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The Effects of a Local Subsidy on the Heat Pump Market

A Study Examining how a Subsidy for Heat Pumps in Bergen Municipality has Affected Price, Demand and Energy Consumption

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This thesis is written as a part of our Master of Science (MSc) degree in Economics and Business Administration.

Our motivation to write this thesis stems from the increasing focus on climate change, and policies that can be enacted to combat it. Our wish is that this thesis provides a valuable contribution, that can help policy makers in deciding on whether to subsidise heat pumps to decrease energy consumption.

We would like to give a special thanks to all the informants who took the time to provide valuable information during the interviews. Their answers have given us unique insights, that have helped us investigate the market for heat pumps. Finally, we would like to express our sincerest gratitude to our supervisor, Fred Schroyen, for providing contributions that have proved invaluable to us in writing the thesis.

Abstract

In this thesis, we investigate a municipal heat pump subsidy. We examine the subsidy in two ways: how demand and price is affected, and whether the subsidy achieves its goal of reduced energy consumption. Through interviews with market participants across the supply chain we contribute with new understanding of subsidy effects. The subsidy is studied through a new theoretical framework and then compared to the findings from the interviews. The findings show that the subsidy effects do not fully correspond with general economic theory, indicating special market characteristics for heat pumps. We find that there are contrasting views regarding the subsidy's effect on changes in demand between market participants. Additionally, the market for heat pumps has historically had consistent prices and has not changed due to the subsidy. Finally, we cannot conclusively state that the subsidy has reduced total energy consumption.

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1. Introduction

1.1 An Overview

This thesis seeks to understand the various economic and societal effects of a local heat pump subsidy in Bergen Municipality. Heat pumps are an emerging heating device for buildings, which have seen high growth rates in its adoption the last 10-15 years. Their high energy efficiency compared to traditional heating methods and their environmental friendliness are the main reasons behind this trend. However, heat pump adoption has some clear differences between countries and regions depending on politics, policies, and comparative advantages. This has affected how countries currently achieve the conversion to cleaner energy types through heat pump adoption. These differences also affect how policies will work in various countries, as current market trends and characteristics can mean variation in consumer and market behaviour. By looking to the subsidy introduced by Bergen Municipality on the heat pump adoption in private households, we seek to understand whether such a policy measure can be deemed effective, given the characteristics of the Norwegian heat pump market.

1.2 Motivation for Research Topic

Knowledge regarding the effects of subsidies is important for policymakers for several reasons. Understanding the effects of subsidies helps policymakers make informed decisions regarding resource allocation, policy refinement, and overall governance. Furthermore, it assists policymakers at intervening in markets where it is beneficial in terms of relevant economic and societal goals. In addition, such knowledge helps prevent possible negative outcomes of policies and ensures that governmental funds are efficiently allocated. Increased understanding of different subsidies helps us improve current and future policy decisions, and in addition creates possibilities for the achievement of long-term goals such as sustainability, economic growth, and societal well-being.

In the case of a heat pump subsidy, this subsidy scheme is especially interesting due to the recent introduction of municipal heat pump subsidies in Norway. During the autumn of 2023, a total of 14 municipalities introduced an active subsidy scheme for heat pumps, and Bergen is currently the most populous city to introduce such a scheme (NOVAP, 2023). Accordingly, the knowledge surrounding consumer behaviour and demand, supply, and price effects are still uncertain. Additionally, factors such as consumer characteristics and climate make the Norwegian market different from other Western countries, meaning research from other regions is not necessarily a good representation of the Norwegian market and the effects of such a subsidy.

Moreover, heat pumps are regarded as an important part of reaching global and local climate targets. Whether a heat pump subsidy is effective will therefore depend on the impact it has on reducing emissions. This thesis will therefore seek to understand whether the subsidy achieves its target of reduced energy consumption in households.

1.3 Purpose and Disposition

With this elementary overview in mind, the purpose of this thesis is to examine how a local heat pump subsidy in Bergen Municipality affects the market in terms of demand and price effects, and total energy consumption. The goal is to produce an elaborative analysis which explains the changes in demand, price, and energy consumption due to the subsidy, and discuss factors contributing to these effects. As the main goal of the subsidy was to reduce overall energy consumption in households, our main objective is to find whether the subsidy achieves this goal. As the findings of the thesis are based on qualitative interviews, an important focus will be subjected to understand the general market trends and characteristics for the market for heat pumps, in addition to modelling a market specific theoretic framework to analyse the expected effects through general economic theory.

Section 2 introduces basic knowledge on heat pumps and their features. Section 3 describes the market for heat pumps both globally and domestically. Section 4 explains the subsidy scheme introduced by Bergen Municipality. In section 5 a theoretical framework is presented. In section 6 important findings from previous research, and relevant empirical studies are presented. Section 7 explains the methodology used for information gathering. In section 8 relevant findings are presented. In section 9 the findings are discussed and analysed in relation to the theoretical framework and market characteristics. Section 10 summarises the paper and presents concluding remarks. Section 11 discusses the limitations of the thesis. Finally, section 12 explores suggestions for future research.

2. Introduction to Heat Pumps

In this section a fundamental introduction to the topic of heat pumps will be provided. First, it will be explained how a heat pump functions, and the technologies used to generate heat. Thereafter, the three main variations of heat pumps will be introduced.

2.1 What are Heat Pumps?

A heat pump is an electrical heating and cooling device for use in buildings. Its main difference to that of traditional heating technology is the use of heat transfer technology rather than heat generation. The main principle of a heat pump is equal to that of air-conditioners. However, heat pumps can also generate heat indoors.

A basic heat pump system consists of an indoor and outdoor fan, refrigerator coils, a reversing valve, and a compressor to heat the air (Cowan & Homer, 2023). In heating periods, when one wants to increase indoor temperature, the system begins by extracting air from the extraction source. In this example this is done through the outdoor fan, which then moves the captured air to the refrigerator coils. Further on, the compressor pressurises the refrigerant into vapour. The system then uses foundational thermodynamics stating that heat always moves towards colder temperatures and releases the heat from the vapour to the indoor fan, which distributes the now warm air. After releasing the heat, the refrigerant is again returned to the liquid state and is sent back to repeat the process. The process is shown in Figure 1. It is, however, important to note that this is a simplified illustration of the instruments and functional systems in a heat pump. Furthermore, as will be explained later, there are several categories of heat pumps where each will have individual configurations. The foundational concept will nevertheless always be the same, i.e., to transfer heat from an outdoor source to the indoors.

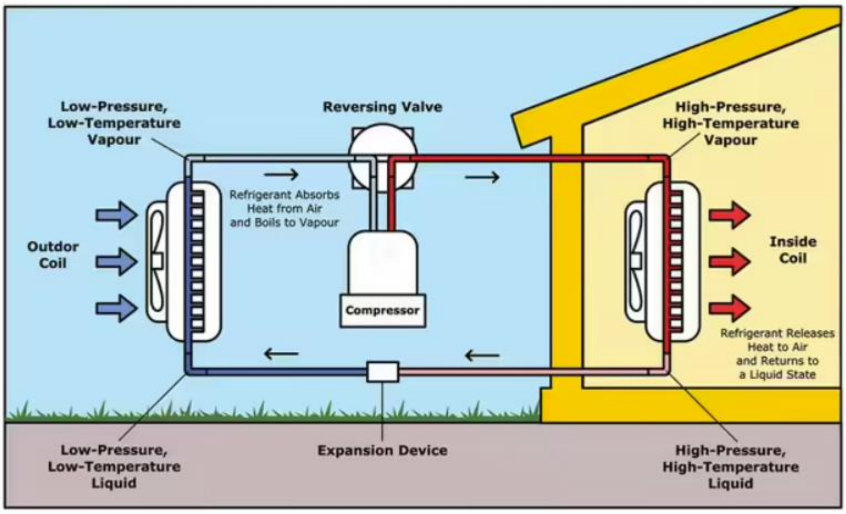

Figure 1 - Illustration of an air-to-air Heat Pump

Source: (Cowan & Homer, 2023)

Using heat transfer instead of heat generation makes heat pumps far more efficient than other heating alternatives, such as boilers or electrical heaters (IEA, 2022). The output of heat energy compared to the energy input of operating a heat pump is usually three to four times as efficient as other heating alternatives (Evergreen Energy, n.d.). A common metric for heating performance is the Coefficient of Performance (COP), which illustrates the difference between energy output and input (Heat Pump Information, n.d.). For a general household the COP is normally between 2-4, meaning the heat pump generates two till four times as much heat energy than required to operate the heat pump (IEA, 2022). In contrast, gas boilers often operate at a COP level of 1, meaning output is equal to energy input. The difference in COP is what enables the substantial increase in energy efficiency associated with a switch to heat pumps. Using Seasonal COP (SCOP) is regarded as a more accurate metric, as it considers the seasonal temperature changes' effect on heat pumps, which results in an average value for the efficiency (Evergreen Energy, n.d.).

2.2 Heat Pump Variations

All heat pumps are based on heat transfer, however, there are some important factors dividing heat pumps into mainly three different categories. These categories are based on the heat resource used in the extraction process. The main types of heat pumps can be divided into air-to-air, air-to-water, and water-to-water. Moreover, the latter two types are commonly referred to as "waterborne heat pumps" (CTC, n.d.). The wording explains the source for the heat extraction and distribution method. The categories are different in installation, technology, and investment costs.

The illustrative heat pump system shown in Figure 1 depicts an air-to-air heat pump. This means it uses air both to extract and distribute the heat. Air-to-air heat pumps are the cheapest and most common variation of heat pumps (Department of Energy, n.d.). Investment costs, including installation, generally amount to 15,000-30,000 NOK, and additional energy savings contribute to yearly operating cost reductions of 3,000-7,000 NOK (Varmepumpeinfo, 2023). It is important to note that heat pumps can have both a heating and cooling effect, meaning it can also work as an air conditioning (HVAC) system during warm seasons. During the winter, heat is extracted from outside, and then distributed indoors through air, whilst during the summer, indoor air is sent outdoors to reduce indoor temperatures. Air-to-air heat pumps in Norway have an average seasonal COP of 2.4 (Varmepumpeinfo, 2023). Based on this average estimate, they will generally pay themselves off within only 3-6 years, which is significantly less time than their life expectancy of 12-15 years (Varmepumpeinfo, 2023).

Air-to-water heat pumps are another variation of heat pumps. These are similar to air-to-air heat pumps, with the only difference being the source for heat distribution indoors. Instead of indoor fans, they distribute heat through either tap water, waterborne floor heating, radiators, or fan coils. A downside of this variation is that for them to be used for cooling during the summer period, fan coils are the only viable option. Air-to-water heat pumps have an expected lifetime of 12-15 years and generally pay themselves off within 6-10 years (Varmepumpeinfo, 2023). The price depends greatly on the heating effect and can differ between 70,000-140,000 NOK, including installation (Boligsmart, n.d.). These heat pumps generally cover 75% of the household's need for heating and warm water, and with an average SCOP of 2.7, they contribute with yearly energy savings of 5,000-16,000 NOK (Varmepumpeinfo, 2023).

The last category, water-to-water heat pumps, is here a collective term for all types of heat pumps that extract heat from other sources than air, such as water, groundwater, or soil. However, water-to-water heat pumps using direct water sources such as lakes or oceans, are the most efficient type of heat pumps, approximately 4-5% more efficient than ground source heat pumps (Thermal Earth, n.d.). It is the yearly stable temperature of water accompanied with better heat transfer in water, which makes this category efficient (Energy Saving Trust, 2019). Water-to-water heat pumps are also more expensive than the other two variations of heat pumps, requiring investment costs of minimum 170,000 NOK, depending on what source of heating is chosen (Boligsmart, n.d.). Furthermore, these types of heating systems are expected to have lifetimes of 20 years and are paid off within 8-12 years (Varmepumpeinfo, 2023). Moreover, these heat pumps are only applicable for heating and cooling through water distribution. Using the same estimates for yearly energy consumption, and with an average SCOP of 3.4, water source heat pumps will generally save 9,000-20,000 NOK a year, assuming a 1 NOK/kWh price level (Varmepumpeinfo, 2023).

3. General Market Description

This section describes the market for heat pumps. An understanding of broader market descriptive knowledge is important to grasp the later analysis. First, a general market description both domestically and internationally will be presented to understand historical trends and comparative differences. Thereafter, the market trends will be explained in accordance with the increased focus on climate change and sustainability. Lastly, potential challenges and bottlenecks in the market will be presented.

3.1 Global and Regional Market Trends

Globally, in 2020, the total number of installed heat pumps amounted to 177 million (Rosenow, Gibb, Nowak, & Lowes, 2022). China, North America, and Europe represent 68% of all installations, each contributing with 33%, 23%, and 12%, respectively. In 2022, heat pump sales had an 11% global increase, it being the second year in succession with double-digit growth (IEA, 2023). The sale of heat pumps did, however, have modest growth levels for a longer period in the early 2000s, before the market began to change at around 2015 (Zimny, Michalak, & Szczotka, 2015).

Since then, Europe has been the leading continent for heat pump adoption with continuous double-digit yearly growth (European Heat Pump Association, 2022). In 2022, Europe reached a peak of almost 3 million heat pump units sold (IEA, 2023). This amounts to a 38.9% increase from 2021 sales (Nowak & Westring, 2023). Assuming a life expectancy of 20 years per heat pump, the current heat pump stock in Europe is estimated to be at almost 18 million heat pumps in use for space heating (Nowak & Westring, 2023). Further estimations, assuming 120 million residential buildings, indicate that heat pumps have a market share of 16% in the European building stock.

The European market is, however, based around a few countries with high adoption rates. 40% of European heat pump sales occur in France, Italy, and Germany (IEA, 2023). Even in these populous countries with high growth in heat pump adoption, France is the only one where heat pump sales exceed that of fuel boilers (Monschauer, Delmastro, & Martinez-Gordon, 2023). This occurred for the first time in 2022, coinciding with the first year of a national ban on gas boilers in new buildings. While the market for fuel boilers is decreasing in several major European countries, most still have higher market shares than heat pumps. For instance, in Italy and Germany, twice as many fuel boilers were sold as heat pumps in 2022. (Monschauer, Delmastro, & Martinez-Gordon, 2023).

In particular, Europe experiences high growth in the segment of air-to-water heat pumps. These heat pumps are compatible with typical radiators and underfloor heating systems, which is a common heating solution around Europe. The sale of air-to-water heat pumps increased by 50% in Europe in 2022 (Monschauer, Delmastro, & Martinez-Gordon, 2023).

The trend of heat pump adoption in North America is similar to that of Europe. 2020 was the first year in the United States were the sale of heat pumps exceeded that of gas furnaces (NYSERDA, 2023). After a decline in 2021 due to the coronavirus pandemic, heat pump sales surpassed gas furnaces again in 2022. The sale of 4.3 million heat pumps, compared to 3.9 million gas furnaces, illustrates the current shift in the building heating sector. The United States has also seen steady yearly growth above 5% for air source heat pumps since 2015, with a peak of 15% growth in 2021 (AHRI, 2022).

China, despite having the largest quantity of heat pumps worldwide, has seen a slowdown in yearly growth rates (IEA, 2023). Nonetheless, China still had 7% growth in 2021, with 12.5 million units sold, something the IEA contribute to effective policy mandates and financial incentives (IEA, 2022). In spite of overall slower growth, some specific heat pump variations show increasing growth rates. In 2022, China and Japan experienced a 20% and 19% growth, respectively, in air-to-water heat pump adoption (IEA, 2023). This trend mirrors the significant growth observed in Europe for this variation of heat pumps.

3.2 Norwegian Market Trends

Compared to general market trends in Europe and North America, Norway differs in several ways. Most notably the market in Norway has matured earlier than the average European country, meaning forecasted growth and market trends differ.

In 2022, the amount of heat pumps sold in Norway was 156,000 (Norwegian Heat Pump Association, 2023). 2022 is the highest yearly sales quantity reached to date. Figure 2 displays the historical unit sales for heat pumps, and the distribution between heat pump types. It is clear the market has seen significant growth during the last 15 years. Except for a slowdown period between 2012-2014, the market has mostly seen yearly growth in sales.

