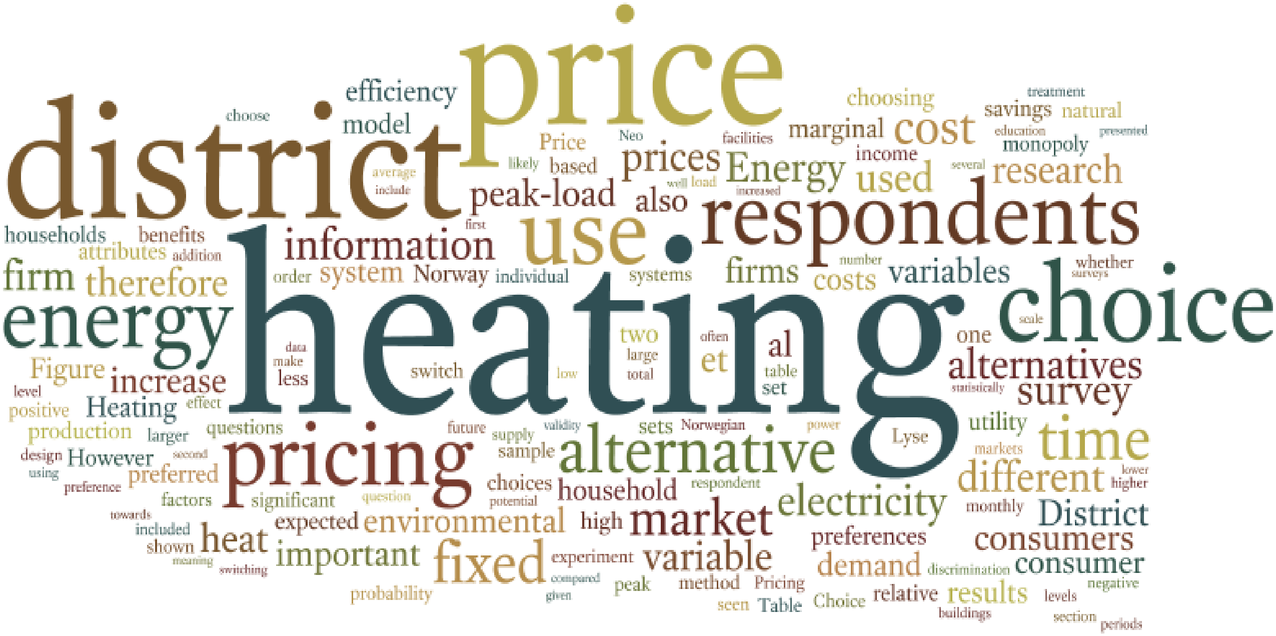
Pricing District Heating: An Empirical Analysis of Consumer Preferences



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Pricing District Heating: An Empirical Analysis of Consumer Preferences

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ABSTRACT

Increased awareness and concern for climate issues in recent years has brought about greater support for environmentally friendly solutions in the energy sector. This has put pressure on the sector to adapt to renewable energy sources. District heating has emerged as an important contributor to achieving climate policy goals because of its potential to protect the environment, increase energy efficiency and enhance energy security for the future. As a relatively new heating option, district heating has potential for future growth in Norway as a step towards a more sustainable development in the energy sector.

This thesis adopts a discrete choice experiment approach to address the research objective of identifying households' and firms' preferences and attitudes towards district heating. More specifically, preferences towards different types of district heating pricing are explored based on survey data from households and firms in Southern Rogaland in Norway. Lyse Neo AS is the region's leading provider of district heating. Thus, the empirical analysis seeks to bring forth useful information that can assist Lyse Neo AS in price-making decisions.

