conditions is important for the consumers in order to become an actor in the hydrogen market?*

6.1 The current market situation and the affected actors

The current market situation indicates that the consumers have a higher willingness to pay for hydrogen fuel than the current market price. This situation can lead to a shortage in the market, if the number of consumers hydrogen demand exceeds the number of producers' abilities to supply the market. The Norwegian government is therefore perceived as the most important actor as the government has the power to regulate the market with funds and subsidies. These market tools can generate market displacements for a healthy market structure. The environmental aspect of introducing hydrogen increases the importance of the Norwegian government's role in the hydrogen market. One of the major targeted goals in the NTP is to fulfill the requirements that 75 percent of new long-distance busses, and 50 percent of new lorries are zero-emission vehicles within the year of 2030. These targets are interpreted to be achievable, with the introduction of hydrogen to the transportation sector.

Hydrogen fuel is expected to be an important energy source for the transportation industry within several sectors. Hydrogen ferries are chosen as an environmental friendly variant by

Statens vegvesen due to favorable capabilities such as range extenders. Hydrogen is additionally perceived as a potential replacement to the diesel locomotives in Norway, in order to reduce the emissions from the Norwegian railway industry. Other potential hydrogen markets are hydrogen used as reserve power systems for Norwegian base stations, such as hospitals.

Suppliers to the environmental friendly hydrogen industry are expected to be producers of renewable energy sources. The excess hydropower resources in Norway have the possibilities to generate employments to the existing hydropower industry, as well as the hydropower resources are exploited.

Introducing hydrogen to the Norwegian market will be of substantial importance for several actors. Developing a value chain where exploitation of the hydropower resources in Norway in order to generate hydrogen for vehicles, will preferably lead to reaching the emission reduction targeted goals set by the government.

The potential actors of the hydrogen market are presumably ready for an environmental friendly fuel such as hydrogen. The possibilities hydrogen can develop are several, and the limits are endless as long as there are supporting funds for the projects. Hydrogen for heavy-duty vehicles would potentially generate an emission reduction and gain sustainable development for the future of the Norwegian society. Furthermore, hydrogen could potentially increase the security of supply by interfering with the current energy sources and fuels. This development can be of substantial importance for Norway, as the last forty years has had a specific petroleum related focus.

6.2 The consumers intention towards hydrogen

The road transportation companies, involved in this research as potential consumers, express a positivistic attitude towards using hydrogen technology and fuel on their future vehicles. The factor of attitude is, through the regression analysis of this research, defined as the most important factor for determining the consumers' future intention towards purchasing hydrogen vehicles.

The social norm of using hydrogen fuel and the company's environmental and climate perspective is substantial. The majority expresses a positive attitude of others opinion towards a hydrogen fuel shift. Even though it is indicated through this analysis that the transportation

industry isn't that affected by the other companies' opinion, it is perceived that the aspect of being an environmental friendly company is a social norm generated by the government through laws and regulations.

The consumers perceived behavioral control is affected by their perceived willingness to pay for the vehicle, fuel and maintenance of the vehicle. The level of the consumers' willingness to pay is higher than the current market price, implying that the consumers within the road transportation industry are financially ready for a fuel shift.

The positive intention and the willingness to pay determine that the consumers' intention towards hydrogen is positive. Even though not all potential consumers are interested in being a part of the introduction phase, they are likely to have a positivistic behavior towards hydrogen when the market is fully-fledged.

6.3 Important framework conditions

The informants asked expressed an importance of governmental support in order to purchase and use hydrogen vehicles. The importance of developing a fully-fledged fuel infrastructure is perceived as the most important framework requirement set by the potential consumers. The road transportation industry implies that if hydrogen fuel should be a success, it should be as accessible as other fuels, and be integrated to the commercial filling stations of today.