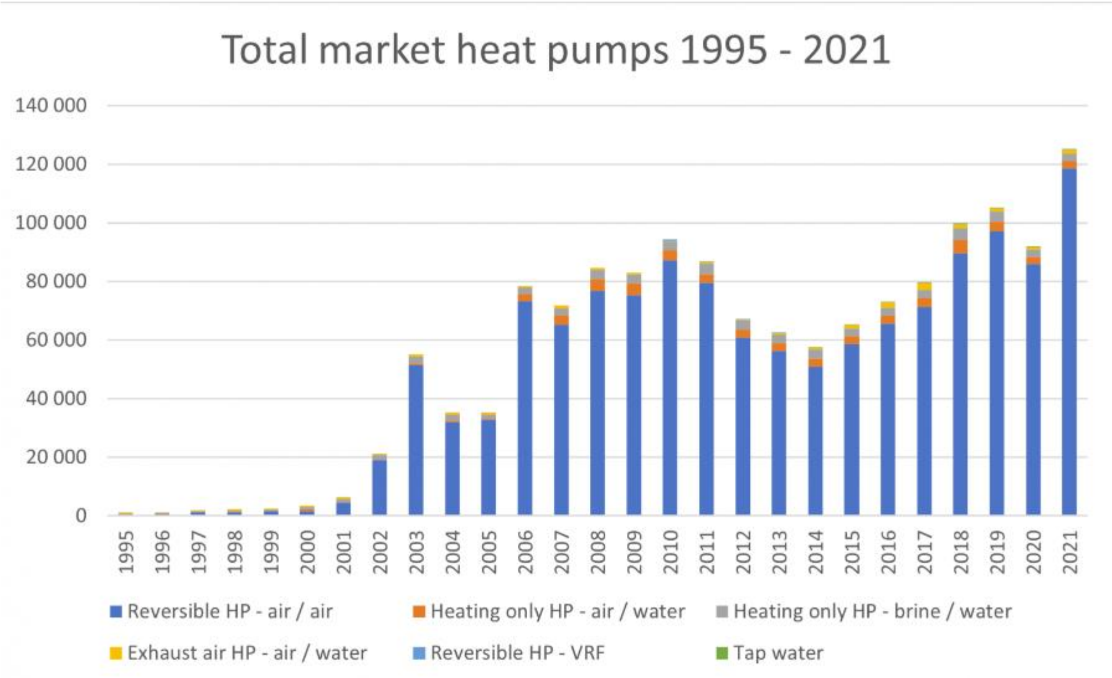

Figure 2 - Historical Heat Pump Sales in Norway

Source: (Norwegian Heat Pump Association, 2023)

The market for heat pumps is expected to have a negative yearly growth compared to 2022 levels, until 2025 (Norwegian Heat Pump Association, 2023). By 2025, it is expected that the market for heat pump replacements will equal that of first-time purchases. Simultaneously, in 2025, it is predicted that the sale of heat pumps will begin to stabilise at approximately 130,000 units per year.

The forecasted slowdown of growth in Norwegian heat pump sales can also be associated with an increasing replacement market. Considering two-thirds of Norwegian households have an installed heat pump, the market for first-time instalments will decrease over time (Rosenow, Gibb, Nowak, & Lowes, 2022). The Norwegian market is therefore currently experiencing a shift towards higher shares of replacement purchases.

3.3 Market Differences – Norway vs. Europe & North America

The concentration of heat pumps in Nordic countries is greater than in the rest of Europe and North America, particularly in Norway, Sweden, and Finland. We will now concisely explain the main differences between the heat pump market in Norway and the rest of Europe and North America.

The catalyst for the transition towards heat pumps in Norway can be explained by the oil crisis in 1973 (Niranjan, 2023). The oil embargo set in effect by OAPEC on imports to countries such as the United States and the United Kingdom, increased oil prices with 300% (Corbett, 2013). This brought Norway, Sweden, and Finland to reduce their dependence on oil, due to volatile market prices. To reduce demand for oil, a key factor was to reduce the need for fossil fuels in the heating of buildings. A shift to the use of firewood and electricity was therefore promoted. Mostly, this shift was dependent on cost incentives for switching out fossil fuels and is regarded as the main reason for the successful market penetration of heat pumps in Norway (Niranjan, 2023). For instance, in 1991, the Norwegian Government (2020) introduced the "carbon tax", a tax on greenhouse gas emissions. This tax on emissions has gradually increased over time, making oil and gas more costly to operate compared to heat pumps. Rosenow, affiliated to the Regulatory Assistance Project, a thinktank that works to decarbonise buildings, points out that Norway's approach to decarbonise buildings can be heavily contributed to making fossil-fuel heating the most expensive heating option (Niranjan, 2023). Another regulation, banning the use of fossil fuels for the heating of buildings in Norway came into effect in 2020, provoking a shift in heating technology (Rosenow, 2023). This ban can explain the spike in the sale of heat pumps for 2018 and 2019, seen in Figure 2. As the ban was approved in 2018, many households likely acted quickly to meet the new regulations.

Furthermore, Norway has some distinct traits making the adoption of heat pumps easier than elsewhere. The abundance of clean renewable energy through hydropower means Norway historically has had some of the lowest electricity prices in Europe. The low prices coupled with a high supply, created opportunities for the electrification of the building sector (Life in Norway, 2022). The lack of such renewable energy sources in other countries has historically meant higher electricity prices, and the reliance on oil and gas for the heating of buildings. For instance, the lack of heat pump adoption in the United Kingdom can partially be explained by their low gas prices compared to that of electricity (Albert, 2022).

Figure 3 shows the stock of heat pumps per 1,000 households in selected European countries, in 2021. Norway is the country in the world with the highest quantity of heat pumps per capita, followed by Finland, Sweden, and Estonia. The United Kingdom, as already stated, are heavily reliant on gas for heating, explaining the low stock of heat pumps compared to the rest of Europe. Something of note from Figure 3 is that the countries with the highest market penetration also tend to have colder climates.

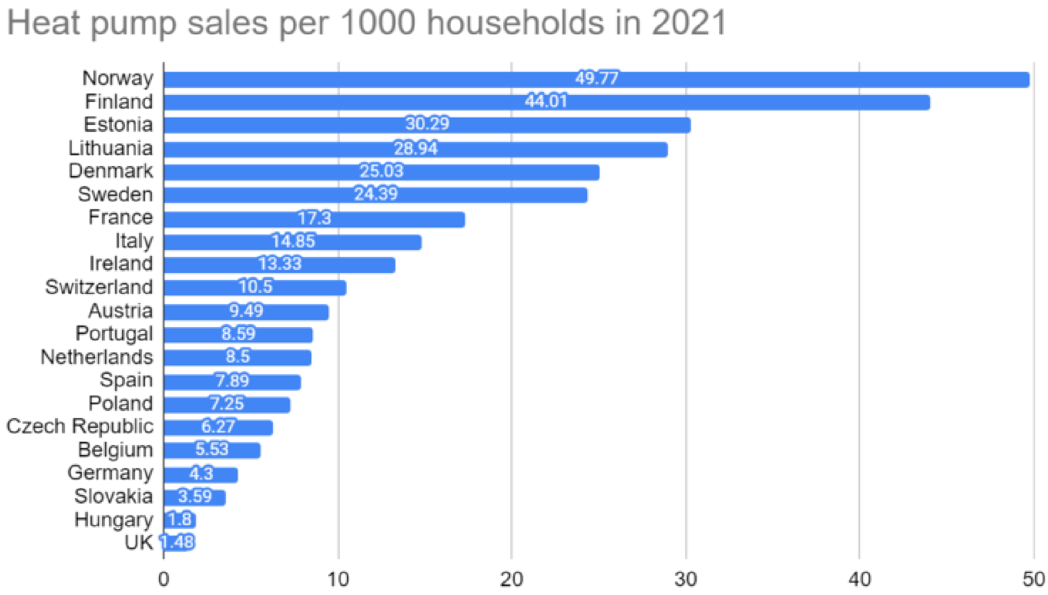

Figure 3 - Heat Pump Sales per 1000 Households in Selected European Countries

Source: (Albert, 2022)

In Figure 4 Rosenow et al (2022) indicate that a country's total number of days requiring indoor heating, i.e. heating days, correlate with heat pumps per 100 households. The four countries with the most heat pumps per 100 households, also have the most heating days. This further shows how Norway is distinctive from most European countries.

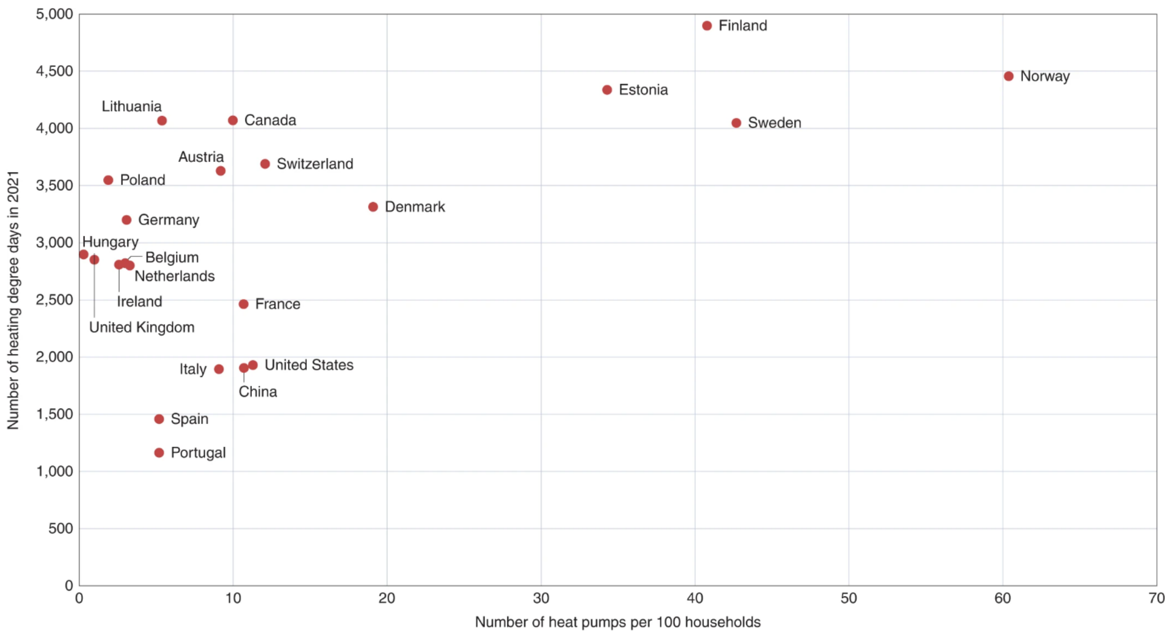

Figure 4 - Correlation between Heat Pumps per 100 Households and Number of Heating Days

Source: (Rosenow, Gibb, Nowak, & Lowes, 2022)

Another characteristic that stands out in Norway, is the high number of air-to-air heat pumps compared to waterborne heat pumps. As existing Norwegian buildings usually do not have waterborne distribution systems, the barriers to implement waterborne heat pumps are considered steep Heide, Thingbø, Lien, & Georges, 2022). Historically, low electricity prices, coupled with the high investments costs of establishing waterborne heat pumps, have contributed to the situation of air-to-air heat pumps being the main option in Norway. As electricity has been the main energy source for most households, the switch towards air-to-air heat pumps has been a simpler and less costly choice, compared to air-to-water and water-to-water heat pumps. This part of the Norwegian market also differs from that of Sweden and Finland, as they have a higher density of waterborne heating (Whittle, 2022). Conversely, more than 90% of heat pump installations in Norway are air-to-air heat pumps (Sadeghi, Ijaz, & Singh, 2022). Figure 5 shows the contrast in heat pump variations between Norway, Sweden, and the United Kingdom. "Reversible air-air w/heating" is the air-to-air variation, "H-ground/water" is the water-to-water variation, and "H-air/water" is the air-to-water variation.

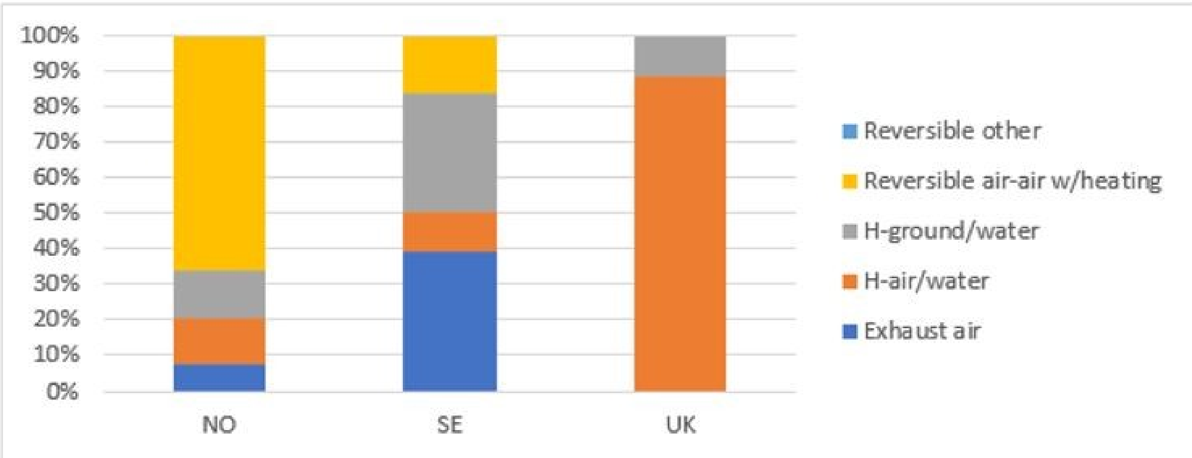

Figure 5 - Distribution of Heat Pump Variations in Norway, Sweden, and The United Kingdom

Source: (Whittle, 2022)

3.4 Heat Pump Adoption in the View of Climate Change

The increasing focus on heat pump adoption can be viewed in relation to energy consumption in buildings, which contributes heavily to overall global greenhouse gas emissions. In 2021, energy consumption in buildings contributed to 40% of final energy consumption and 36% of energy-related greenhouse gas emissions in the EU (Joint Research Centre, 2023). Furthermore, households alone represented 27% of the final energy consumption. This illustrates the importance of energy efficiency and emission reductions to meet climate goals, and why most European countries today incentivise heat pump installation through either one or several subsidy schemes (European Heat Pump Association, 2023).

A significant selling point of heat pumps is their high energy efficiency. Heat pumps are more energy-efficient than other conventional heating technologies, such as boilers or electric heaters (IEA, n.d.). Therefore, policies for heat pump adoption have emerged as an important tool for reaching climate goals such as the Net Zero Emissions by 2050 (NZE) Scenario. Globally, heating in buildings is responsible for 4 gigatonnes of CO_2 emissions annually, which constitutes 10% of global emissions (IEA, 2022). This is largely due to the dependency on natural gas for heating purposes. Globally, more than one-sixth of demand for natural gas comes from heating of buildings, whilst in the European Union this is one-third of the total demand (IEA, 2022).

Heat pumps already contribute substantially to reduction in greenhouse gas emissions. In 2022, the number of heat pumps sold reduced demand for natural gas with approximately 4 billion cubic meters (bcm) of natural gas, avoiding roughly 8 million tonnes of CO_2 emissions (EHPA, 2023). In Europe in 2022, the total heat pump stock avoided 54 million tonnes of CO_2 being emitted, almost equivalent to the yearly emissions of Greece. In addition, the heat pump market has substantial possibilities for future growth. In 2021, just 10% of all global space heating demand were met by heat pumps (EHPA, 2023).

To meet climate targets, and thereby reach the NZE scenario, heat pump adoption is viewed as a crucial measure. In 2022, The European Union experienced only a 2.5% decrease in overall CO_2 emissions, amounting to a 70 million tonnes reduction in emissions. Given the current goals and estimates in the NZE strategy, this decrease is behind what is needed. With a target of 60 million heat pumps installed in 2030, data from Cambridge Analytics shows that EU residential buildings can decrease their emissions by 46%, compared to 2022 levels (EHPA, 2023).