The current method of pricing district heating is commonly based on linear pricing methods. This thesis explores the potential to depart from the current strategies towards alternative forms of pricing based on dynamic pricing. Respondents in this study were faced with two choices between three pricing alternatives, one linear (fixed price) and two dynamic prices (time of use price and peak-load price). The results from the empirical analysis indicate that there exist preferences for the dynamic pricing options. To investigate the preference of environmental considerations in relations to heating decisions, approximately half of respondents received information about environmental and system benefits associated with the dynamic pricing alternatives. The overall results show that among the respondents receiving the information, there was a clear preference for the time of use price. Respondents not receiving the information were shown to prefer the fixed price in the first choice and the time of use in the second choice.

Several variables were identified to impact the choice of preferred pricing method. For instance, it was found that higher education increased the probability of choosing the peak-load price compared to the fixed price. In addition, monthly electricity use and expenditures, as well as household size had significant impacts on the choice probabilities.

ACKNOWLEDGEMENTS

This thesis completes a Master's degree in Business Administration at the University of Stavanger Business School. The research process has been challenging at times, but has been interesting and enlightening, resulting in a great sense of accomplishment. It has been encouraging to see how the thesis has been shaped along the way, from initial ideas to the final result. Especially motivating has been to gather and analyze own data.

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I would also like to thank my fellow students, friends and family for their support and encouragement. A special thanks to my twin sister Sara (English Major) for excellent language advice during the writing process and for carefully proofreading the final result.

Stavanger, June 2016

Sandra Skjæveland

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1. INTRODUCTION

Renewed attention on energy efficiency in recent years has been motivated by issues of pollution, global warming and fossil fuel depletion. Several policy measures now promote utilization of renewable energy and reduced energy end-use, for instance in buildings. District heating has become an increasingly widespread form of energy worldwide over the past decades. With district heating, centralized facilities distribute heated water and steam through pipeline systems to residential and commercial buildings. The concept is based on the idea of energy efficiency, using excess energy from society, which would otherwise be wasted if not used for district heating purposes (Persson & Werner, 2011). The motivation behind this is to use excess primary energy sources instead of using energy sources that are in high demand on their own (Norsk Fjernvarme, 2015). In this sense, district heating has several benefits for the environment and climate, as well as for energy efficiency purposes, providing benefits for society as a whole and for individual consumers. Utilizing district heating can therefore lead to a substantial reduction in primary energy usage and environmentally damaging emissions.

The largest markets for district heating are located in Europe, mainly in Northern and Eastern countries. Although district heating appears to have reached its peak in some Nordic countries, the Norwegian district heating market still has great potential for further growth and development (Gebremedhin, 2012). Most district heating markets, including the Norwegian one, are characterized as natural monopolies, where regional firms have market power over production and distribution. One of the most prominent aspects that distinguish natural monopolies from other market situations is the decision-making regarding price setting. One of the greatest challenges in all firms with market power is in fact how to set correct and fair prices that will uphold the interests of both producers and consumers, as well as of society as a whole. Price setting usually involves a number of considerations and can therefore be complicated.

District heating is a relatively new energy source, so different pricing strategies are currently being developed and evaluated. It is therefore interesting to examine the different pricing options in order to lay the foundation for developing appropriate pricing policies. In addition to the market situation, the degree of regulation in district heating markets will reveal different methods of pricing. Drawing on data collected from a survey-based choice experiment, this thesis will seek to determine attitudes and preferences for different forms of district heating pricing for households and firm consumers. The thesis will focus on the

Southern Rogaland area in Norway. In this region, the municipally owned firm Lyse Neo AS is the primary provider of district heating. The main objective of the research is to identify preferences and attitudes towards district heating and to bring forth useful information that can assist Lyse Neo AS in making pricing decisions for their household and firm consumers. Based on this, the following overall research question will be addressed:

How can district heating solutions be priced to residential and corporate consumers?

Relating to the overall research questions, some specific research questions will be addressed:

1. Does the environmentally friendly nature of district heating affect consumer preferences for different forms of district heating pricing?
2. Which socio-economic factors affect the preferences for different pricing alternatives for district heating?
3. To what degree is price discrimination appropriate for district heating?