The several factors that are determined and labeled as important framework conditions are only affecting factors for performing a fuel change. The consumers that have already decided to purchase a hydrogen vehicle would only see it as positive additional benefits if the government facilitates beneficial solutions. On the other hand, the group that haven't made up an opinion or don't want to purchase a vehicle with new technology, these framework conditions are substantial. If the government decides on subsidizing the usage of hydrogen vehicles it is presumable that the amount of demanders would drastically increase within a short period of time.

The road transportation industry is ready for a fuel shift as long as the main actors in the market contribute significantly. The producers should facilitate and secure a development of fuel infrastructure. The suppliers should generate the amount of renewable energy needed for the hydrogen production and the government should facilitate necessary funds and subsidies in order to gain the consumers demand.

The market depends on all the actors to understand and further focus on their market role in order to generate a fully-fledged hydrogen market. The conclusion to this research is summed up by an informant to this thesis, which stated that in the end *"It is the overall picture which is important when changing from diesel towards hydrogen".*

6.4 Implications

This thesis generated its focus on several theoretical frameworks in order to understand the market situation, the actors of the market and the consumers' behavioral intention towards hydrogen. The theoretical framework was grounded in the theory of supply and demand, the theory of planned behavior and stakeholder theory. The findings from this research were used in order to enlighten the theories towards the hydrogen market perspective. The market was analyzed in order for this research to be an applicable tool for understanding and explaining the status of hydrogen today.

In order to determine the potential consumers' substantial market role the rational choice theory was included in order to underpin the consumer behavior. The theory of planned behavior generated the framework for understanding the future behavior of companies in the road transportation industry. The consumers' attitude, social norm and perceived behavioral control were described through findings, and generated an understanding for the future behavior of the consumers in the road transportation industry. The theory of planned behavior is usually connected to pure quantitative research where the main aim is to test the model. For this research the model and theoretical framework was used in order to describe and understand the future behavioral intention of the potential consumers. The findings illustrated positive relations between the independent variables of attitude and perceived behavioral control and the dependent variable of intention. Social norm indicated opinions but didn't indicate a significant impact on intention in the TPB model. Further research could therefore specifically imply the relationship of social norm and intention within the Norwegian transportation industry.

It is interpreted that this research would be of importance for all the potential actors of the hydrogen market. The research is conducted in order to understand the overall market structure, the directly and indirectly affected actors and the consumers' perspective on a hydrogen market development. The findings in this analysis indicate specific perspectives on the future Norwegian hydrogen market.

The government plays one of the major roles in developing a hydrogen market. The structure of the market can be regulated by governmental funds and subsidies in order to generate a healthy market structure. The government can regulate a high demand through financial support to the producers and low demand through subsidizing the consumers purchase. At this stage in the market, the government cannot force a fuel shift for the consumers. It is therefore important for the government to understand how and which of their funds and subsidies that would impact potential consumers to purchase hydrogen vehicles. This empirical analysis implies that the government can impact the consumers willing to purchase through developing a stable hydrogen filling infrastructure, and further grant advantages through lower fees and taxes.

The concept of attitude is determined through this research as the most important factor for determining consumers' intention and future behavior. The producers in a hydrogen market should be aware of the potential consumers' attitude and try to customize and adjust the hydrogen production in order to satisfy the consumers demand. The potential consumers in the hydrogen market have a currently positive attitude towards hydrogen and their current intention indicates that the consumers would have a positive behavior, as long as the time framework doesn't exceeds. The consumers' positivistic attitude can be amplified through affecting the consumers' emotions towards using hydrogen fueled vehicles.

The consumers perceived behavioral control is additionally an important factor for determining the consumers' intention. The consumers' capacity and willingness to pay is therefore important for future consumer behavior. It is therefore of substantial importance that the introduction price for the vehicle and fuel matches the consumers' willingness to pay.

A hydrogen development would generate further research and development within the area. This could generate beneficial effects for the market, such as employment and enhanced hydrogen technology.

6.5 Suggestions for further research

While conducting this research several topics for discussion has been faced along the process. On the basis of the knowledge and understanding gained through this research, the following suggestions for further research can be introduced.