Following the NZE scenario, worldwide CO_2 emissions from space and water heating are expected to decrease with more than 1.2 gigatonnes, i.e., nearly one quarter of global emissions, by 2030. Of this, almost 40% of reductions will be due to heat pump adoption, equalling the total emissions of Canada in 2021 (EHPA, 2023). However, in advanced economies such as The European Union and the United States, reductions are expected to be considerably higher, with almost three quarters of heating related emissions to disappear due to heat pumps by 2030.

Furthermore, a report by the National Renewable Energy Laboratory shows that heat pumps can cut 142 million metric tons of CO_2 emissions per year in the United States (Thomas, n.d.). Additionally, the report estimates the creation of 6.6 million new jobs and substantial cost savings for households' utility bills.

3.5 Challenges Related to Heat Pump Adoption

As heat pump adoption rates have been increasing, this also institutes the appearance of potential challenges for continued market growth. Whilst research on potential challenges and their effects have been lacking, experts often point to two primary issues with the current growth of heat pump adoption: bottlenecks related to the supply of electricity and a shortage of skilled workers.

Future pressure on the supply side of the electrical grid is often described as a potential bottleneck and challenge for heat pump adoption on a larger scale. Heat pumps contribute around 9% of the expected increase in demand for electricity by 2030 (IEA, 2022), an increase which will only result in modest changes in system-wide electricity peak loads during winters. IEA states that this electricity increase can be comfortably adjusted for without new generation capacity in most regions. However, the increased pressure on electrical grids will require planning to ensure stability, especially in distribution grids. This is due to the likelihood that other sectors will also expect higher electricity usage in the future. If other sectors, for instance transportation and industry, also increase their demand for electricity, the grid may lack stability in peak demand periods.

The growth in heat pump adoption will also significantly increase the demand for skilled workers across the whole value chain. Notably, to meet expected levels of demand, the number of installers will have to almost double by 2030. Many of these additional workers are expected to be attained from the current market for boilers, as the required skills largely overlap (Toleikyte, Reina, Volt, & Carlsson, 2023). In total EHPA expects a 56% increase in the demand for skilled workers in the renewable energy sector by 2030 (EHPA, 2023).

4. The Subsidy Scheme

The subsidy for heat pumps in Bergen was arranged by the Municipality of Bergen, with the purpose of reducing energy consumption from buildings and households (Bergen Municipality, 2023). Preliminarily, the municipality budgeted 14,500,000 NOK for the subsidy scheme, but later increased the expenditure to approximately 20,500,000 NOK, meaning that all valid applications could receive benefits (Climate Department of the Municipality of Bergen , 2023). Households had a time frame of four weeks to submit the application, with the deadline for submission being on the 7th of June 2023. To receive the subsidy, the household had to present proof of purchase and installation.

All households within Bergen Municipality that were homeowners could apply for the subsidy, i.e., tenants were not eligible. In addition, the subsidy was not applicable for cabins, vacation properties, garages, commercial buildings, or buildings outside of Bergen Municipality.

The subsidy did not have retroactive effects, meaning that heat pumps already bought and/or installed before the commissioning of the subsidy scheme could not apply. Thus, the municipality wanted the subsidy to be a triggering factor for applying. However, an exception was made for heat pumps bought after the 10th of May 2023.

The subsidy included only the purchase and installation of air-to-air and air-to-water heat pumps. However, data was not provided indicating the distribution of heat pump variations amongst subsidy recipients. Therefore, we will make a simplifying assumption that only air-to-air heat pumps are covered. Firstly, over 90% of heat pumps in Norway are air-to-air (Sadeghi, Ijaz, & Singh, 2022). Secondly, the subsidy will proportionally cover more of the costs of air-to-air heat pumps, and therefore it will likely be the most attractive option. Thus, the number of air-to-water heat pumps will likely not be significant enough to impact our later analysis. Note that water-to-water heat pumps are not part of the subsidy scheme, as Enova is already providing subsidies for this type of heat pumps (Enova, 2016).

The subsidy was divided into two categories. Households with total income above 750,000 NOK could receive a maximum of 6,000 NOK. In addition, the subsidy could not make up more than 40% of the total costs of buying and installing the heat pump. Households with a total income below 750,000 NOK could receive subsidies of up to 10,000 NOK, also having the limit of covering no more than 40% of the total purchase and installation costs.

Moreover, households needed to meet some additional requirements to receive the subsidy. Firstly, one could only receive subsidies for a single heat pump per household. The heat pump had to be bought from an official vendor, prohibiting the purchase of second-hand heat pumps. All heat pumps had to be installed by F-gas certified companies and installers with valid certification. Also, the installation process was required to follow standard Norwegian regulations for noise-requirements.

The Climate Department of the Municipality of Bergen has contributed with relevant data for the results of the application process. In total, the subsidy scheme received a total of 2877 unique applications, adjusting for duplicated applications and user-faults (Climate Department of the Municipality of Bergen , 2023). Of these applications, 829 (28.5%) applied for 10,000 NOK. The remaining 2048 (71.5%) applied for 6,000 NOK, meaning they had a household income above 750,000 NOK. As the lower income category had to provide documentation on taxable income, some applicants were rejected due to the lack of documentation. In addition, some applications were rejected due to applying in the wrong income category. We have not been provided with specific data on the total number of applications rejected, but the Climate Department of the Municipality of Bergen states that the number is low. We assume this amount is not of much significance to our later analysis. Some applicants also applied despite having their heat pump installed before the 10th of May 2023, omitting them from the application process.

Of the approved applications, the vast majority received the full subsidy, i.e., 10,000 NOK or 6,000 NOK, depending on their income category. This implies a minimum purchase and installation cost of 25,000 NOK for the lower income category, and a total cost of at least 15,000 NOK for the higher income category. The Climate Department of the Municipality of Bergen informs that, among higher-income applicants, fewer than 5 applicants (0.2%) received a subsidy of less than 6,000 NOK. Among applicants in the lower income category, they estimate that fewer than 100 applicants (12%) received less than their maximum potential subsidy of 10,000 NOK.

5. Theoretical Framework

In this section, a theoretical framework will be introduced. The framework is created by Schroyen (2023), and is a model that is designed to cover all aspects relating to the demand for heat pumps, as well as the rebound effect. The results derived from the model will be used later when analysing the findings of the thesis.

5.1 Introducing the Model

We assume that the utility function for a household with a heat pump is:

$$U(x, y) = A(\varepsilon x - \gamma)^{1-\frac{1}{\alpha}} + y$$

Where x is the amount of electricity (which has price p), y is money spent on other goods (which have a price equal to 1), γ is the minimum amount of electricity necessary to survive and ε is the coefficient of performance (COP) for heat pumps, with $\varepsilon > 1$ (Schroyen, 2023). Furthermore, the household has an income m. In other words, if the household buys x kWh electricity, it spends $y = m - px$ on other goods.

To find the marginal willingness to pay for electricity, first substitute the equation for y into the utility function:

$$U(x) = A(\varepsilon x - \gamma)^{1-\frac{1}{\alpha}} + (m - px)$$

Then, take the derivative of the utility w.r.t the amount of electricity, x, to obtain the marginal willingness to pay, denoted as MRS:

$$\frac{\partial U(x)}{\partial x} = MRS = (\varepsilon x - \gamma)^{-\frac{1}{\alpha}} A\varepsilon \frac{\alpha - 1}{\alpha} - p = 0$$

Solving for price p, we get:

$$MRS = p = (\varepsilon x - \gamma)^{-\frac{1}{\alpha}} A\varepsilon \frac{\alpha - 1}{\alpha}$$

Moreover, a condition for the MRS is that it is decreasing as the amount of electricity x is increasing. This can be found by taking the derivative w.r.t x:

$$\frac{\partial MRS}{\partial x} = A(1-\alpha)\frac{\varepsilon^2(\varepsilon x-\gamma)^{-\frac{1}{\alpha}-1}}{\alpha^2}$$

Looking at the equation, we know that $(\varepsilon x - \gamma)$ is positive, as $x \geq \gamma$. Therefore, the only way $\frac{\partial MRS}{\partial x} < 0$, is if $\alpha > 1$, which is thus the only value for α that is feasible.

Having found the MRS, we can now compute the optimal demand for electricity, which will be called x^*. Recall that we have:

$$p = (\varepsilon x - \gamma)^{-\frac{1}{\alpha}} A\varepsilon\frac{\alpha-1}{\alpha}$$

Solving this for x^*, we get the optimal demand for electricity:

$$x^* = \frac{\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{-\alpha}}{\varepsilon} + \frac{\gamma}{\varepsilon}$$

5.2 Elasticities of Price and COP

Having found x^*, we can now calculate the price elasticity of demand for electricity. This is done by taking:

$$\frac{\partial x^*}{\partial p}\frac{p}{x^*} = \frac{\partial \log x^*}{\partial \log p}$$

Which in our case is:

$$\frac{\partial \log x^*}{\partial \log p} = p\left(\frac{\varepsilon}{\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{-\alpha}} + \frac{\varepsilon}{\gamma}\right)\frac{-\alpha}{\varepsilon p\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{\alpha}}$$

Solving this, we find that the price elasticity of demand is:

$$\frac{\partial \log x^*}{\partial \log p} = -\alpha\frac{\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{-\alpha}}{\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{-\alpha} + \gamma}$$

With this equation, we see that the elasticity of demand is equal to $-\alpha$ when $\gamma = 0$, but is smaller than α (in absolute value) when $\gamma > 0$.

With the model, the rebound effect can also be derived. Gillingham, Rapson & Wagner (2015) describe the rebound effect as "the phenomenon that an increase in energy efficiency may lead to less energy savings than would be expected by simply multiplying the change in energy efficiency by the energy use prior to the change".

To find the rebound effect, we calculate the elasticity of electricity demanded w.r.t ε:

$$\frac{\partial \log x^*}{\partial \log \varepsilon} = \frac{\partial x^*}{\partial \varepsilon}\frac{\varepsilon}{x^*}$$

To find the elasticity, we first derive $\frac{\partial x^*}{\partial \varepsilon}$:

$$\frac{\partial x^*}{\partial \varepsilon} = \frac{-\gamma\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha} + \alpha - 1}{\varepsilon^2\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha}}$$

Which means we can now calculate the elasticity:

$$\frac{\partial \log x^*}{\partial \log \varepsilon} = \frac{\partial x^*}{\partial \varepsilon}\frac{\varepsilon}{x^*} = \frac{-\gamma\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha} + \alpha - 1}{\varepsilon^2\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha}}\left(\frac{\varepsilon^2}{\left(\frac{\alpha p}{A\varepsilon(\alpha-1)}\right)^{-\alpha} + \gamma}\right)$$

Which simplifies to:

$$\frac{\partial \log x^*}{\partial \log \varepsilon} = \frac{\alpha}{1+\gamma\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha}} - 1$$

From this, we see that there are two effects working in opposite directions. On the one hand, a 1% increase in ε will lead to a percentage decrease in electricity demanded x^* equal to -1%. This part can be thought of as the immediate effect of switching to heat pumps, which is that the household will decrease energy consumption, all else equal, due to an increase in efficiency.

On the other hand, a 1% increase in efficiency, ε, will lead to a percentage increase in x^* equal to:

$$\frac{\alpha}{1+\gamma\left(\frac{A\varepsilon(\alpha-1)}{\alpha p}\right)^{-\alpha}}$$

This is the rebound effect, where the increase in energy efficiency can potentially increase energy consumption. For instance, the increase in energy efficiency might lead the household to increase their indoor temperature, leading to a higher consumption of electricity, all else equal.

Furthermore, we can evaluate the requirements for there to be an increase, or decrease, in energy consumption after the subsidy. Immediately, we can see that we have the rebound effect being so strong, that we have an increase in x^*, when $\gamma = 0$, because, when substituting this in we get:

$$\alpha - 1 > 0$$

Additionally, the rebound effect is strong enough to increase energy consumption if the following inequality holds:

$$\frac{\alpha}{1 + \gamma \left(\frac{A\varepsilon(\alpha - 1)}{\alpha p}\right)^{-\alpha}} - 1 > 0$$

Which, if we solve for γ, simplifies to:

$$\gamma < \frac{\alpha - 1}{\left(\frac{A\varepsilon(\alpha - 1)}{\alpha p}\right)^{-\alpha}}$$

Conversely, we have that the rebound effect is not strong enough for there to be an increase in electricity consumption, when:

$$\gamma > \frac{\alpha - 1}{\left(\frac{A\varepsilon(\alpha - 1)}{\alpha p}\right)^{-\alpha}}$$

Thus, we have shown that the effects of the subsidy on the total demand for electricity are uncertain and will depend on the magnitude of the rebound effect.

5.3 The Indirect Utility Function and WTP

Putting x^* back into the utility function, we can obtain the indirect utility function, which we will denote as $V(p, m, \varepsilon)$:

$$V(p, m, \varepsilon) = A\left(\varepsilon\left(\frac{\left(\frac{\alpha p}{A\varepsilon(\alpha - 1)}\right)^{-\alpha}}{\varepsilon} + \frac{\gamma}{\varepsilon}\right) - \gamma\right)^{1-\frac{1}{\alpha}} + m - p\left(\frac{\left(\frac{\alpha p}{A\varepsilon(\alpha - 1)}\right)^{-\alpha}}{\varepsilon} + \frac{\gamma}{\varepsilon}\right)$$

This expression can be simplified into:

$$V(p,m,\varepsilon) = A^{\alpha}\left(\frac{p}{\varepsilon}\right)^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha} + m - \frac{p\gamma}{\varepsilon}$$

Which is the maximum utility a household with a heat pump can reach.

If we assume that a regular heater will have a coefficient of performance (COP) $\varepsilon = 1$, we can substitute this value into the indirect utility function, and obtain the maximum value for a household that uses a regular heater, as:

$$V(p,m,1) = A^{\alpha}(p)^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha} + m - p\gamma$$

With these two expressions in mind, we can calculate the maximum willingness to pay a household will have for a heat pump. To find this, we take the difference between the maximum utilities for having a heat pump and a heater, respectively:

$$V(p,m,\varepsilon) - V(p,m,1)$$

$$= A^{\alpha}\left(\frac{p}{\varepsilon}\right)^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha} + m - \frac{p\gamma}{\varepsilon} - \left(A^{\alpha}(p)^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha} + m - p\gamma\right)$$

The incomes m cancel out. We can rewrite this expression as:

$$WTP(p,\varepsilon) = V(p,\varepsilon) - V(p,1)$$

Which is equal to:

$$WTP(p,\varepsilon) = A^{\alpha}p^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha}(\varepsilon^{\alpha-1} - 1) + p\gamma\left(1 - \frac{1}{\varepsilon}\right)$$

This is the maximum willingness to pay for a heat pump. Going a little further, we can investigate some of the properties of this function. One of these properties is that willingness to pay is increasing with γ:

$$\frac{\partial WTP}{\partial \gamma} = p\left(1 - \frac{1}{\varepsilon}\right) > 0$$

This expression is positive as $1 > \frac{1}{\varepsilon}$. The intuition here is that the willingness to pay increases as the minimum need for electricity to survive increases. Furthermore, we have that the willingness to pay increases with the COP, ε:

$$\frac{\partial WTP}{\partial \varepsilon} = A^{\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha}(\alpha-1)p^{1-\alpha}\varepsilon^{\alpha-2} + \frac{p\gamma}{\varepsilon^2}$$

This expression is positive as $\alpha > 1$, and all other parameters are positive. The intuition here is that the consumer is willing to pay more for a heat pump when its efficiency increases. Moreover, we have that willingness to pay increases with price:

$$\frac{\partial WTP}{\partial p} = \frac{A^{\alpha}\left(\frac{\alpha-1}{\alpha}\right)(1-\alpha)(\varepsilon^{\alpha-1}-1)}{p^{\alpha}} + \left(1-\frac{1}{\varepsilon}\right)\gamma > 0$$

This expression is also positive. The expression follows the logic that the willingness to pay for heat pumps will increase with the price of electricity, because there are larger savings with a heat pump when electricity is expensive, compared to when it is cheaper.

5.4 Aggregate WTP

Previously, we found the willingness to pay for an individual. Now, we will find the aggregate willingness to pay for all households.