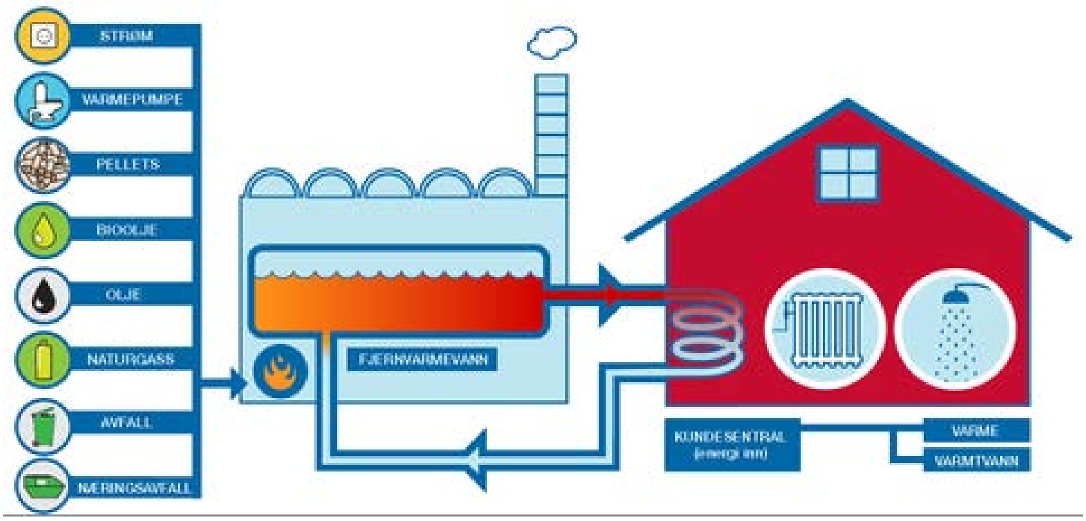
The remainder of this thesis is structured as follows. Chapter 2 will examine the background of district heating, considering technical, legal and other non-economic aspects. Chapter 3 will be an assessment of previous research on preferences and pricing aspects of district heating. Further, chapter 4 describes the theoretical foundations for the topic of the thesis. Chapter 5 describes survey methodology and design, and chapter 6 gives a description of the implementation of the surveys, as well as descriptive statistics of the samples. Chapter 7 contains empirical analysis and results. Chapter 8 will be a discussion of the findings, as a basis for final conclusions and recommendations offered in chapter 9.

2. BACKGROUND

2.1 District Heating

District heating is a technical system characterized by a centralized facility used for heating water. This is connected to an isolated pipeline system that distributes heated water or steam to consumers in residential, commercial and industrial sectors (Statistics Norway, 2015a). Figure 2.1 illustrates the process from the primary energy source through to the end user. Different primary sources are used as inputs to the centralized heating facility, and once water is heated it is transported through a pipeline system. When the water has reached the building it will supply, it enters the building's heating and plumbing system, which further distributes the water through the building for heating and hot water purposes (Statistics Norway, 2015a).

Figure 2.1 - The District Heating System



Source: (Norsk Fjernvarme [Picture], 2015)

The main idea of district heating is to use excess energy carriers as inputs into the production of heat (Otterlei, 2014). To do so, there are several methods used to produce heated water in a district heating facility, commonly characterized into six groups; recycled heat, bio energy, spillover heat, electricity, oil and gas.

2.1.1 Recycled Heat

About half of Norwegian district heat is produced from recycled heat (Statistics Norway, 2015a). With recycled heat, residual heat from industry production is used as inputs into the district heating facility. This method is environmentally friendly, as no "new" energy sources are used. Examples of these include burning industrial waste, household waste incineration, using recycled heat from industry production and from CHP (combined heat and power) plants. Heat produced with waste incineration is often used as a base load in district heating facilities, because waste as an input is a reliable source throughout the year. Waste incineration is also an important part of Norway's waste policy as a supplement to reusing and recycling policies (Otterlei, 2014).