This thesis focuses on the Norwegian road transportation industry's perspective on hydrogen fueled vehicles. It is through this research presumable that other transportation industries are interested in the possibilities and opportunities that hydrogen technology can contribute to in their sectors. Especially the shipment and ferries sectors is presumed to have a highly hydrogen focus within the next years, and are interesting fields of research.

A future analysis on the consumers purchasing patterns towards hydrogen vehicles will determine if this research conducted correctly anticipations and will further indicate the success or failure of heavy-duty hydrogen fueled vehicles.

A more in-depth analysis of the market adjustments and disruptions connected to the introduction of hydrogen fuel in Norway would be substantial in order to predict the future market situation.

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Appendices

Appendix 1 Diesel and oil prices

Dieselprices by YX the 07.04.2017

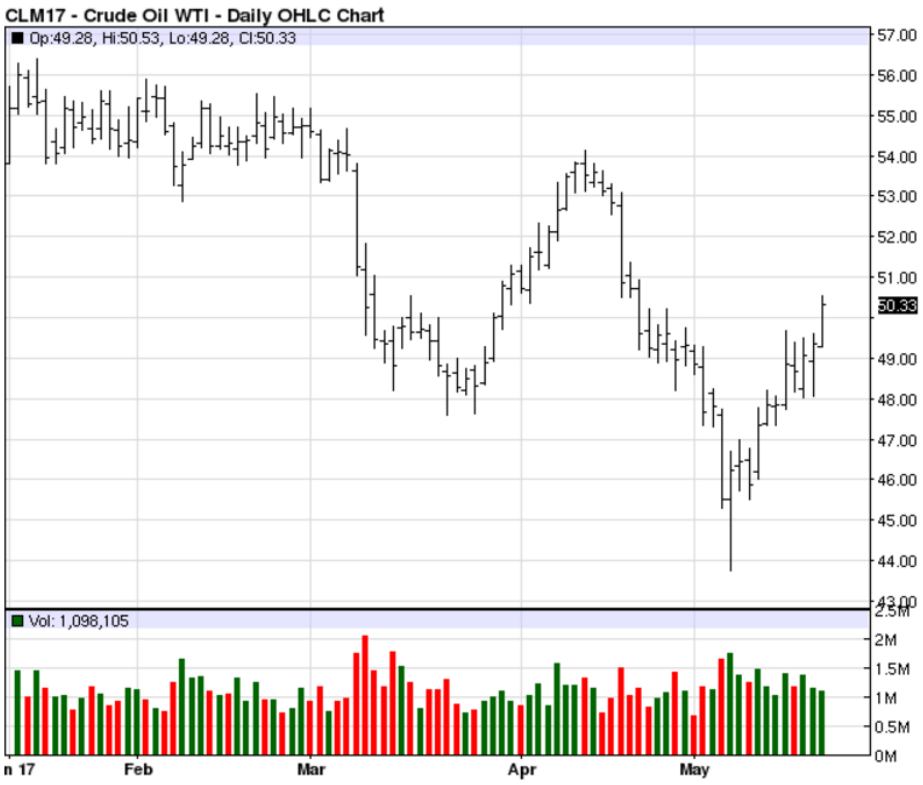
Pris eks.mva:

Diesel 06.04.2017	Avgiftsfri diesel 06.04.2017
Kr **10,71** Per liter	Kr **9,01** Per liter

Pris ink.mva.:

Diesel 06.04.2017	Avgiftsfri diesel 06.04.2017
Kr **13,39** Per liter	Kr **11,26** Per liter

Oilprice WTI Crude by olprice.com 19.05.2017 (oilprice.com, 2017)



Appendix 2 Survey
Spørreundersøkelse

Det skjer en endring mot mer miljøvennlige godstransportløsninger. I forslag til Nasjonal transportplan (NTP 2018-2029) fokuseres det på lavere utslipp fra godstransport på vei. Med dette som bakteppe ønsker jeg i min masteroppgave å fokusere på mulig bruk av hydrogen som energikilde ved godstransport.