To begin with, let us make some assumptions. We assume that the various households have different needs for heating, which will be reflected by the households having different values of γ. To simplify, let us assume that γ is uniformly distributed over the interval $[\gamma_L, \gamma_H]$, where γ_L is the value of the household with the lowest γ, and γ_H is the value of the household with the highest γ. If we refer to the total number of households as N, we have that the number of households with $\gamma \leq g$ is equal to $Q = \frac{\gamma_H - g}{\gamma_H - \gamma_L} \times \mathrm{N}$. Looking at Q, we can see that $\frac{\gamma_H - g}{\gamma_H - \gamma_L} \times \mathrm{N} \geq 1$, because $g \geq \gamma_L$, meaning the numerator is always at least as big as the denominator.

Let us now imagine that we put all the different households on a row, where we start off with the household with the highest γ, then the household with the second highest value of γ and so on. With this in mind, we can begin to find an expression for $WTP(Q; p, \varepsilon)$, where Q represents the first Q households.

To start off, we solve the expression for Q w.r.t g:

$$g = \frac{Q(\gamma_L - \gamma_H)}{N} + \gamma_H$$

Then, we can substitute g for γ in WTP to obtain:

$$WTP(Q;p,\varepsilon) = A^{\alpha}p^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha}(\varepsilon^{\alpha-1}-1) + p\left(\frac{Q(\gamma_L-\gamma_H)}{N}+\gamma_H\right)\left(1-\frac{1}{\varepsilon}\right)$$

To show what happens with WTP when Q increases, we take the derivative of WTP w.r.t Q:

$$\frac{\partial WTP}{\partial Q} = -\frac{\left(\varepsilon-\frac{1}{\varepsilon}\right)(\gamma_H-\gamma_L)p}{N} < 0$$

This means that when there is an increase in Q, the willingness to pay decreases. This is not surprising, as it means that when we are investigating more households, the willingness to pay for the final household will be lower. If we then were to look at yet another household, i.e., increase Q even further, they would have an even lower WTP, and so on.

The $WTP(Q;p,\varepsilon)$ will represent the aggregate demand, and consistent with economic theory, it is thus downward sloping. The function can be illustrated in the following graph, where the x-axis represents quantity Q, and the y-axis the willingness to pay (WTP):

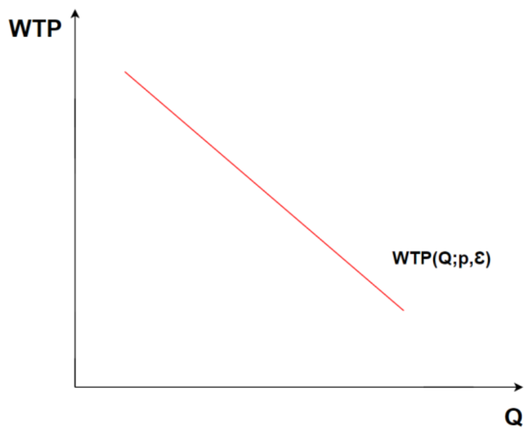

Figure 6 - Aggregate Demand for Heat Pumps

Expanding on the model, let us assume that heat pumps have a price P. The price for a heat pump will, in a perfectly competitive market, then be equal to the aggregated willingness to pay:

$$P = WTP$$

Which is:

$$P(Q) = A^{\alpha} p^{1-\alpha} \left(\frac{\alpha - 1}{\alpha}\right)^{\alpha} (\varepsilon^{\alpha-1} - 1) + p\left(\frac{Q(\gamma_L - \gamma_H)}{N} + \gamma_H\right)\left(1 - \frac{1}{\varepsilon}\right)$$

To find the number of households who purchase a heat pump, we solve the above equation w.r.t Q, giving us the market demand curve:

$$Q(P) = \frac{N}{p(\gamma_H - \gamma_L)} \times \left(A^{\alpha} p^{1-\alpha} \left(\frac{\alpha - 1}{\alpha}\right)^{\alpha} (\varepsilon^{\alpha-1} - 1) + p\gamma_H \left(1 - \frac{1}{\varepsilon}\right) - P\right)$$

Note that here, we take all parameters, except for P, as a given. Thus, with the price of a heat pump being P, then $Q(P)$ out of N consumers will purchase a heat pump. Conversely, the number of consumers who do not buy a heat pump will be the remaining amount of N, equal to $N - Q(P)$:

$$N - Q(P) = N - \frac{N}{p(\gamma_H - \gamma_L)} \times \left(A^{\alpha} p^{1-\alpha} \left(\frac{\alpha - 1}{\alpha}\right)^{\alpha} (\varepsilon^{\alpha-1} - 1) + p\gamma_H \left(1 - \frac{1}{\varepsilon}\right) - P\right)$$

The quantity demanded is, as expected, decreasing with price P, which we can check, as:

$$\frac{\partial Q}{\partial P} = -\frac{N}{p(\gamma_H - \gamma_L)} < 0$$

Now, we can also look at what the optimal quantity of electricity is for the two groups of consumers. For the consumers buying heat pumps, the optimal quantity of electricity is the same as we derived earlier. We will refer to these consumers as having an optimal quantity of electricity as x_{HP}^*:

$$x_{HP}^* = \frac{\left(\frac{\alpha p}{A\varepsilon(\alpha - 1)}\right)^{-\alpha}}{\varepsilon} + \frac{\gamma}{\varepsilon}$$

However, for the consumers not buying a heat pump, we know that they will use heaters, which we assume have a COP $\varepsilon = 1$. Therefore, we can write their optimal quantity of electricity demanded, which we will refer to as x_H^*, as:

$$x_H^* = \left(\frac{\alpha p}{A(\alpha - 1)}\right)^{-\alpha} + \gamma$$

As previously discussed, it is not certain that users of heat pumps overall consume less energy, due to the rebound effect.

5.5 Introducing a Subsidy

5.5.1 Effect on Demand for Heat Pumps

Now, let us introduce a subsidy, call it s, to see how it affects the consumers' willingness to pay. By introducing a subsidy s, the WTP will be:

$$WTP(Q;p,\varepsilon) = A^{\alpha}p^{1-\alpha}\left(\frac{\alpha-1}{\alpha}\right)^{\alpha}(\varepsilon^{\alpha-1}-1)+p\left(\frac{Q(\gamma_L-\gamma_H)}{N}+\gamma_H\right)\left(1-\frac{1}{\varepsilon}\right)+s$$

Taking the derivate of this function w.r.t s, we can see the effects of the subsidy on the willingness to pay:

$$\frac{\partial WTP}{\partial s} = 1 > 0$$

The derivative being positive means that the introduction of a subsidy will increase the willingness to pay. The intuition here is straightforward: the subsidy leads to the heat pumps effectively becoming cheaper, which will increase the willingness to pay for the product.

To investigate how the subsidy will affect market equilibrium, we will introduce marginal cost functions of the firms. In the long run, the marginal cost will be flat, whilst in the short term, it will be increasing. The reason for it being increasing in the short term, is that there are capacity constraints, which will rise with output. Examples of this could be having to hire more workers to meet demand or increasing overtime. In the long run, however, the firm will be able to adjust to the new equilibrium, leading to a flattening of the supply curve.

We will assume that the short run marginal cost takes the form:

$$MC_{SR} = B + \beta Q$$

where MC_{SR} is the short run marginal cost, B is a constant, and β is a coefficient, multiplied with the quantity Q. A graphical illustration of how market equilibrium is affected after a subsidy is introduced in the short run is shown below.

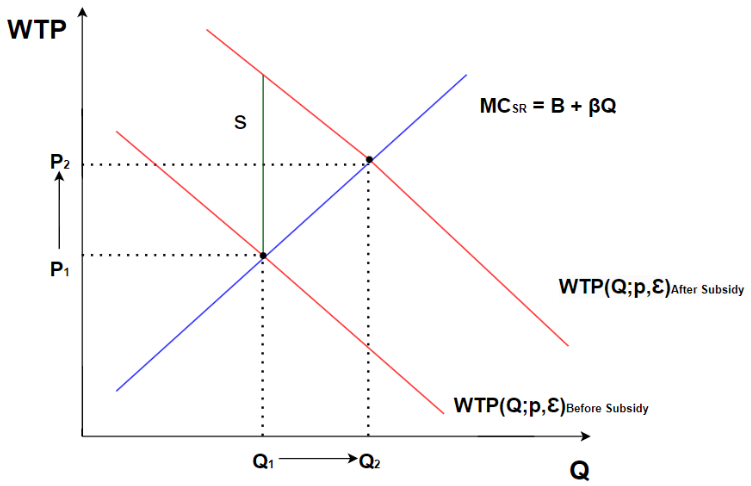

Figure 7 - Short-run Equilibrium After the Introduction of a Subsidy

Before the subsidy, market equilibrium is where the marginal cost equals the willingness to pay, where we have the equilibrium point at $(P^*, Q^*) = (P_1, Q_1)$. When a subsidy is introduced, the demand curve shifts upwards, and we have a new equilibrium at the intersection $(P^*, Q^*) = (P_2, Q_2)$. The green line, s, represents the subsidy, which is equal to the upwards shift in demand. We can see that, with a subsidy, both the quantity demanded, as well as the prices of heat pumps, shift upwards. The shift in price, however, is smaller than the subsidy amount s. This means that the consumer will benefit from the subsidy, but will effectively not be receiving the full amount, due to the increase in price.

A similar analysis can be done for the effects of a subsidy in the long run. In the long run, the firm will not have any problems relating to capacity, meaning that the marginal cost will be smaller. Assuming a flat supply curve, the marginal cost in the long run will be $MC_{LR} = C$, where MC_{LR} is the marginal cost in the long run, and C is a constant. The effects of a subsidy on market equilibrium in the long run are graphically illustrated below.

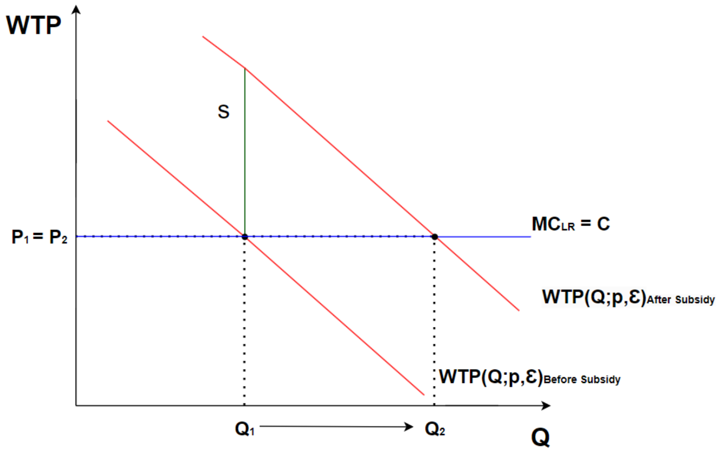

Figure 8 - Long-run Equilibrium After the Introduction of a Subsidy

Due to the marginal cost being flat, we see that there, in this case, is no change in price, with $P_1 = P_2$. Due to this, the consumer will effectively be receiving the whole subsidy, equal to s. However, the increase in quantity will be greater, and the subsidy will give a new equilibrium at $(P^*, Q^*) = (P_2, Q_2)$.

5.5.2 Effect on Electricity Consumption

Furthermore, we can quickly investigate how the subsidy will affect overall energy consumption. A way of looking at the subsidy, is that it will on average increase the COP, ε, for the households, due to the heat pumps being more efficient. As already discussed, the impact a change in ε has on demand for electricity, depends on the size of the rebound effect. If you recall, given that $\gamma > 0$, the rebound effect will be sufficiently strong to increase energy consumption if:

$$\gamma < \frac{\alpha - 1}{\left(\frac{A\varepsilon(\alpha - 1)}{\alpha p}\right)^{-\alpha}}$$

Thus, one cannot definitively say that the increase in heat pump adoption will lead to a decrease in energy consumption. There will only be a decrease when rebounding is not sufficiently strong, i.e., when the above inequality does not hold.

5.6 Weaknesses of the Model

An assumption made was that γ is linear, and uniformly distributed at the interval $[\gamma_L, \gamma_H]$. This assumption is made to simplify our analysis and is likely not realistic. If we were to assume it follows a different distribution, such as a normal distribution, we would see that the WTP would be concave or convex. This would, however, complicate our analysis, and for our purposes we have therefore chosen to simplify the assumption of distribution.

Another limitation of this model is that income m is not included in either the optimal quantity for electricity x^*, or in the aggregate willingness to pay $WTP(Q; p, \varepsilon)$. As we will discuss later, we see that both the demand for heat pumps, as well as the amount of electricity consumed, do in fact partially depend on income.

The model also does not consider the bargaining process between stakeholders. For instance, when there is an increase in the price of electricity, the consumer will benefit more from having a heat pump. In some ways, the consumer will become more "desperate" for a heat pump, and will thus, in the negotiation process with the seller, have fewer incentives to negotiate around price.

Despite these weaknesses, the model provides good insights into the effects a subsidy will have on demand for both heat pumps, and electricity. The theoretical framework that has been derived here, will be used later, when the findings will be related and compared to it. The model can on the one hand provide reasonable explanations in the cases where the real world corresponds with theory. Additionally, in the instances where the findings differ from what the model predicts, alternative explanations for the findings will be provided.

6. Empirical Evidence

This section will consider previous research that is relevant to understanding the overall impact of the subsidy scheme. Firstly, empirical evidence regarding the effect of heat pump adoption on energy consumption will be presented. Then, how a household's socioeconomic background is correlated with energy consumption will be considered. Finally, research on how heat pumps subsidies are distributed across income groups will be explored.

6.1 Energy Consumption after Heat Pump Adoption

As heat pumps often are depicted as an important tool for cleaner energy and efficient building heating, the real effects of heat pump adoption have been studied in several research papers. Research on the rebound effect, i.e., how changes in behaviour can lead to increased energy consumption, is in this context often mentioned. The findings are somewhat conflicting, possibly due to differences in the age of datasets, local climate, and differences in consumer behaviour characteristics.

A study by Halvorsen & Larsen (2013) found that heat pump adoption does not lead to a decrease in energy usage. They created a behavioural model based on a conditional demand model to estimate how a household changes its consumption when acquiring a heat pump in Norway. The model dissects the by-products of heat pump ownership, considering behavioural shifts in energy and firewood consumption, indoor temperature regulation and other germane factors. The net results of their findings show an increase in electricity consumption, although these results were not of statistical significance.

Findings from a study on heat pump adoption in Arizona show similar results. Liang, Qui, & Xing (2022) use data on hourly electricity consumption over a 5-year period between 2014-2019, from 13,000 residential consumers. The paper then studies the changes in hour-of-day electricity loads after heat pump adoption. Utilizing propensity scores matching, fixed effects regression and difference-in-differences, they cannot conclude that heat pumps lead to electricity savings. Furthermore, the paper estimates the economic costs of environmental damages inflicted by heat pumps. Their estimates indicate that a switch from natural gas furnaces to heat pumps, lead to increased daily environmental damages of 0.59$ per household during the summer and 1.64$ during the winter. Therefore, the adoption of heat pumps is not necessarily environmentally friendly.

Somewhat contradictory, conditional demand analyses by Papineau et al. (2021) show net reduced energy consumption after adoption of local heat pumps in Canada. The paper concentrates on households with electricity as the primary method of heating and estimates changes in electricity consumption after adoption of different electrical heating systems. The results from both random and fixed effects panel regressions show energy savings for local heat pumps during heating seasons, giving yearly reductions of 2000+ kWh. However, central heat pumps are found to use more electricity during cooling seasons, with no changes during heating seasons. The distinction between a local and a central heat pump is in this paper based on whether heating is provided to one or several rooms. The net result shows an increase in yearly energy consumption. Additionally, the paper finds that newer homes consistently reduce electricity consumption, with the largest effects being for homes built after 2010.

6.2 Rebound Effect and Socioeconomic Background

Research has been conducted, indicating that there is a difference in energy consumption across households based on income levels. One study in Denmark found that, for a reduction in energy cost, households earning less than 800.000 DKK annually increased energy consumption by more than households earning above this threshold (Fazeli & Davidsdottir, 2016). This means that they have a higher price-elasticity, which is correlated with a higher rebound effect.