2.1.2 Bio Energy

Bio fuels used for district heating are mainly byproducts from forestry, woodworking and agricultural production. These include pellets, wood shavings, corn-husks and biogas. In addition, there has been a large increase in the use of bio oils to replace fossil fuels in recent years. In Norway, these bio oils are retrieved from fish production, used frying oil and residues from meat production. Since emissions from bio fuels are a part of nature's cycle, CO_2 emissions from combustion of bio fuels in district heating is most often set to zero in emission accounting. However, biofuels do emit other greenhouse gases such as CH_4 (methane) and N_2O (nitrous oxide), which cannot be said to be a part of the natural cycle, and must be accounted for (Otterlei, 2014).

2.1.3 Spillover Heat

Spillover heat is obtained as excess heat from soil, oceans, rivers and sewage. Many Norwegian district heating firms are located in near proximity to such sources and are able to efficiently utilize their surroundings for inputs into facilities. In addition, solar energy began being utilized for district heating purposes in Norway in 2013 and has since gained a larger share of spillover heat production. Norway is currently at the forefront of innovations and investments in spillover heat for district heating, including utilizing excess heat from buildings (Fjernkontrollen, 2015).

2.1.4 Electricity

Using electricity as an input in district heating facilities can take advantage of price fluctuations in the electricity market. In periods of excess electricity in the energy system, giving low electricity prices, the use of electricity in district heating production increases. Similarly, the use of electricity in district heating production decreases when there is a shortage of electricity in the market, giving high electricity prices. During such times, district heating firms will use other production inputs. In this way, district heating contributes to even out the power peaks and off-peaks in the electricity system. Thus, the use of electricity in district heating production is said to be flexible and somewhat dependent on the conditions in the power market (Otterlei, 2014).

2.1.5 Fossil Oil

The use of fossil oils only accounts for 1.3% of total heat production in Norwegian district heating facilities. These oils are separated into two categories; light crude oil and heavy crude oil. Light crude oil is most used and is less polluting than heavy crude oil. The use of heavy crude oil is beginning to phase out, but is still occasionally used in some older facilities. Because of the polluting nature of fossil oils, there has been a shift towards more renewable input sources in recent years (Otterlei, 2014).

2.1.6 Fossil Gas

In district heating, fossil gasses are primarily used as peak load sources. This means that they are mostly used as supplementary sources in periods with high heat demand. The gasses are grouped into two types – LPG (propane) and natural gas (LNG or dry gas). District heating firms are currently working towards a gradual phase-out of fossil fuels as inputs in district heating plants, substituting towards greener alternatives (Fjernkontrollen, 2015).

2.2 Advantages of District Heating

There are several advantages of using district heating compared to its alternatives, one of the most significant of those being district heating's ability to increase energy efficiency. In addition, the IEA and OECD (2004) identify five main advantages for consumers, suppliers and society: *meeting consumers' energy needs*, *protecting the environment*, *energy security*, *stimulating economic development* and *facilitating energy reform.*

2.2.1 Energy Efficiency

Energy efficiency and energy conservation has taken on new importance in energy policy discussions as concerns about global climate change have intensified (Gillingham, Newell, & Palmer, 2009). Linares and Labandeira (2010, p. 573) define energy efficiency as "[…] the improvement (increase) in the efficiency with which energy is used to provide a certain product or service, measures in units of output per energy unit." One way in which district heating is efficient is that it gives the opportunity to make use of excess heat that would otherwise not be used (Benonysson, Bøhm, & Ravn, 1995). In general, energy efficiency allows us to save scarce economic resources, delay the depletion of non-renewable energy sources and to reduce carbon dioxide emissions. Linares and Labandeira (2010) identify these benefits from increased energy efficiency to reside from the fact that consumers do not consume energy itself, but rather energy services. Therefore it can be possible to provide the same energy services while using less energy. The basis for energy efficiency is expressed as (Bhattacharyya, 2011, p. 142):

$$\text{Energy Efficiency} = \frac{\text{Useful output of a process}}{\text{Energy input into a process}} \tag{2.1}$$