Denne spørreundersøkelsen er en viktig del av datagrunnlaget for oppgaven. Jeg vil derfor sette stor pris på om du tar deg tid til å svare på spørreskjemaet.

Svarene fra spørreundersøkelsen holdes anonymt og skal ikke spores tilbake til bedriften.

Utfyllingen tar maksimalt 5 minutter. Marker tydelig valgt alternativ

Hvilket firma representerer du, og hvor holder dere til?

Firmanavn_____
Fylke_____

Hvor stor er bedriften du er eier av/ ansatt i?

- ☐ Mindre enn 20 ansatte
- ☐ Mellom 21 og 50 ansatte
- ☐ Mellom 51 og 100 ansatte
- ☐ Mellom 100 og 200 ansatte
- ☐ Over 200 ansatte

Hvor mange tyngre kjøretøy/ trekkvogner eier/ disponerer firmaet? (Dersom du er usikker, gi et anslag)

Antall:_____

Disponerer dere noen kjøretøy med teknologi for tilnærmet null-utslipp i dag?

Ja Nei Vet ikke

Hvis ja, hvilken type kjøretøy er dette?

_____

Hvor viktig er det for ditt firma å være miljøvennlig?

Svært viktig Viktig Hverken viktig eller uviktig Lite viktig Svært lite viktig

I hvor stor grad tror du at andre anser deres firma som miljøvennlig?

Svært stor grad Stor grad Hverken/eller Liten grad Svært liten grad

I den kommende Nasjonal Transportplan (2018-2027) frontes hydrogen som en løsning for å senke klimagass-utslippene. **Hvor stiller din bedrift seg til bruk av hydrogen som drivstoff på de lastebiler og trekkvogner dere disponerer?**

Svært positiv Positiv Hverken/ eller Negativ Svært negativ

For min bedrift er bruken av renere drivstoff

Svært viktig Viktig Hverken/eller Lite viktig Svært lite viktig

Hvordan stiller din bedrift seg til følgende utsagn, sett ring ved passende alternativ

	Svært enig	Enig	Hverken enig eller uenig	Uenig	Svært uenig
Min bedrift forventer å være tidlig ute i bruk av hydrogenkjøretøy					
Min bedrift ønsker å være tidlig ute i bruk av hydrogenkjøretøy					

Min bedrift har som intensjon/ formål å være å være tidlig ute i bruk av hydrogenkjøretøy					

Hvordan tror du at andre bedrifter i samme næring vil oppfattet deg om du hadde skiftet til hydrogen som drivstoff i dag?

Svært positivt Positivt Hverken/ eller Negativt Svært negativt

I hvilken grad tror du at andre vil oppfatte din bedrift som mer miljøvennlig ved bruk av hydrogen?

Svært stor grad Stor grad Hverken/eller Liten grad Svært liten grad

Hvordan stiller din bedrift seg til følgende utsagn, sett ring ved passende alternativ

	Svært enig	Enig	Hverken enig eller uenig	Uenig	Svært uenig
Bedrifter i samme næring forventer at jeg er tidlig ute i bruk av hydrogenkjøretøy					
Bedrifter i samme næring ønsker at jeg er tidlig ute i bruk av hydrogenkjøretøy					

I hvilken grad tror du at din bedrift har midler og kapasitet til å skifte til hydrogendrevne kjøretøy? Her med tanke på kostnader ved innkjøp, opplæring og lignende

Svært stor grad Stor grad Hverken/eller Liten grad Svært liten grad

Hvis ytelsesfaktoren på lastebilen/ trekkvognen er den samme ved bruk av hydrogen som ved bruk av diesel, hvordan er din bedrifts

	Vesentlig høyere enn diesel	Noe høyere enn diesel	Samme nivå som diesel	Noe lavere enn diesel	Vesentlig lavere enn diesel
Betalingsvillighet for selve drivstoffet					
Betalingsvillighet for innkjøp av lastebilen/ trekkvognen					
Betalingsvillighet for service og kontroller					

Hvor vesentlige er de følgende faktorene for at ditt firma skal skifte til hydrogen som drivstoff?