Chitnis et al. (2014) found that, in the United Kingdom, low-income households had a higher rebound effect for heating than high-income households. They estimated that the lowest income quintile had a total rebound effect of up to 106% compared to a rebound effect of up to 74% for all households. This implies that the lowest income quintile increases overall energy consumption, after an increase in energy efficiency. Chitnis et al. (2014) explain this finding by the fact that lower-income households have a higher expenditure elasticity for consumption of various goods, compared to higher-income households.

Besides household income, the rebound effect is also highly correlated with whether the household is an owner or a tenant. A study by Madlener and Hauertmann (2011), found that, in Germany, lower-income tenants had a higher rebound effect. For owners, however, there was a direct rebound effect of 14% for higher-income households, against a direct rebound effect of 13% for lower-income households. Direct rebound effects "derive from increased consumption of energy services, such as heating or lighting, whose effective price has fallen as a result of improved energy efficiency" (Chitnis et al., 2014).

In the Netherlands, it was also found that homeowners' direct rebound effect for residential heating was 26.7%, whilst tenants' direct rebound effect was higher, at 41.3% (Aydin, Kok, & Brounen, 2017). However, this study found that, among homeowners, the upper quantile of household income had a direct rebound of 19%, and the lowest quantile of income had a direct rebound of 40%.

Overall, research is not fully conclusive on which socioeconomic factors are most closely linked to the scale of rebound effects, though there is reason to believe income will be correlated with it. Generally, lower-income households are "further away from their satiation in consumption of energy services, including thermal comfort" (Boardman & Milne, 2000). On the other hand, higher-income households are more likely to have already reached "a satisfying level of comfort, so that any efficiency improvement will not affect their usage" (Farsi, Hediger, & Weber, 2018).

6.3 Effect of Household Income on Subsidy Recipience

Research done in the United States point towards heat pumps being evenly distributed across income groups (Davis, 2023). Davis (2023) finds that, in the United States, heat pump adoption rates are between 12% and 15% across all income groups, ranging from those earning less than 30,000$ annually to those earning above 150,000$. These findings would suggest that belonging to a certain income group does not correlate much with the decision to adopt a heat pump.

Conversely, research have also been conducted, showing that income does correlate with the effect subsidies have on adopting heat pumps. A study from Zhao et al. (2012) found that, in Leon County, Florida, households with an annual income below 50,000$ were 13 times more likely to request a higher minimum tax credit rate when deciding to buy an energy efficient heating/air conditioning system, compared to households earning above this threshold. The implication here is that, for a given amount of tax credits, or subsidies, lower-income households are less willing to purchase a new heating system compared to higher-income households.

Higher-income households having a higher adoption rate can be explained by them having the means to afford the high upfront costs of heat pumps, when compared to lower-income households (Shen, Qiu, Liu, & Patwardhan, 2022). Shen et al. (2022) discovered that, in North Carolina, the effects of a rebate program was increasing in income, until it reached about

60,000$. From 60,000$ onwards, the effects flattened out, i.e., an increase in income from that point had no effect on adoption rates. These findings point towards there being a correlation between household income and heat pump adoption rates.

Regarding our case in Bergen, the numbers suggest there is a slight trend towards households with a higher income, on average benefiting more from the subsidy. The raw numbers introduced earlier state that at least 71.5% of the beneficiaries had an income higher than 750,000 NOK. As previously mentioned, the real percentage is slightly higher, due to faulty applications for the subsidy. Numbers from Statistics Norway (2021) suggest that the median household income in Bergen, before tax, is 725,000, meaning there might be a slight tendency of the subsidy going to the wealthier.

This trend is likely correlated with the fact that lower-income households have a higher propensity for renting. A report from Statistics Norway (2018) finds that amongst households belonging to the top quintile of income, 95% are homeowners, compared to only 35% of households belonging to the lowest quintile. Therefore, as only homeowners are allowed to apply for the subsidy, it is not surprising to see a trend of higher-income households being the main beneficiaries of the subsidy scheme.

7. Methodology

The research methods chosen to investigate the market for heat pumps were qualitative in nature. Existing literature, theories and research done on the topic have already been presented, and will be used later when discussing the findings. To compliment this, we conducted interviews with various participants in the industry, to get an inside look into the market for heat pumps. These interviews will later be presented in section 8.

In this section, a general overview of our thought process behind the interviews will be presented. Firstly, the chosen research design will be explained. Then, it will be looked at how the interviewing process was, and who our selection of informants included. Finally, we will discuss potential biases that might have taken place, and investigate ethical considerations we had to account for during the process.

7.1 Research Design

The research design is defined as the "general plan of how you will go about answering your research question" (Saunders, Lewis, & Thornhill, 2019). For our purposes, we have chosen a combination of a descriptive- and an exploratory design. The reasoning for this is that, on the one hand, we needed some hard facts regarding whether there has been a price change for example, which is what a descriptive design provides. On the other hand, exploratory questions are useful when there is a lack of research done on the topic (Saunders, Lewis, & Thornhill, 2019), such as questions regarding the causes of potential changes in demand.

Combining these qualitative methods with a quantitative approach was an initial wish, but it proved to be impossible. Initially, we attempted to also collect data from various local dealerships from Bergen, by sending them a form they would fill out, where we inquired about data for the monthly history of prices and quantity sold of a selection of popular heat pumps. Then, we would collect the same type of data from a municipality that has not had the subsidy, and we would attempt to infer if the subsidy has had an effect through a difference-in-differences analysis. This, however, was not feasible, as none of the firms contacted were willing to provide the data, with their explanations generally being that they either did not have the data readily available, or that they did not have time for filling out the forms, due to the demand being high. Therefore, the analysis will be mostly qualitative and descriptive in nature.

7.2 Data Collection

7.2.1 Interviewing Process

To gather insights on the market for heat pumps, we have chosen a qualitative approach of conducting semi-structured interviews. Semi-structured interviews are conducted in a way where the interviewer starts with a list of themes and key questions they want to gather information on, but unlike a traditional interview, it is more open and less rigid in nature (Saunders, Lewis, & Thornhill, 2019). The interview consisted of both concise, yes/no – type questions, whilst also including question that were more open and builds more on the informant's personal experiences.

An advantage with this approach was that it allowed for greater flexibility than a traditional interview (Saunders, Lewis, & Thornhill, 2019). With this structure, the informants were able to speak rather freely and could answer more expansively than in a traditional interview. This led to the informants occasionally bringing up points that were not directly asked for but were nonetheless relevant for our purposes. However, as we had an interview guide[1], we could still steer the interview back to where we wanted if they were expanding upon points we thought were of no relevance. Overall, the flexibility of this interviewing style provided all the advantages of an open conversation, whilst keeping a clear structure and theme behind it.

7.2.2 Selection of Informants

In our selection of interview objects, we ensured that they had a wide range of backgrounds. Informants were chosen from bigger and smaller firms, as well as from both distributors and dealerships, all based in Bergen. In total, four people were interviewed, and they will be referred as Informant A, Informant B, Informant C and Informant D, respectively, as their confidentiality will be retained.

A key reason for having a wide variety is that it gives a better overall outlook for the heat pump market, as the type of knowledge will vary across the supply chain. For instance, as will be seen later, representatives from distribution firms will have a better insight into how competition is between firms on that part of the chain, whilst representatives from the dealerships will have better insights into negotiation processes between them and individual customers. Overall,

[1] See "Appendix -Interview Guide"

having a wide selection of market knowledge enables us to get the best possible market overview.

Informant A is a board member of the Norwegian Heat Pump Association (NOVAP) and has held this position there for almost a decade. The informant possesses knowledge and a deep understanding of the market, and shared valuable information on various topics, ranging from trends in the market and how the customers are, to some personal opinions on the subsidy and the outlook for heat pumps.

Informant B and C hold positions as a department manager and sales director, respectively, and work in separate firms in the distribution chain. They were able to provide some similar insights as Informant A but were also able to go more in depth on topics regarding the relationship between distributors and dealerships, and they also shared their thoughts on how the subsidy has affected their firms.

Informant D is the CEO of a significant dealership in the Bergen area. The interview with informant D was a little shorter, as the themes discussed related more to areas from the perspective of the dealership, rather than discussions relating to the general heat pump market. A key topic discussed during the interview included the relationship between the customers and the dealerships, and the informant also provided an inside look into how competition is between the various heat pump dealerships in Bergen. Informant D and their dealership were also directly affected by the subsidy, and the informant shared how it impacted their firm.

Below is a summary, showing the positions of the informants, where they worked, the dates of the interviews, and finally the durations of the interviews. As anonymity is preserved, the names of the two firms on the distribution side will be referred to as “Distributor 1” and “Distributor 2”, respectively, and the dealership will be referred to as “Dealership 1”.

Firm	***Position***	***Date***	***Duration***
Norwegian Heat Pump Association (NOVAP)	Board member	7.11.2023	1:12:16
Distributor 1	Department Manager	8.11.2023	55:59
Distributor 2	Sales Director	22.11.2023	1:17:25
Dealership 1	CEO	24.11.2023	34:20

7.3 Potential Biases

During the interviews, it was important to avoid asking questions in a way that could lead to biased answers. An example would be asking leading questions, or generally asking questions that are trying to confirm a hypothesis. Such questions could lead to biased answers, overall leading to the data being less credible (Saunders, Lewis, & Thornhill, 2019). To avoid this, we tried to frame the questions in a way that would make as few assumptions as possible.

Note, however, that due to the semi-structured nature of the interviews, questions might have been subconsciously framed in a way leading to biased answers. For instance, there would often be follow up questions to the informants asking them to clarify something or expand upon a point they made. Such questions were usually spontaneous and might therefore have been asked in a way that could lead to biased answers. Besides leading questions, the tone of voice, body language, and other factors could have an impact, leading to potentially biased answers (Saunders, Lewis, & Thornhill, 2019).

Additionally, there might have been a participation bias present, which is defined as a bias resulting from the nature of the type of individuals that agree to be interviewed (Saunders, Lewis, & Thornhill, 2019). In fact, besides the four informants we ended up interviewing, we asked many more from the industry if they wanted to be interviewed, but they declined. The people who ended up agreeing to be interviewed may have had characteristics to them that differ greatly to those who declined, leading to them having different views. For instance, it might be the case that only people whose businesses are doing well decided to be interviewed, and those who struggle decided to decline. In such an instance, we would be getting biased answers, and they would not fully be representing the industry.

7.4 Ethical Considerations

Before conducting the interviews, we ensured the informants that they would remain anonymous. Keeping their anonymity was important, as they would otherwise either be reluctant to share some answers during the interviews, or they would not be willing to have the interviews at all, as they would potentially worry about giving confidential information away. By remaining anonymous, there would be fewer such concerns, and they would feel more comfortable speaking freely.

Additionally, prior to the interviews commencing, we asked for permission to record, and made it clear that they would be used only for the purposes of writing the thesis. This way, in case the informant did not feel comfortable being recorded, we gave them an opportunity to opt out. Fortunately, they all confirmed that being recorded was of no issue.

When transcribing the interviews, we faced some issues regarding how we would transcribe them in a way that best represents the informants' opinions. Firstly, the interviews were conducted in Norwegian rather than English. This meant that we faced a challenge of translating them as accurately as possible. Occasionally, like when certain idioms or expressions are used, direct translation can be impossible. In such instances, we opted for an approach of translating in a way that best preserves the point they were making. To ensure that the translations were as accurate as possible, both of us translated the transcripts independently of each other. By doing this, we could be relatively certain that the translations were accurate if they largely overlapped, and in the parts where they differed somewhat, we would by the means of discussion come to an agreement on the best translation possible.

Additionally, we had to make sure that the informants were accurately represented, and that their statements were not taken out of context. As will be seen in the section presenting the interviews, there will be skips between statements, and, on occasion, we put brackets next to their quoted statements, where a clarification of what the informant meant is put forth. These measures were made to make the interviews more comprehensible and readable. Otherwise, by including a full, literate transcript, the reader would encounter filler words, occasional digressions that are not relevant, and the comprehensibility would overall go down significantly. As this comes with the risk of misrepresenting statements, we therefore put a considerable effort into making sure that the interpretation of statements was equal to the ones the informants themselves had.

8. Findings

In this section, the answers from the in-depth interviews will be presented. The answers will be divided into different segments, based on the topics behind the questions. These findings will later be used in the analysis.

8.1 Informant A

Demand

Regarding whether there are any clear trends in the market, informant A has noticed an increase in people's awareness about heat pumps.

> *"What is special about Norway, Sweden, Finland, and Estonia, is that we have the highest utilization per capita of heat pumps in Europe, probably in the world […] when you control for noise, the heat pump-market follows the electricity prices like this [shows with his hands that it varies accordingly with the electricity prices] […] there is generally an increase in awareness, and especially when we have these high electricity prices, I think people think to themselves that "it really is time now to get myself a heat pump"".*

The informant also stated that firms do not typically experience problems with meeting market demand.

> *"In periods like those with Corona, or with the war in Ukraine, there have been some delivery problems […] but under normal conditions, there are no restraints where it is difficult to get heat pumps".*

Competition

Informant A said that there is strong competition between distributors to get deals with local dealerships. Additionally, they spend a lot of money on running advertisement campaigns.

> *"There is extremely tough competition between distributors. They work systematically towards dealerships and try to serve them. Most costs go towards marketing, and it is the distributors who take care of those. They spend a lot of money on campaigns, on for example social media, local newspapers, tv, radio, and to sponsor sports teams […] a*

lot of them also give them [dealerships] market support, in case they buy big volumes of heat pumps, if they, however, only were to buy a few, they do not get significant market support".

Regarding how the market structure is on the dealership's side, the market has many dealerships with varying backgrounds.

"You have local firms that you probably have not even heard of; some of them are 2–3-man firms who work only regionally, whilst others can be composed of 10-20 people working in them".

On the question of whether firms consider their competitors' prices, the informant stated that firms are not able to increase prices by much, due to the competitive nature of the market.

"Yes, but to answer it simply in relation to economic theory: this is a mature, well-functioning market with extremely tough competition. There is very little room for anyone to increase prices significantly [...] You cannot allow yourself to increase prices a lot, because when people then check prices on the internet and such, they will see that prices elsewhere are much lower".

Opinion on the Subsidy

Informant A opined that subsidy schemes should not be provided for air-to-air heat pumps. Instead, the informant would prefer that subsidies helping lower-income households should be prioritised.

"Regarding the need for a subsidy or not: we have for many years argued that you do not need to subsidise air-to-air heat pumps. We consider it to be a well-functioning market, which we have seen for many years. Most people belong to the middle class and have a good personal economy. What matters more is awareness or willingness [...] we see that [for awareness] it has helped that, at almost every football game or radio broadcast, there are, especially during the winter, commercials for heat pumps, there are "heat pumps everywhere" and politicians are discussing them; overall, there is an increase in awareness" [...] Our priority politically has, instead, been to develop a subsidy scheme for low-income families, as for them, there is a real barrier where even if the heat pump is profitable, they simply do not have the money".

Miscellaneous

Looking at how the Norwegian heat pump market compares to the rest of Europe, the informant pointed out that Norway is ahead in electrification of the country, and that adopting heat pumps is easier as we lack the gas infrastructure of countries like Germany.

> *"What is special about Norway, Sweden, Finland, and Estonia, is that we have the highest utilization per capita of heat pumps in Europe, probably in the world [...] so there are some macro-trends, where we are far ahead. We have come further with the electrification of society than other countries [...] in Germany, for instance, even with the most efficient heat pumps, it has been difficult to compete with gas, as it is so cheap".*

Regarding whether the customers themselves lean on being price-sensitive or not, the informant feels they generally have a high willingness to pay for higher-quality products.

> *"Here in Norway, Sweden and Finland, there is a high willingness to pay for high quality products, which makes us have a higher prevalence of expensive heat pumps, when compared to the rest of Europe [...] the Nordic models dominate right now, and they cost 25-30,000 after installation".*

Some articles and studies argue that heat pumps do not lead to energy savings, due to a rebound effect where people increase indoor temperature after acquiring heat pumps. In response to this, the informant argued that whilst there might be a slight rebound effect, overall, there will be energy savings with heat pumps.