The basic relation in equation 2.1 is often adjusted for different energy analysis to measure energy efficiency in physical terms for different activities or sectors. Occasionally, the basic ratio is inversed: energy input per unit of output. The most common approach in residential and commercial sectors is to use energy input per square meter as an indicator in the numerator. In addition, it assumes that the energy requirement is directly proportional to the area of the building. However, this can sometimes be incorrect, as cooking, heating and similar processes may not be directly related to the area of the building (Bhattacharyya, 2011). At a broader aggregate level, energy efficiency can also be measured as "[…] the level of gross domestic product per unit of energy consumed in its production" (Gillingham et al., 2009, p. 598).

From an economic perspective, energy efficiency choices involve a trade-off between higher initial investments and uncertain future energy costs. The initial cost is the difference between the purchase and installation costs of an energy efficient product and the cost of an equivalent product that provides the same energy service but uses more energy. The decision of making an energy efficient investment therefore requires weighing of the initial capital cost against future savings (Gillingham et al., 2009).

2.2.2 Meeting Consumers' Energy Needs

With a readily available infrastructure, it is uncomplicated and inexpensive for new consumers to connect to district heating pipelines. District heating provides good indoor air quality and is space efficient. In addition, it provides unlimited hot water supply and requires little maintenance compared to individual boilers (Lyse AS, 2015a). These benefits provide consumers with a cost-efficient and reliable heating source. Compared to using individual boilers, district heating networks reduce expenses and complications related to maintenance of the heating system. District heating only requires a small heat exchanger to be installed in the building, which tends to be more reliable than an individual boiler (IEA & OECD, 2004).

For consumers, district heating can therefore be competitive with other heating systems (Persson & Werner, 2011).

2.2.3 Protecting the Environment

When managed correctly, district heating can have significant positive environmental effects. In most parts of the world, fossil fuels still dominate energy supply, and have a significant environmental impact through emissions of greenhouse gasses (GHGs), such as carbon dioxide (CO_2). Energy supply is therefore a major contributor to the greenhouse effect (Henning, Amiri, & Holmgren, 2006). To combat these issues, district heating is a good heating option compared to its more polluting and emitting alternatives.

As a renewable resource, district heating creates both local and global environmental advantages. Locally, the utilization of district heating contributes to reduce local emission of GHGs. Since the heat is produced off-site, the heat provided to buildings produces less indoor air pollution (IEA & OECD, 2004). Producing one unit of heat requires less primary energy and emits less GHGs than fossil fuel based heating. The primary energy savings from using district heating can be as much as 55% (Mahapatra & Gustavsson, 2008). From a global perspective, district heating can contribute to improve air quality by reducing emissions and improving energy efficiency. Many countries are adapting policies aiming to reduce or completely eliminate the use of fossil fuels. Because of its environmentally friendly nature, district heating can play an important part in this conversion (Lund, Möller, Mathiesen, & Dyrelund, 2010).

For most households, it is troublesome and expensive to install own pollution prevention equipment. Since district heating operated centralized facilities on a large scale away from the supplied buildings, it is more manageable to adapt such pollution prevention systems at each facility than it is in each household. When these measures are made outside the building, users connected to the facilities feel more environmentally safe as pollution management is handled by external operators (Yoon, Ma, & Rhodes, 2015).

2.2.4 Enhancing Energy Security

Energy security involves providing reliable supply of energy. District heating can be important in achieving the International Energy Agency's *Shared Goals.* The first goal states that "Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable" (IEA, 2007, p. 49). District heating can provide diversity, efficiency and flexibility in that many different input sources can be used, often within the same facility. Facilities can often switch fuels without much delay should there arise any unforeseen situations. Also, district heating facilities are efficient in that they utilize sources that would otherwise be wasted, and can deliver more energy per unit of input than competing heating solutions can (Persson & Werner, 2011). These security advantages make district heating an important contributor to energy security worldwide (IEA, 2007).