	Svært vesentlig	Vesentlig	Hverken/Eller	Uvesentlig	Svært uvesentlig
Lavere årsavgift					
Lavere bomavgift					
Lavere ferjetakst					

Lavere engangsavgift					
Særskilte rettigheter ved parkering					
Fyllestasjon på eget anlegg					
Fyllestasjon på ordinære fylleanlegg					
Dyrere diesel					
Krav til bruk av hydrogen i anbudskonkurranser					
Krav til lavere utslipp på godstransport					

Beskriv med et enkelt ord din holdning til bruk av hydrogen som drivstoff ved godstransport

_____

Hvis du har noen synspunkter som du tror kan være viktige for min oppgave, vær vennlig og noter det nedenfor

_____
_____
_____
_____

_____
_____
_____
_____
_____
_____

Tusen takk for hjelpen!

Solveig Gaundal

Mastergradsstudent ved Nord universitet

Appendix 3 Independent variables

Attitude

"How important is it for your company to be environmental friendly?"

Attitude	Frequency	Percent
Important	40	87
Neither important nor unimportant	4	8,7
Unimportant	2	4,3

"How is your company's position in usage of hydrogen fuel on your disposed vehicles?"

Attitude	Frequency	Percent
Positive	22	47,9
Neither positive nor negative	19	41,3
Negative	5	10,9

"For my company the usage of clean fuel is..?"

Attitude	Frequency	Percent
Important	37	80,4
Neither important nor unimportant	8	17,4
Unimportant	1	2,2

Social norm

"To what extent do you believe that other perceive your company as environmental friendly?"

Social norm	Frequency	Percent
Large extent	18	39,1

Neither large nor small extent	23	50
Small extent	5	10,9

"How do you believe other companies in the same industry as you would perceive your company if you had changed to hydrogen fuel today?"

Social norm	Frequency	Percent
Positive	28	60,9
Neither positive nor negative	16	34,8
Negative	2	4,3

"To what extent do you believe that other perceive your company as environmental friendly with the usage of hydrogen?" are illustrated in the following table.

Social norm	Frequency	Percent
Large extent	30	65,2
Neither large nor small extent	14	30,4
Small extent	2	4,3

Perceived behavioral control

"To what extent do you believe that your company has the funds and capacity to change to hydrogen fueled vehicles?" are illustrated in the following table.

PBC	Frequency	Percent
Large extent	11	23,9
Neither large nor small extent	15	32,6
Small extent	20	43,5

"How is your company's willingness to pay for hydrogen fuel?"

PBC	Frequency	Percent
Higher level than diesel	7	15,2
The same level as diesel	30	65,2
Lower level than diesel	9	19,6

"How is your company's willingness to pay for a hydrogen vehicle?"

PBC	Frequency	Percent
Higher level than diesel	9	19,6
The same level as diesel	28	60,9
Lower level than diesel	9	19,6

"How is your company's willingness to pay for a hydrogen vehicles service and maintenance?"

PBC	Frequency	Percent
Higher level than diesel	6	13,0
The same level as diesel	31	67,4
Lower level than diesel	9	19,6

"My Company expects to be early in the process of using hydrogen vehicles"

Intention	Frequency	Percent
Agree	11	23,9
Neither agree nor disagree	28	60,9
Disagree	7	15,2

"My Company wishes to be early in the process of using hydrogen vehicles" are stated.

Intention	Frequency	Percent

Agree	18	39,1
Neither agree nor disagree	23	50,0
Disagree	5	10,9

"My Company intends to be early in the process of using hydrogen vehicles".