> *"There are a few studies that are referenced regarding this, usually the one done by Statistics Norway (SSB) in 2013. When it is discussed by for example the ministry of finance, they talk about the rebound effect from this study, and there were a lot of news stories about this in its time, and that all energy savings are lost due to the rebound effect [...] But amongst those that work with heat pumps in Enova and the Norwegian Water Resources and Energy Directorate (NVE), they know that this is not the case, and that there are real energy-savings with heat pumps. All else equal, and I have discussed this with people from SSB, most people with a regular heater will keep an indoor temperature at 22-23 degrees, then they switch to a heat pump and keep the same temperature, thus having real energy savings".*

Regarding potential technological advancements, informant A argued that there are no expectations of any significant improvements in the future.

> *"They [the manufacturers] work all the time to see how they can make their products both cheaper and better, as there is hard competition, and if one manages to make a product cheaper, then you are suddenly out of business […] When it comes to technological advancements, whilst there is some tweaking to the products all the time, there is no expectation by us [in the industry] that heat pumps will get way better than they are now".*

Finally, the informant argued that there are few to no issues with having a lack of qualified installers for air-to-air heat pumps.

> *"For air-to-air heat pumps, we do not have such problems […] To get a certificate [for an installer], they must pass an exam, and to pass the exam, they must undergo a course where they learn how to install these heat pumps. Otherwise, [without the certificate] they would be working illegally […] other places in Europe, however, plenty of installers have barely heard of a heat pump".*

8.2 Informant B

Demand

Informant B said that there has been a general decrease in price the last two decades, and the informant referred to it as a deflation.

> *"If we look at what a heat pump cost in 2005-06, it was more expensive than today. They usually cost 34-40,000 kroner, after installation. Today, I would guess that it is around 25-26,000 after installation. […] But there has been a deflation in this industry for most heat pumps. The prices have gone down, whilst the inflation has gone up, and this has lasted for 15-16 years".*

The informant mentioned that due to the demand for heat pumps being seasonal, it is important for firms to have other sources of income besides only the sale of heat pumps.

> *"It is a new industry with big swings, in the second quarter, meaning April, May, June, only 13% of our annual turnover comes from there. Thus, there is an extremely low*

turnover for an entire quarter, and it is the same for the dealerships. It is therefore important to have an extra leg to stand on, such as services or something similar: I would guess many of the dealerships you have seen offer other things like solar control solutions, or something else".

Further, informant B believed that the subsidy scheme in Bergen has not had any effect on increasing prices for heat pumps.

"My perception is that the subsidy has had no effect on increasing prices on a readily installed heat pump […] If you look at last year's rollout, it was only Stavanger that begun with this subsidy, you could neither see an effect on the prices, nor that they [the firms] got a significantly higher payout. […] I do not think that the subsidy has been a price driver in any way possible".

Regarding the firms' ability and capacity to meet demand, the informant said that this is not an issue, as it is easy and quick for firms to have access to qualified installers, due to the requirements for being a certified installer being easy to meet. Informant B compared this to a situation where if it took years for installers to get certified, rather than a few weeks, we would likely see issues relating to a shortage in manpower as demand increases.

"Our industry has been able to train and get more [qualified installers] in the industry. In the plumbing industry for example, it takes 2-4 years of schooling [to become certified]. On the other hand, there are low barriers to entry to install a heat pump, only a few weeks of training is needed, then you have everything you need […] On the dealership's side, you have few barriers, there is an investment cost of maybe 50.000 NOK and two weeks' vacation […] if there were heavy entry barriers, with long lead times, 2-4 years education, we would have seen an effect where there would have been a shortage in manpower to install this [heat pumps], and then the price would follow thereafter. But because you have a rational and efficient refill with new people [qualified installers] according to demand, you have not seen an increase in price here […] we see that there has been a big influx of new dealerships that have taken F-gas certificates".

Informant B believed that providing extra services, as well as maintaining a customer base, can make significant contributions to a firm's bottom line. In fact, informant B considered that a reason newer firms make up a bulk of those going bankrupt, is that they do not have this type of income stream from potential long-time customers.

"Service is really important for many, because that is what one tries to book in when they are out of season, such as between March and August, where it is very quiet in the heat pump market […] I just talked with someone, and he has been in the business since 2005-06, and 35% of his heat pump sales are from existing customers that he has had in his portfolio, that now want a new heat pump […] Yes, there are a lot from that part of the chain [dealerships] that are small, and that is partly because of the low barriers to entry. Not that we have data on this, but we have a lot of bankruptcies in our customer base [when asked if newer firms struggle due to a lack of long-time customers]".

Furthermore, the informant considered heat pumps to be standalone in the market, noting that they are significantly cheaper than many of its alternatives.

"It is very standalone. You can always substitute windows and such, but that quickly amounts to 150-200.000 kroner for a regular home, and you do not save more than 4-5000 kilowatt hours per year on that, which is as much as you save with a heat pump costing you only 25.000 kroner. So, if you want to save energy in large quantities with a small investment, heat pumps are one of the first actions you could take".

Competition

Informant B explained that there is tough competition between distributors, and that this is partially reflected in the prices of heat pumps, which have gone down despite significant increases in efficiency.

"There is a hard-fought battle between the manufacturers of products, and it is extremely difficult for distributors to come in and be the provider for the local dealerships around the country that sell heat pumps […] You can see this a little considering the prices now with an installed heat pumps, they are many times more efficient now compared to 15 years ago, but the prices have still kept going down. The consumers get way more value for their money now".

A follow-up question came up about what the deciding factors were for getting access to deals with local dealerships. Informant B noted that a key factor is the ability to spread information easily and explain to the dealerships why they should choose their products.

"You need to help inform them of their choices, and often you must serve them as much [information] as possible around the product. That could be everything from marketing

material to brochures that they use when visiting "Olav and Karin" [i.e. common people], when they explain to them why they should choose their product".

Further, the informant stated that "the big four" heat pump manufacturers, being Panasonic, Toshiba, Daikin and Mitsubishi, take up about 80% of the market share in Norway.

"We believe that the big four brands take up 80% of the market in Norway [...]"

The informant explained that most of the market shares for business-to-customers sales is covered by local dealerships, with the remaining shares belonging to retailers.

"We believe that 25% [of the market share] belongs to retailers, and that 75% is covered by what we call specialist dealerships".

Miscellaneous

When the informant was asked about how he/she considers the power dynamics between dealerships and distributors, and whether there are possibilities for negotiating prices, informant B pointed out that how high a price the distributor will be able to take largely depends on the quantity provided.

"It is clear that those who buy, say, 500 heat pumps from us every year, will get a better price than those buying only 30 a year. It is that simple".

Informant B remarked that, regarding the individual customers, they tend to largely focus on quality, and that they make sure they get a heat pump suited for the Norwegian climate.

"What one sees, is that customers are concerned with the heating effect, and that the heat pump works and is of high quality, and that the one they buy is still there in 5-8 years, if anything is to happen [...] There are a lot of these parameters that one looks at such as the fuse rating, if it has air filters, Wi-Fi controls and so on [...] I believe 90% of heat pumps in Norway are handled to face the Norwegian climate, and that 90-95% of the big providers' best sellers can handle -25 degrees and colder".

Regarding running advertisements and commercials, the informant stated that mainly the manufacturers do this, but that also local firms can help with some marketing as well.

"On the national level, it is the manufacturers who contribute to that, as it is there the money comes from [...] The local ones are quite small but are still able to help with marketing as well, through their website, Facebook or their customer base".

The informant stated that there may be some technological improvements in the future, but that they will likely be marginal.

> *"You can get them even more efficient, but it will be marginal how much the consumer will save with this […] getting the little extra is important, and lots is spent on marketing and such to be the best heat pump. But there are fewer and fewer margins here".*

Finally, informant B said that, amongst their customers in Norway, they have approximately 350 dealerships.

> *"We have customers that are dealerships, and we have about 350 active dealerships [in their customer base]".*

8.3 Informant C

Demand

Informant C stated that, adjusting for factors such as inflation, there has not been an increase in price in general for heat pumps the last 20 years.

> *"When I began working with heat pumps in 2003, a top model cost 26,000 NOK after installation. Today, a top model from us costs 33,000 – 34,000 NOK after installation. When adjusting for the consumer price index and inflation […] heat pumps are in fact cheaper today, adjusting for CPI, than it was 20 years ago".*

Informant C had not noticed an increase in demand for heat pumps in Bergen after the subsidy was implemented. The informant said that subsidies like this do not have a significant impact on demand, and that the main driving force behind changes in demand is the price of electricity.

> *"No [when asked if there has been a change in demand]. If you were to put the graph for electricity prices up against the graph for the quantity of heat pumps sold in the Norwegian market, we see that, historically, the price of electricity is a driver for increasing energy efficiency, and for energy-saving products, it varies more with a high electricity price than with subsidy schemes".*

The informant stated that right now is the time of the year when the demand for heat pumps is at its highest, but that the differences across quarters are smaller now than they once were.

"The third and the fourth quarter is oftentimes what we define as the high season, but we opine that the "low season" has vanished, as the market for replacements becomes bigger and bigger for each passing year. We see an increasing trend that, for example, if your heat pump breaks in April, people also replace it in April".

The informant explained they have not had issues this year with meeting demand for heat pumps. However, problems with meeting demand have occurred in the past with both air-to-water heat pumps, as well as with water-to-water heat pumps, due to events such as the war in Ukraine and the COVID-19 pandemic.

"This year we have had good control, and have a big stock of heat pumps, and have no challenges relating to deliveries for air-to-air heat pumps. However, with water-to-air and with water-to-water heat pumps, it has since the war in Ukraine, and the pandemic, been challenging, but it is starting to look better now, and we are capable of delivery at this moment".

Competition

Informant C expressed satisfaction regarding the state of competition, as having competitors signals that the topic of heat pumps is interesting.

"I would say the state of competition is very good. We are very happy that we have good competitors, had we been alone and had a monopoly for heat pumps, it would be a signal that heat pumps are not particularly interesting, and that no one wants anything to do with them, so we are happy to have competitors".

The informant explained that an important strategy for them to both obtain, as well as to keep agreements with local dealerships, is for them to emphasise the quality of their products, as well as to nurture good relationships with their existing base.

"We have competitors who consider price to be an important sales argument. For us, we have a business plan that conflicts with this, we do not have the cheapest heat pumps, we want to develop our dealerships, to build good relations and competency in the market [...] we want partners who are loyal, and that wish to deliver and use only our heat pumps".

Regarding what influences the negotiation process between them and different dealerships, key factors include the volumes they purchase, as well as how competent the dealerships in general are.

> *"Often when you have big volumes, and purchase a lot with us, you have a better case in negotiations. And often it is the big customers who are good at this, and they are kind of "low maintenance". They do well and deserve a better price because they move big volumes, and do not use us much for technical issues, and are able to manage themselves well".*

Customers

Informant C considered that generally, for the customers, the quality of the product is significantly more important than the price. Additionally, design and how the heat pump looks can factor in when the customers choose which heat pump to purchase.

> *"We see from our insight-analysis that it is more important for the consumer that the heat pump saves energy, than what the heat pump costs. So, the customers rank that it saves energy higher, in their feedback, than the price of the product. Quality is at the top, then the product being good at energy-saving comes second, and this about price comes all the way down at seventh or eighth place [...] our new top model, for instance, has a tree-look to it, and is often chosen as the customer thinks it fits neatly into their oak-kitchen".*

Regarding the background of the customer base, informant C stated that middle-aged men are their main target group.

> *"We see with us that our main target group is "Male, 35-40+ years of age". It is they who are interested, and who click on advertisements, and are interested in the products, and who talk with us at fairs. But we also see an increasing trend amongst younger people who have recently bought a home or apartment, so it is a wide range of customers. But generally, we target males who are 35-40+ years of age".*

The informant went on to state that the specific dealerships can heavily influence the customers when they are in the process of buying a heat pump.

> *"They have a lot of influence [regarding the influence of dealerships on the customers]. I know dealerships who have operated with air-to-air heat pumps for many years, and*

then suddenly contact us and say, "Now I will begin to sell floor mounted heat pumps, because I have begun to like them, and they are very good these models". Overnight, they thus go from selling wall-based models to focusing exclusively floor mounted models, and they reach the exact same sales with the floor mounted models as previosusly".

On the customers' knowledge regarding heat pumps, the informant explained that this has improved greatly the past two decades.

"I remember when I started to sell and install back when I started, I go to some customers, and they ask, "what is in the heat pump, what is actually this thing?" [...] Today, the questions asked are more around specific functions, how efficient this particular model is compared to a rival's and so on, people are more aware now".

Opinion on the Subsidy

When asked about an opinion on the subsidy, the informant opined that, rather than having a lack of subsidy schemes, a significantly bigger problem is the building code in Norway. According to the informant, it does not reward having a heat pump in a building, contrary to the building codes of some neighbouring countries.

"I feel like I work in an industry that does not ask for subsidies [...] if you build a home in Sweden, Finland or Denmark, there is a 98.8% chance, I believe, that you have waterborne heating with heat pumps as the main source of heating. When building a detached house in Norway, it is the consumer himself who must force it through, because the building code does not say you need to have it. We are, I believe, the only country in Europe that does not have a building code rewarding heat pumps in buildings [...] the market for waterborne heat pumps is around ten times bigger in Sweden than in Norway".

The informant further went on to state that the heat pump industry, rather than subsidies such as those in Bergen, wish to see a new building code in Norway, that rewards having a heat pump in buildings, as they believe this is a better means of increasing energy efficiency.

"So instead of a subsidy, the industry would rather see a building code that rewards heat pumps in buildings. What we in the industry wish for, is a new building code that stimulates and rewards heat pumps in buildings. And that is not because we want to profit off it, but rather because we want to work with the "green shift" and to increase

energy efficiency [...] So I think that is a better way to go than to subsidise air-to-air heat pumps".

Miscellaneous

Regarding marketing, informant C stated that they run advertisements on Google, and that they market themselves through Facebook, and in newspapers.

> *"We conduct marketing with Google ads, and we also market ourselves a lot through Facebook, and on social medias we see an increasing trend for those kinds of marketing, which of course targets potential younger customers, but this year we have even, for the first time, had an entire page on the newspaper as well".*

Generally, the different brands do not appear to differ much in terms of quality.

> *"If you purchase a Panasonic top-model, or a Toshiba top-model etc., it is not like you will bitterly regret your decision, as if one model is much better than the other".*

Finally, the informant did not believe that there will be significant technological improvements for heat pumps in the near future.

> *"With the development of technology that is currently ongoing, I would be surprised if in say three years there has happened something revolutionary with heat pump technology".*

8.4 Informant D

Demand

Informant D stated that their busiest period lasts from the beginning of August through to Easter, and that their revenues are at their lowest during the Easter.

> *"We have the high season from the 1st of August to Easter. [...] In terms of revenue, it is at its lowest when it is Easter".*

The informant said that the subsidy has led to a noticeable increase in demand.

> *"There is a higher demand for the people from Bergen, the demand has increased [...] Yes, the demand has become much bigger in Bergen".*

Despite this increase in demand, when asked whether the prices of their products have changed after the subsidy, the informant stated that they have not changed.

> *"No, our prices have not changed after the subsidy. We change the prices only when there are real changes in price".*

Regarding potential problems with meeting demand, the informant stated that they have not had any issues meeting it. Furthermore, they have not had to employ more workers either, but they have been forced to work more overtime.

> *"No, things are like they normally are at this time of year for us, the waiting time is at eight weeks anyway [regarding a question about potential issues meeting demand] [...] We have a little more overtime. We have not employed anyone new, we have not dared to do that".*

Competition

Informant D stated that there are around ten competitors in the market in Bergen, and that they are one of the three oldest. Also, the informant does not feel like they are pressured by their competitors.

> *"There are three of us that have been here the longest, then another three new ones have come in. Then there are another few smaller ones out there in the periphery, there are probably around ten firms altogether. [...] But I do not feel like we are fighting [as in competing heavily] or something, because there is a market to us all, there is room for everyone".*

The Informant considered that many of their competitors, particularly newer businesses, make a mistake of having too low prices when they first enter the market, in an attempt to establish themselves quicker.