2.2.5 Stimulating Economic Development

The core goal of improving economic development is to increase the welfare of citizens, through economic growth and job creation. District heating has great potential for economic development in that greater efficiency increases gross domestic product (GDP) (IEA & OECD, 2004). As GDP is a measure of all economic activity within a country, it is an estimation of the average living standards of a country's citizens (Feenstra, Mandel, Reinsdorf, & Slaughter, 2013). In their study of district heating in transition economies, such as Russia and the Baltics, the IEA and the OECD (2004) found that approximately 70% of households rely on district heating. Families in these countries pay as much as 30% of their disposable income on utilities, primarily district heating. Reducing this burden by improving energy efficiency in homes would allow families to improve their standard of living. Also, improving supply-side efficiency could decrease the cost of heating for households and lessen their financial burden.

2.2.6 Facilitating Energy Reform

District heating reforms can facilitate broader energy reforms that can have a lasting effect on the district heating markets itself as well as on other areas within the energy sector. Henning and Gebremedhin (2012) argue that district heating using surplus heat should be promoted in the same way as pure renewable energy, where extensive use of policy instruments create incentives to switch to more renewable production.

Reforming the district heating sector will make it more sustainable and efficient. For instance, appropriate policies can create incentives for a stable sector with minimal subsidies. In addition, district heating reforms can have ripple effects on firms in other energy sectors. Fixing economic issues in district heating through appropriate policies can strengthen the position of other energy sectors, and facilitate more comprehensive policies because of their interdependencies. When district heating firms can operate in an economically efficient way, other companies in supporting industries can also benefit by achieving higher revenues, which they can use to reinvest or increase production (IEA & OECD, 2004).

2.3 Current Role of District Heating

2.3.1 District Heating in Global Energy Markets

District heating first started its developments in Europe in the 14^{th} century. Today, it is available around the world, but Europe still remains the largest district heating market by far (Rezaie & Rosen, 2012). Outside Europe, large countries with high population densities such as Japan, China, Korea and the US, are the largest markets for district heating (Euroheat & Power, 2015). There currently exist about 6000 district heating systems in Europe. In total, these systems have about 200,000 km of distribution pipes and the total revenue for heat sold from these is €30 billion yearly. Approximately 73% of the 502 million EU residents live in urban areas, indicating that a major part of the EU's buildings are in high heat density areas, which is an argument for the utilization of district heating in Europe (Connolly et al., 2014). In Europe, district heating is also widespread in countries that are less densely populated, such as the Nordic countries, the Baltics and Russia (IEA & OECD, 2004). These countries have national shares of the heat market amounting to 40-60%, while only about 13% of the total European heat market is covered by district heating (Connolly et al., 2014).

2.3.2 District Heating in the Norwegian Energy Market

Norway is the world's third largest exporter of energy, after Russia and Saudi Arabia (IEA, 2011). Norway's main exporting products are oil and natural gas, making up NOK 550 billion, accounting for 46% of total Norwegian exports for 2014 (Statistics Norway, 2015b). With this prominent role in the global energy market, Norway contributes to global energy security and supply for consuming countries. At the same time, Norwegians attach great importance to sustainability and environmental issues, consequently focusing much on climate policy. The International Energy Agency (IEA) regard Norway as having "a unique twin role as a major oil and gas producer and is a strong global advocate of climate change mitigation" (IEA, 2011, p. 7). Norway has set itself an ambitious target of reducing greenhouse gas emission by 30% of Norwegian 1990 levels by 2020, and to become carbon neutral by 2050. Since the Norwegian energy market is already low emitting, this target can be challenging to reach. However, with Norway's large petroleum revenues it is well equipped to invest in new solutions to reduce environmental impacts. District heating can contribute as a central component in reaching Norwegian policy targets (IEA, 2011).