Intention	Frequency	Percent
Agree	14	30,4
Neither agree nor disagree	24	52,2
Disagree	8	17,4

Appendix 4 Multiple regression analysis

Multiple regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	,010	1,433		,007	,994
	Attitude	,693	,171	,541	4,051	,000
	SocialNorm	,173	,204	,109	,845	,403
	PBC	,197	,097	,233	2,026	,049

a. Dependent Variable: Intention

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,740[a]	,548	,516	1,68960

a. Predictors: (Constant), PBC, SocialNorm, Attitude

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	145,427	3	48,476	16,981	,000[b]
	Residual	119,900	42	2,855		
	Total	265,326	45			

a. Dependent Variable: Intention

b. Predictors: (Constant), PBC, SocialNorm, Attitude

Appendix 5 Variable statistics

Attitude

Statistics

		Hvor viktig er det for ditt firma å være miljøvennlig?	I den kommende Nasjonal Transportplan (2018-2027) frontes hydrogen som en løsning for å senke klimagass-utslippene. Hvor stiller din bedrift seg til bruk av hydrogen som drivstoff på de lastebiler og trekkvogner dere disponerer?	For min bedrift er bruken av renere drivstoff
N	Valid	46	46	46
	Missing	0	0	0
Mean		2,17	2,54	2,22
Std. Deviation		,486	,887	,467
Minimum		2	1	2
Maximum		4	5	4

Hvor viktig er det for ditt firma å være miljøvennlig?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Viktig	40	87,0	87,0	87,0
	Hverken viktig eller uviktig	4	8,7	8,7	95,7
	Lite viktig	2	4,3	4,3	100,0
	Total	46	100,0	100,0	

I den kommende Nasjonal Transportplan (2018-2027) frontes hydrogen som en løsning for å senke klimagass-utslippene. Hvor stiller din bedrift seg til bruk av hydrogen som drivstoff på de lastebiler og trekkvogner dere disponerer?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Svært positiv	5	10,9	10,9	10,9
	Positiv	17	37,0	37,0	47,8
	Hverken/ eller	19	41,3	41,3	89,1
	Negativ	4	8,7	8,7	97,8
	Svært negativ	1	2,2	2,2	100,0
	Total	46	100,0	100,0	

For min bedrift er bruken av renere drivstoff

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Viktig	37	80,4	80,4	80,4
	Hverken/ eller	8	17,4	17,4	97,8
	Lite viktig	1	2,2	2,2	100,0
	Total	46	100,0	100,0	

Social Norm

Statistics

		I hvor stor grad tror du at andre anser deres firma som miljøvennlig?	Hvordan tror du at andre bedrifter i samme næring vil oppfattet deg om du hadde skiftet til hydrogen som drivstoff i dag?	I hvilken grad tror du at andre vil oppfatte din bedrift som mer miljøvennlig ved bruk av hydrogen?
N	Valid	46	46	46
	Missing	0	0	0
Mean		2,72	2,43	2,39
Std. Deviation		,655	,583	,577
Minimum		2	2	2
Maximum		4	4	4

I hvor stor grad tror du at andre anser deres firma som miljøvennlig?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stor grad	18	39,1	39,1	39,1
	Hverken/ eller	23	50,0	50,0	89,1
	Liten grad	5	10,9	10,9	100,0
	Total	46	100,0	100,0	

Hvordan tror du at andre bedrifter i samme næring vil oppfattet deg om du hadde skiftet til hydrogen som drivstoff i dag?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Positivt	28	60,9	60,9	60,9
	Hverken/ eller	16	34,8	34,8	95,7
	Negativt	2	4,3	4,3	100,0
	Total	46	100,0	100,0	

I hvilken grad tror du at andre vil oppfatte din bedrift som mer miljøvennlig ved bruk av hydrogen?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stor grad	30	65,2	65,2	65,2
	Hverken/ eller	14	30,4	30,4	95,7
	Liten grad	2	4,3	4,3	100,0
	Total	46	100,0	100,0	