> *"This mistake the new ones coming in make [...] they set the price down by 4.000 – 5.000 for a heat pump, and I have told them that they need to stop doing this, because they are only ruining things for themselves. [...] When they then dump the prices, one or two years pass by before they are bankrupt. Because they cannot pay out salaries, pay for rent, cars, insurance and so on. [...] I know several in the business who have done this, and they all went bankrupt".*

Informant D stated that, relative to the size of the firm, they have a good market share.

"We are only three people working, and I hire one on service as well, and we have rented him for 10-12 years […] You can say some are bigger than us, I like to say that we are small, but also big [referring to having a bigger market share despite their smaller size] […] Here, we install twice as much as others do, to put it like that".

Customers

It was also stated that the customers are significantly more knowledgeable about heat pumps in 2023 compared to before.

"Today, the customers know a lot more, if we go back five or ten years, they knew very little […] now, people are more attuned, and will order a heat pump in May, so they are ready for when autumn comes".

Furthermore, their customers have a great deal of trust in their installers, and they are able to significantly influence the customer's decision in the choice of heat pumps.

"When you go to the customer [on an inspection], the customer will listen to him [the installer] who is out on inspection, and the one doing the inspections for us, is also the one who installs the pump. We are the only firm who have the installers themselves doing the inspections, so you immediately get a relation to the customer […] For instance, we recently had a customer here who initially wanted a small pump in kilowatts, but we saw it was too small, and it would break after six years […] Then the installer went on inspection and looked at it, and he [the customer] ended up going from a 5 kilowatt heat pump to a 7.2 kilowatt one. It makes it 5.000 – 6.000 [NOK] more expensive, but like we told him, he will make that money back as the pump will last 15 years".

Building on the last statement, the informant further explained that it is common for customers to initially focus on price, but after talking to an installer, they change their mind and value quality higher instead.

"It usually starts with price, but they quickly change their mind when you explain the difference between various things. Because if you take the cheaper heat pump, it will in fact become more expensive eventually, as you will have to replace it much sooner, so they [the customers] understand that they will save money in the long run [by choosing the more expensive option]".

Informant D stated that an important source of income for them comes from having service deals with their existing customer base.

> *"All our customers get a service agreement. We call our customers every other year and talk to them […] they get it [services] 200 kroner cheaper if they have our service deal, and there is no one who does not have it. And they are also obliged to have service checkups twice within five years, otherwise their guarantee is not valid. Like, if there is dust and they have not had service and cleaned up […] And with all of them we have a connection, no one cancels the deal within five years".*

Furthermore, they also have a source of income from replacing old heat pumps for long-time customers.

> *"Now the "big replacement market" has begun. The ones we sold 15-16 years ago have to be replaced […] so we have a technician who does that job [replacing heat pumps], I hire him in".*

The informant went on to state that a key factor for them to retain long-time customers, has been to focus on keeping good relations with their customers, by doing regular check-ups, as well as phone calls.

> *"And those [customers] that have been there since we started, they replace their heat pumps today. Because we have been at their place every other year, they have a customer-relationship with us. That is why I always say that we should call our customers, and if we cannot reach them, we send them a nice message, that it is time for service and such".*

Nowadays, there is barely any haggling around prices, which the informant said is contrary to how it was around five years ago.

> *"There is very little haggling today. If we go back five years, there was a lot of haggling. Today, we personally have almost no haggling. […] And those who do haggle [with the dealership], get a 1000 kroner discount. […] Yes, there is very little of it. It is not something that happens daily anymore. It used to be like that, now it is only on a rare occasion".*

Opinion on the Subsidy

Informant D supported the subsidy in general but thought that the deadlines for both applying for the subsidy, as well as getting the heat pump installed, were too short.

> *"The mistake they have made in Bergen, is that they have given too short deadlines, they [the customers] had only a month to apply. […] and when they got it [the application] granted, they had five months to get it installed. And then they had to apply for an extension, because of the high demand and sales, it is impossible to install all of them [the heat pumps]".*

Miscellaneous

Informant D stated that they do not give much attention to advertising, keeping it mostly restricted to their own website and social media pages.

> *"No, nothing [when asked about if they do advertisement campaigns], we are on our website, and we also have Instagram and Facebook".*

According to informant D, there are fewer unserious people in the business than prior, largely because of the F-gas certification required to be able to install a heat pump.

> *"There were, unfortunately, a lot of "cowboys" [as in unserious people] like they call it, but it is not that cowboy-like anymore. If we go back 12-15 years, it was the wild west. Back then, anyone could install a heat pump. This they cannot do anymore, due to a new law from 2011 that requires the installer to have an F-gas certification".*

Furthermore, informant D stated that most of their customers are from the private market, but that they also have a market share amongst firms and the public sector.

> *"[…] we have stuff at Haukeland hospital […] so we are in a lot of large firms, even though we mostly operate in the private market".*

Finally, their firm uses only two brands of heat pumps, which they get provided by two distributors of these brands. Furthermore, it was stated that the quality of brands was the deciding factor in their choice of brands. The names of the brands are anonymised.

> *"We keep to [Brand 1] and [Brand 2], they are reliable heat pumps, they last long. […] When we started out, we also had [Brand 3] and [Brand 4]. We quickly found out these were not good enough heat pumps; they do not live long enough".*

9. Discussion and Analysis

In this section, we will look at some of the most important findings from the interviews and relate some of the findings to the theoretical model presented earlier. First, a summary of the interviews will be provided. Then, the findings will be analysed and discussed. Thereafter, a discussion on whether the subsidy reduces energy consumption will follow. Finally, alternative solutions and policies for reducing energy consumption will be explored.

9.1 Summary of Interviews

9.1.1 Market Structure

The market for the sale of heat pumps in Norway can generally be split into three segments: manufacturers, distributors, and dealerships. According to informant C the market for air-to-air heat pumps is heavily dominated by four big manufacturers, namely Panasonic, Toshiba, Daikin, and Mitsubishi Electric. This statement is supported by market research, which has found that these four manufacturers are among the five most popular brands (Bytt.no, n.d.).

The distributors in the market are national businesses concentrating on business-to-business sales, focusing solely on the supply of heat pumps to local dealerships and retailers. The distributors are often sole distributors of a few specific brands of heat pumps. As it is indicated that competition between distributors to enter agreements with dealerships is high, distributors will often cover dealerships' costs relating to marketing and staff training.

Finally, we have the local heat pump dealerships, aiming to sell and install heat pumps to the end-customer. These dealerships are often smaller companies and make up most of the business-to-customers sales in Norway, as indicated by informant B. However, larger retailers in Norway, such as Elkjøp, Power, Coop, and Monter make up a quarter of the market. These retailers also often sell less popular brands such as Qlima, Wilfa, Samsung or Bosch.

9.1.2 Overview of Most Important Findings

The subsidy does not seem to have changed the prices of heat pumps. Informant B believed the subsidy has not had an impact on price, whilst informant D stated that their dealership did not change their prices after the subsidy was introduced. This finding contrasts with what the theoretical model predicted in the short run, where it found that a subsidy would lead to an increase in demand, thereby increasing the price of heat pumps. However, it is instead consistent with the model in the long run, where supply is assumed to be perfectly elastic, and there is no change in price.

Informants A, B and C all say that there has been a general trend of real prices of heat pumps declining over the past 10-20 years. This is despite the general demand for heat pumps being significantly higher today, indicated by the higher sales numbers now compared to 10-15 years ago. This again is somewhat unexpected, as economic theory would suggest that a generally higher demand should lead to a higher price. However, this finding can possibly be explained through improvements in technology and supply chain efficiencies. Such improvements may have led to a reduction in marginal costs for heat pumps, which would be consistent with the trend of lower real prices.

Factors mentioned such as low barriers to entry, or that there are several new competitors in the market this year, are indications of the market being competitive. Notwithstanding that, informant B and D stated that the bulk of firms going bankrupt are newer firms, with the latter stating that the newer firms often price their products lower, in an attempt to penetrate the market. These factors indicate that established firms have a competitive advantage. True perfect competition is rarely, however, seen in the real world, and it can therefore be said that the market between dealerships is highly competitive, resembling perfect competition.

Regarding the customers, all informants state that they are more focused on quality of the heat pumps than the price. Informant D said that whilst some of their customers initially are focused on price, when talking to the installer doing the inspections, they usually become convinced in opting for the higher-quality product.

There does not seem to have been any issues recently regarding capacity constraints or meeting the demand for heat pumps. There have been some issues in the past when the coronavirus pandemic, or Ukrainian war, started, but currently there are few issues. Informant D also stated that they have not had any issues with meeting demand, but that they have had to increase overtime hours. According to informant B, due to it only taking two weeks for an installer to obtain the necessary certification, increasing the number of qualified installers accordingly with demand is of no issue.

The interviews indicate that one part of the income for dealerships come through replacing old heat pumps, as well as through inspections. Informant B knew a market participant where 35%

of the dealership's income came through replacing old heat pumps. Informant D stated that "the "big replacement market" has begun", in relation to replacing heat pumps, and mentioned that they make an income through service deals with customers. Both state that these income streams come from long-time customers, with many of them being there since the businesses started.

Informants A and C were both rather reluctant in supporting the subsidy scheme. Rather, they believed that there are better policies than the subsidy scheme, that could instead be implemented. Informant A had the opinion that air-to-air heat pumps should not be subsidised due to it already being a well-functioning market. Instead, the informant would rather see subsidy schemes that benefit low-income families. Informant C would rather see a change in building code that rewards having a heat pump, citing Sweden, Finland, and Denmark as examples of countries whose building codes have led to universal adoption of waterborne heat pump systems. The informant considered that a change in building code could lead to an overall increase in energy efficiency.

9.2 Effects on Demand and Price

Based on our findings we cannot with certainty state that demand has changed due to the subsidy. There are various market traits which can explain this lack of firm evidence. Firstly, the opposing perspectives on demand changes between informant D, representing the local dealership, versus the distributors, i.e., informant B and C, show the uncertainty in the subsidy's effect. These opposing views can commence from an inequal revenue stream and local awareness. It is reasonable to assume that local dealerships will notice smaller changes in demand compared to big distributors operating on a national basis. Smaller changes will expectedly not be statistically significant for distributors, as the extra generated revenue from local demand changes make up a smaller amount of total income. These rivalling perceptions indicate that even if there is an actual demand effect, it is likely not of considerable size.

Relevant for the demand effect on the local market in Bergen is also the current high market shares of heat pumps in Norwegian households. As two-thirds of households already own a heat pump, it is reasonable to assume that a part of the last third of households face some distinct barriers for heat pump adoption. Such barriers will prevent a subsidy scheme to affect demand considerably. Normally, there will always be a proportion of a market with noticeably higher willingness to pay than others, making a subsidy of maximum 40% of the costs potentially too small of an incentive to heat pump adoption. Furthermore, several households will, regardless of the subsidy, deem the investment costs too steep or have practical building restrictions diminishing the returns for investing in a heat pump. For instance, for a lower income single-person household, which is defined as 60% of the median national net income for single-person households, an air-to-air heat pump investment can make up almost 70% of monthly net income (Statistics Norway, 2022). Approximately 10.7% of the Norwegian working age population, excluding students, fit this definition.

Recent years' high electricity prices, especially in 2021 and 2022, can also contribute to a skewed view of what is considered a "normal" market demand. As explained by informant D, they have experienced some increase in demand during the period of the subsidy scheme. As we have only conducted interviews with one dealership firm, their experience can nevertheless differ to that of their competitors. This can for instance be due to different local market shares, prices, customer relationships etc. Additionally, the demand in 2021 and 2022, can perhaps have changed the opinion of what is considered "regular" demand levels. Especially since the subsidy requires the heat pump to be installed within either the year's third or fourth quarter, the subsidy coincides with the market's peak for seasonal demand. It can therefore be argued that without the subsidy, demand would have been lower than previous years.

Even though informant D has experienced some shift in demand during the subsidy period, it is possible that this is more due to a shift in time of purchase, rather than capturing new customers into the market. Many households that planned for heat pump adoption before the subsidy was introduced, have likely expedited the heat pump adoption to be applicable for receiving the subsidy. Such an effect has been discussed in Germany, where the sale of heat pumps plummeted in the first half of 2023, possibly due to a reduction in subsidies amounts in 2023, and that subsidies with greater payouts were to be introduced in 2024 (Wehrmann, 2023). For every household in which this is the case, the subsidy has not achieved sustainability improvement, but rather cost savings for households. Of course, the acceleration in heat pump adoption for households can possibly generate reduced emissions, depending on the size of the rebound effect, but this effect will likely be quite insignificant in the long term.

Even though the subsidy impacts the market in a short time-period, the price effect does not coincide with the short-run equilibrium from the theoretical framework. None of the informants state that there have been explicit price changes in relation to the subsidy. Our findings in section 8 help put context to this unpredictable subsidy effect. One of the reasons for the lack of price changes can be attributed to the heat pump market's supply and pricing structure. As distributors and manufacturers operate with national prices, this creates a problem with local demand differences. The websites of manufacturers and distributors are a common way for customers to search for heat pump products and prices, making it difficult to change prices depending on location.

The lack of change in prices is, however, consistent with what the model predicts in the long run. In the long run, the marginal cost was assumed to be flat, due to there not being capacity constraints. This is also consistent with what we discovered from the interviews, where it was stated by several of the informants that there have not been any issues with capacity or meeting demand after the introduction of the subsidy. Thus, despite having a short-term impact, the subsidy has overall resembled what one expects to see in the long run regarding price.

The informants generally consider the customers to value quality more than price, which could indicate that customers tend to be price inelastic. Generally, economic theory states that an inelastic demand is associated with a higher increase in price after an increase in demand (Stiglitz & Rosengard, 2015). The exception to this is when marginal cost is constant, in which case the elasticity does not matter, as the price will remain the same. Therefore, if it is true that consumers generally are price inelastic, it could point towards marginal cost being constant, as the price would have increased with a rising marginal cost, given inelastic demand.

As heat pumps gradually are bought more often as a replacement due to general wear and tear instead of as first-time instalments, the focus on customer relationship and repeating customer sales should expectedly become more important. Studies indicate that the probability of selling products and services to existing customers can be up to 60-70%, compared to a probability of 5-20% for new customers (Chapman, n.d.). As mentioned by informant B, 35% of a dealership's heat pump installations can come from repeating customers replacing older heat pump models. As this percentage gradually will increase, customer retention will be of high importance in the market. This market situation can help to understand the lack of price changes. As the distributors and dealerships know that keeping customers for future replacement purchases can be highly beneficial, price changes might be seen as dangerous in terms of customer trust and relationships. High churn rates will decrease the long-term market shares, as there will be fewer first-time customers available in the market. Even though some companies could benefit from increased prices and short-term revenue gains, this will likely not be the case for the majority.

The additional importance of maintenance services for existing customers during seasonal low demand periods, will also be an important revenue factor which relies on customers satisfaction and relationships. Empirical evidence indicates that 96% of customers mention customer service as the primary factor behind long-term loyalty (Rubkiwicz, 2023). Maintenance services can therefore both generate extra revenue in addition to creating stronger customer relationships. As an example, assuming a local dealership increases its prices during the subsidy scheme, they might not decrease quantity sold due to the overall high market demand from the subsidy. This will followingly generate higher revenues and profits for the dealership. However, if the company could have gained more customers instead, but produced less profits short-term, one can still argue that they will benefit from this through consistent revenue streams from maintenance and higher probabilities of replacement sales.

Finally, a potential factor for the subsidy's lack of effect on price changes, is based on the theory of price stickiness. Price stickiness refers to the resistance of market prices to change quickly towards optimum, despite shifts in costs or demand (Blinder, Canetti, & Lebow, 1998). Generally, the reason for this phenomenon is explained through "menu costs", i.e., practical costs associated with changing the price, such as marketing changes or website updates. Additional empirical research has also found that price adjustment speed also depends on the sensitivity of a firm's profits depending on the deviations from the optimal price (Dias, Marques, Martins, & Santos Silva, 2011). In the context of the subsidy, this can mean that a change in heat pump prices necessarily would not have great effects on total profitability. Additionally, because the subsidy is only applicable for a short period of time, the "menu costs" associated with it will become relatively higher. Menu costs would occur both in the process of price increases, and for price decreases when the subsidy period is over. This can be a key explanation for the market's lack of price changes.

9.3 The Subsidy's Impact on Energy Consumption

Having discussed how the subsidy has affected price and demand, we will now investigate whether the subsidy itself accomplishes its goal of reducing energy consumption. To evaluate this, we need to look at potential rebound effects associated with switching to heat pumps, and if there may exist better options for reducing energy consumption. In this section, we will work under the assumption that demand for heat pumps have increased due to the subsidy, and investigate whether, given this premise, the subsidy scheme is an efficient way of reducing energy consumption.

Recalling some of the empirical evidence, there will likely be a rebound effect present, though it might be smaller than what some of the papers suggest. Whilst the papers generally found a strong rebound effect indicating insignificant energy savings, the case in Bergen is different, as the people adopting heat pumps due to the subsidy are biased towards higher-income households, who are all homeowners. As discussed in 6.3, households having these characteristics generally have a lower rebound effect. Due to this, the rebound effect associated with the subsidy likely is weaker, potentially leading to overall energy savings amongst those benefitting from the subsidy.

Relating this to the question of whether the subsidy is successful in achieving its goals depends on the perspective one takes. A viewpoint could be that, if the subsidy does in fact reduce overall energy consumption, even if it comes with a significant rebound effect, it is successful in reaching its goals. After all, the stated goal of Bergen Municipality is to "reduce energy consumption from buildings and homes" (Bergen Municipality, 2023), which can be accomplished even with some rebound effects.

A counterpoint to this though, is that there might be more efficient approaches to reducing energy consumption, that are not being prioritised. With this viewpoint, one could argue that, even if the subsidy does reduce energy consumption, it is still not successful, as the same expenditure, or less, could be spent elsewhere to a greater effect. Thus, in the following part, it will be discussed whether there are other policies that could instead be implemented and prioritised, leading to greater reductions in energy consumption.

9.4 Alternative Policy Implementations

As we saw from some of the interviews, there is an impression that a significant part of the heat pump industry does not support the subsidy scheme, as they believe there are better solutions to increase heat pump adoption, and generally to increase energy efficiency. In this section, we will look at some other potential solutions and see what existing literature says regarding their efficiency.

9.4.1 Subsidising Lower-Income Households

Informant A would have liked to see a subsidy that targets lower-income households to a greater extent. In the case of this subsidy, an example could be to increase the maximum subsidies received by households earning less than 750,000 NOK to an amount higher than 10,000 NOK.

On the one hand, as has already been mentioned, lower-income households generally have a higher rebound effect with energy consumption. Thus, increasing the adoption rate of heat pumps among lower-income households will, all else equal, lead to more rebounding, due to differences in price elasticities across income groups.

However, an advantage with increasing the proportion of low-income households receiving the subsidy is that it can mitigate the free-rider problem. The free-rider problem in this context would be related to the amount of people who make use of the subsidy to buy a heat pump, but that would buy one without the subsidy anyway. Higher-income households are associated with having a higher proportion of free riders (Nauleau, 2014), this is due the fact that higher-income households likely could afford the product before the subsidy was introduced, unlike lower-income households.

Overall, there is a trade-off here, where overall heat pump adoption will be increased, but the rebound effect per consumer will be higher. In terms of reducing overall energy consumption, implementing subsidies prioritising the poorer will thus be better if the increase in adoption rate of heat pumps is high relatively to the increase in rebound effect. Conversely, such subsidies could have a negative effect on energy consumption if it does not increase adoption rates by much, relative to the increase in rebounding.

9.4.2 Prioritising Waterborne Heat Pumps

Informant C would rather see a change in building code that incentivises heat pump adoption, namely for waterborne heat pumps. In this section, we will consider whether it generally is a better idea to shift the focus from air-to-air heat pumps, to instead trying to increase the adoption of waterborne heat pumps.

Based on the information we have it is not certain if prioritising waterborne heat pumps is a better option. On the one hand, they have a higher COP than air-to-air heat pumps, meaning they will be more efficient. However, they are significantly more expensive, and to effectively increase adoption of them would require a substantially higher subsidy than both Bergen, and Enova, have been offering. Additionally, as already seen, waterborne heat pumps being more efficient does not mean there will be higher energy-savings, due to potential rebound effects.

An advantage of subsidising waterborne heat pumps is that there likely are lower rebound effects. Such a subsidy would mostly be going to higher-income households, due to the high investment costs. The lower rebound effects of richer households, coupled with the higher efficiency of waterborne heat pumps, mean there would probably be higher energy savings. Additionally, the free-rider problem may not be as big of an issue here, as adoption rates of waterborne heat pumps is rather low to begin with in Norway, as informant C mentioned.

A change in building code in Norway could happen, which might increase the adoption of waterborne heat pumps. This change could happen due to a proposal being made by the EU that seeks “to boost renovation and decarbonisation of buildings” (European Commission, 2021). The proposal states that, as of 2030, all new buildings must be zero-emissions, and that the “worst-performing 15% of the building stock of each Member State to be upgraded from the Energy Performance Certificate’s Grade G to at least Grade F by 2027 for non-residential buildings and 2030 for residential buildings” (European Commission, 2021). If these proposals are approved of, they would lead to changes in the building practices of Norway, which could include an increase in waterborne heat pumps. In fact, an estimated 200.000 Norwegian houses would have to be refurbished to meet the new standards (Hovland, 2022).

A part of the solution in increasing the energy-efficiency could be the implementation of waterborne heat pumps. Indeed, changing the heating system from one that, for instance, uses fossil fuels into heat pumps is common when refurbishing buildings to make them more energy efficient (Miljødirektoratet, n.d.). Waterborne heat pumps would be a particularly attractive option here, considering that they are the most energy efficient of all heat pumps.

9.4.3 Effects of Changing the Building Code

In this section, we will look at whether a change in building code, and generally building practices, could lead to more savings in energy consumption. A change in building code would require a change in policy at the national level, rather than at the municipal level. However, the shift towards cleaner energy solutions requires cooperation and unity at local, national and international level. Thus, we deem it relevant to also discuss policies beyond the local level, especially when informant C indicates that the industry would like to see a change in building code.

Studies conducted show varying results of how changing building codes impacts energy consumption. In California, a building code was implemented in 1978, which was supposed to reduce pollution by 80% in newer buildings (Levinson, 2014). However, Levinson (2014) finds that, when “controlling for observable characteristics of the houses and their occupants”, there is no difference in consumption of electricity between buildings built before and after the change in building code. Amongst potential causes for this finding are homeowners failing to maintain appliances and insulation, as well as the rebound effect (Levinson, 2014).

In Florida, it was found that buildings constructed after a building energy code was implemented in 2002 were associated with a decrease in electricity consumption (Jacobsen & Kotchen, 2013). In the paper by Jacobsen & Kotchen (2013), they compared the monthly utility billing data of households living in homes that were built both before and after the change in building code. After controlling for observable characteristics, they found that buildings constructed after the change in code were associated with a 4% decrease in electricity consumption.

In Italy, it was discovered that there is a rebound effect present when buildings are refurbished with the purpose of increasing energy efficiency (Corrado, Ballarini, Paduos, & Primo, 2016). The rebound effect they calculate by comparing expected consumption after retrofitting of buildings, with the actual consumption, as is expected. It is found that the rebound effect is as high as 35% - 55% when there is a renovation in thermal systems used, while it is lower at only 10% in the case of major renovations of a building (Corrado et al., 2016).

9.4.4 A Potential Policy Implementation

A possibility could be to implement several of the suggested policies, rather than having to choose just one. For instance, one of the suggested policies was to implement subsidies that increase heat pump adoption amongst low-income households, whilst another was to increase adoption of waterborne heat pumps. Applying both these policies can be illustrated by an example.

A policy which could be implemented could be to increase the subsidy in Bergen by an even higher amount for low-income households. The effects of this could then be such that more low-income households that would not buy a heat pump otherwise, can now afford one. Thus, there would be an overall increase in heat pump adoption.

Simultaneously, the government could increase the support from Enova for water-to-water heat pumps further, to an amount much higher than 10,000 NOK. The effects of this could be that higher-income households would rather invest in a water-to-water heat pump, than in an air-to-air heat pump. This implies that some of the free-rider effects found among high-income households would be mitigated, as they would now be investing into something they otherwise would not. Additionally, overall energy savings are higher when more high-income households use water-to-water heat pumps, as these heat pumps are the most efficient, whilst high-income households also are the ones with the lowest rebound effects.

Implementing several policies could in total lead to a further decrease in energy consumption. Implementing them would require cooperation between the government and the municipality, as the subsidy for water-to-water heat pumps would be done at a national level. Overall, implementing these policies could both lead to an increase in heat pump adoption, and further reduce rebounding among higher-income households, as more of them shift to water-to-water heat pumps.

10. Conclusion

In this thesis, we investigated the overall effects of a subsidy for heat pumps in Bergen Municipality. This topic is of great interest, as it is not covered by any existing literature. Overall, the goal of the thesis can be divided into two parts, (1) whether the subsidy scheme has had an impact on price and demand for heat pumps in Bergen, and (2) if the subsidy scheme is successful in its goal of reducing energy consumption. To investigate these topics, we used a combination of existing empirical research, a theoretical model by Schroyen (2023), and finally, in depth interviews with representatives from different parts of the industry.

Through the interviews, it was discovered that there have not been any changes in price after the subsidy. A reason for this included that increasing price could antagonise customers, and ultimately lead to losses in the long term. This is due to customers usually sticking with the same provider if satisfied, whereas a sudden increase in price could lead them to change provider. Additionally, the stickiness of prices can also be an explanation for why the prices have not changed. Somewhat surprisingly, the prices not changing is more consistent with what the theoretical framework predicts in the long run, rather than the short run, due to the firms' not having capacity constraints.

Based on the findings, it cannot be conclusively stated that the subsidy has led to a change in demand. Whilst informant D claimed there has been an increase in demand, a part of this could be that customers who would otherwise buy the heat pumps at a different point of time, expedited the adoption of heat pumps to take advantage of the subsidy. Moreover, high electricity prices will also greatly influence the demand for heat pumps. Additionally, informants B and C perceived that there were no changes in demand due to the subsidy. Overall, it is difficult to say definitively how quantity demanded has changed, as there are many different factors besides the subsidy that have influenced it.

It is tough to say whether this subsidy will be considered to successfully achieve its goals in reducing energy consumption. The extent of the rebound effect present is uncertain, with some existing research stating it is so great, that there are no savings present. However, as there is a trend in Bergen of higher income households receiving the subsidy, the rebound is thus likely not as great, though we cannot for certain comment on the exact extent of this.

Moreover, there might be other policies that are more efficient, that are not being implemented, which could also be used as an argument against the subsidy. From the interviews, significant parts of the industry are rather negative to the subsidy, stating that other subsidy schemes and policies would be more efficient. Amongst policies mentioned, are prioritising low-income households, as well as changing the building code in order to incentivise the adoption of waterborne heat pumps. Whether these options are better than the subsidy scheme of Bergen is uncertain, as there would also be a rebound effect present there as well. In fact, one can say that a general theme with all policies with the aim of reducing energy consumption, is that there will be a rebound effect present. Therefore, one cannot definitively say how efficient an energy policy will be, unless thorough research has been made into the effects of the specific policy in question.

11. Limitations of the Thesis

A weakness with the thesis is the lack of informants, particularly amongst dealerships. We were able to conduct only one interview with an informant working at a dealership. The limited sample size will decrease the reliability of our answers, as a limited number of perspectives were provided. For instance, if more people were interviewed, and their views all largely overlapped, one could with a higher degree of certainty state that their views hold true.

Another weakness is that we were not able to fully isolate the effects the subsidy has on air-to-air heat pumps. This is because the subsidy was given for both air-to-air heat pumps, as well as for air-to-water heat pumps. An assumption we made was that most of the subsidy recipients would buy air-to-air heat pumps. Firstly, this assumption was based on the fact that more than 90% of heat pump installations are air-to-air. Additionally, it is reasonable to assume that more households will buy air-to-air heat pumps as they are significantly cheaper, thus, the subsidy will proportionally be covering more of the costs for this type of heat pump. However, we were not provided data for how many of the recipients of the subsidy bought an air-to-air, and air-to-water heat pump, respectively. Thus, if our assumption does not hold true, and a significant part of the subsidy went to air-to-water heat pumps, the thesis will not be able isolate the effects of the subsidy on the demand for air-to-air heat pumps.

Finally, based on this study, it is hard to state conclusively the effects the subsidy has had on the quantity of heat pumps demanded. As seen, even if there has been an increase in demand, one cannot ascribe this fully to the subsidy, without more data. To fully grasp the effects the subsidy has had on demand, one would, therefore, need to do a quantitative analysis. This, however, was not a possibility for us, and will therefore remain a weakness with our study.

12. Suggestions for Future Research

It would be interesting to do a quantitative analysis to investigate to what extent the subsidy has changed demand in Bergen. As mentioned earlier, we initially wanted to do this, but the high demand at this time of year meant many firms did not have the time to provide us with data. Therefore, we suggest that such a quantitative study should be attempted during the low season for heat pump dealerships. Attempting to acquire data during the low season will likely be more successful, as the dealerships will not be as overworked.

Many studies are conducted regarding the rebound effects of heat pumps in general, but few make a distinction between the types of heat pumps. Most of the articles we cited on this topic, for instance, claimed that there was an overall rebound effect with heat pumps, but did not comment on the scale of the rebound effect for air-to-air, air-to-water and water-to-water heat pumps, respectively. More research on how the rebound effects between the types of heat pumps differ could greatly impact policy for which kind of heat pumps should be subsidised more in case there is heterogeneity in rebounding between them.

Finally, research done on the rebound effects of heat pumps in Norway is somewhat old and could use an update. The main paper cited in this context is that from Halvorsen & Larsen (2013), where the rebound was so strong with heat pumps, that there were no energy savings. Since then, much has changed regarding both heat pump technology, but also amongst the consumers themselves. There is a general increase in awareness around the topic of climate change, and people may be more reluctant to consume as much energy now as they were then. If that is the case, this would likely be reflected in a lower rebound effect. A lower rebound could change the conclusion from 2013, into one where a switch to heat pumps leads to a reduction in energy consumption.

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Appendix – Interview Guide

Below is a list of questions that were used during the interviews, separated into different categories. Note that, as the interviews were open and loose in structure, the questions asked did not follow the exact order presented below and the order of questioning varied greatly between interviews. Moreover, the questions below were not necessarily always asked literally as is written below. Additionally, as the informants varied in background, the detail and depth in answers varied greatly between them, with some of the questions not being answered by each informant.

Part 1 – Questions Regarding Demand

1. Has there been a change in the number of orders since June this year?
2. How has the price development of heat pump been the past 10-15 years?
3. Are there any clear trends on the market?
4. In your experience, how is the capacity of firms to meet demand?
5. For the past year, have you made any changes regarding capacity, by for example hiring more people, working more overtime and so on?

Part 2 – Questions Regarding the Competition

1. How do you experience the competition in acquiring new customers in the market?
2. How is the competition for distributors to acquire local specialist dealerships?
    a. Follow up question: What is the power balance between the distributors and specialist dealerships like?
3. How is the market structured, and who are your main competitors/rivals?
4. Do you see yourselves as a market leader?
5. Do you pay much attention to your competitors' pricing?

Part 3 – Questions Regarding the Customers

1. How do you experience the power balance between the customer and the distributor during the negotiation process?
2. Are the customers price sensitive, or do they pay more attention to the quality of the product?
3. Do you have any general impressions on the background of the customers since the subsidy was enacted, are there any trends here?

Part 4 – Miscellaneous

1. Do you run any advertising campaigns, and if so, through what channels?
2. Any thoughts on the potential for technological improvements?
3. In general, what is your opinion on this subsidy?
    a. Follow up question, if informant shows scepticism: Do you believe there are better solutions for reducing energy consumption, or increasing heat pump adoption?

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