Bedrifter i samme næring forventer at jeg er tidlig ut i bruk av hydrogenkjøretøy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Enig	5	10,9	10,9	10,9
	Hverken enig eller uenig	29	63,0	63,0	73,9
	Uenig	12	26,1	26,1	100,0
	Total	46	100,0	100,0	

Bedrifter i samme næring ønsker at jeg er tidlig ute i bruk av hydrogenkjøretøy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Enig	4	8,7	8,7	8,7
	Hverken enig eller uenig	32	69,6	69,6	78,3
	Uenig	10	21,7	21,7	100,0
	Total	46	100,0	100,0	

Percieved behavioral control

Statistics

		I hvilken grad tror du at din bedrift har midler og kapasitet til å skifte til hydrogendrevne kjøretøy? Her med tanke på kostnader ved innkjøp, opplæring og lignende	Betalingsvillighet for selve drivstoffet	Betalingsvillighet for innkjøp av lastebilen/ trekkvognen	Betalingsvillighet for service og kontroller
N	Valid	46	46	46	46
	Missing	0	0	0	0
Mean		3,20	3,0435	3,0000	3,0652
Std. Deviation		,806	,59466	,63246	,57357
Minimum		2	2,00	2,00	2,00
Maximum		4	4,00	4,00	4,00

I hvilken grad tror du at din bedrift har midler og kapasitet til å skifte til hydrogendrevne kjøretøy? Her med tanke på kostnader ved innkjøp, opplæring og lignende

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stor grad	11	23,9	23,9	23,9
	Hverken/ eller	15	32,6	32,6	56,5
	Liten grad	20	43,5	43,5	100,0
	Total	46	100,0	100,0	

Willingness to pay

Betalingsvillighet for selve drivstoffet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Noe høyere enn diesel	7	15,2	15,2	15,2
	Samme nivå som diesel	30	65,2	65,2	80,4
	Noe lavere enn diesel	9	19,6	19,6	100,0
	Total	46	100,0	100,0	

Betalingsvillighet for innkjøp av lastebilen/ trekkvognen

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Noe høyere enn diesel	9	19,6	19,6	19,6
	Samme nivå som diesel	28	60,9	60,9	80,4
	Noe lavere enn diesel	9	19,6	19,6	100,0
	Total	46	100,0	100,0	

Betalingsvillighet for service og kontroller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Noe høyere enn diesel	6	13,0	13,0	13,0
	Samme nivå som diesel	31	67,4	67,4	80,4
	Noe lavere enn diesel	9	19,6	19,6	100,0
	Total	46	100,0	100,0	

Intensjon

Statistics

		Min bedrift forventer å være tildlig ute i bruk av hydrogenkjøretøy	Min bedrift ønsker å være tidlig ute i bruk av hydrogen kjøretøy	Min bedrift har som intensjon/formål å være tidlig ute i bruk av hydrogenkjøretøy
N	Valid	46	46	46
	Missing	0	0	0
Mean		2,9130	2,7174	2,8696
Std. Deviation		,62632	,65534	,68666
Minimum		2,00	2,00	2,00
Maximum		4,00	4,00	4,00

Min bedrift forventer å være tildlig ute i bruk av hydrogenkjøretøy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Enig	11	23,9	23,9	23,9

	Hverken enig eller uenig	28	60,9	60,9	84,8
	Uenig	7	15,2	15,2	100,0
	Total	46	100,0	100,0	

Min bedrift ønsker å være tidlig ute i bruk av hydrogen kjøretøy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Enig	18	39,1	39,1	39,1
	Hverken enig eller uenig	23	50,0	50,0	89,1
	Uenig	5	10,9	10,9	100,0
	Total	46	100,0	100,0	

Min bedrift har som intensjon/formål å være tidlig ute i bruk av hydrogenkjøretøy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Enig	14	30,4	30,4	30,4
	Hverken enig eller uenig	24	52,2	52,2	82,6
	Uenig	8	17,4	17,4	100,0
	Total	46	100,0	100,0	