District heating has a significant share in energy systems in the Scandinavian countries. Norway however, has a significantly lower share of district heating in the total final energy consumption than for instance Sweden and Denmark. The shares of district heating in

Sweden and Denmark are currently at 14% (SEA, 2015) and 17% (DEA, 2015) of total energy use, respectively, while this number is only 2.2% for Norway (Statistics Norway, 2015c). Another comparison shows that 63% of Danish citizens and 52% of Swedish citizens are currently served by district heating, while the corresponding figure for Norway is only 1% (Euroheat & Power, 2015). Gebremedhin (2012) recognizes this small portion to be due to the abundance of hydropower in the Norwegian energy market, resulting in lower power prices, thus making direct electric power the most used source of heating in Norway. However, district heating is increasing in Norway, with an average annual growth rate of 6.5% over the last 15 years, which is unique in a European perspective (Statistics Norway, 2015a).

Increased awareness of environmental issues and concerns from the population has led to an increased interest in more energy efficient and environmentally friendly energy sources. Particularly for areas where fossil fuels are the dominant energy sources, there has been greater interest in district heating (Benonysson et al., 1995). This trend has been evident in Norway, where consumption of district heating has seen a steady increase since its statistic recordings started in 1983. However, the most recent statistics show that consumption decreased by 5.1% in 2014, compared to 2013. One explanation for this decrease could be the simultaneous increase in district cooling. This shift can be seen in conjunction with record high average temperatures in 2014, where the average temperature was 2.2 degrees above normal[1]. Also, decreased consumption along with lower prices for district heating contributed to reduce sales revenues in 2014. The average price decreased from 59.2 øre/kWh in 2013 to 58.5 øre/kWh in 2014. This caused revenues from district heating to decrease by 5.8% compared to 2013, amounting to NOK 2.5 billion. Nevertheless, investments in district heating increased by 7.4%, equaling about NOK 1.5 billion in 2014, showing a considerable future commitment to this type of heating (Statistics Norway, 2015a).

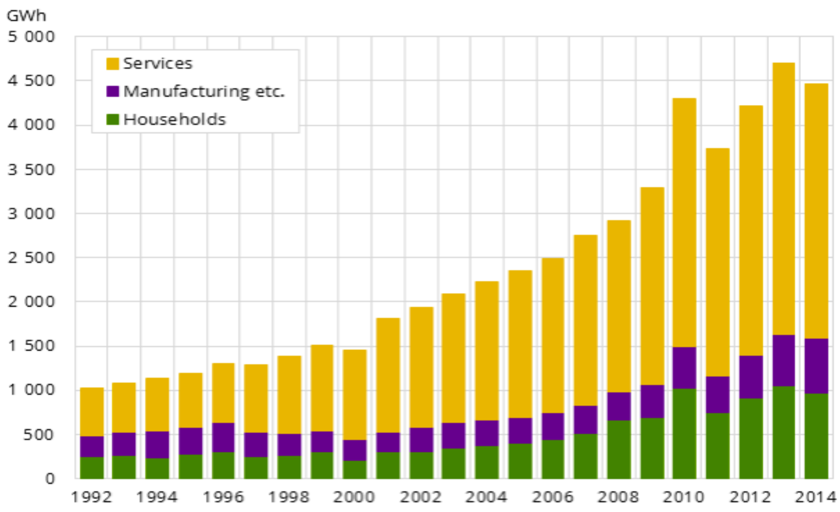
In the Norwegian governmental agency Enova's annual report for 2014, it is shown that about 90% of major Norwegian cities currently have a well built out infrastructure for district heating, or are in the process of implementing them. Most of the ongoing activity is therefore concentrated on expansions of already existing systems (Enova, 2015).

District heating consumption also varies between sectors, with service industries accounting for the largest portion, making up 65% of total consumption for 2014. Figure 2.2 shows the distribution between the three main consumer groups. It is evident that the service

[1] The average value of annual mean temperatures for the period between 1980 and 2011.

industry has been the largest consumer, followed by households and the manufacturing industry (Statistics Norway, 2015a).

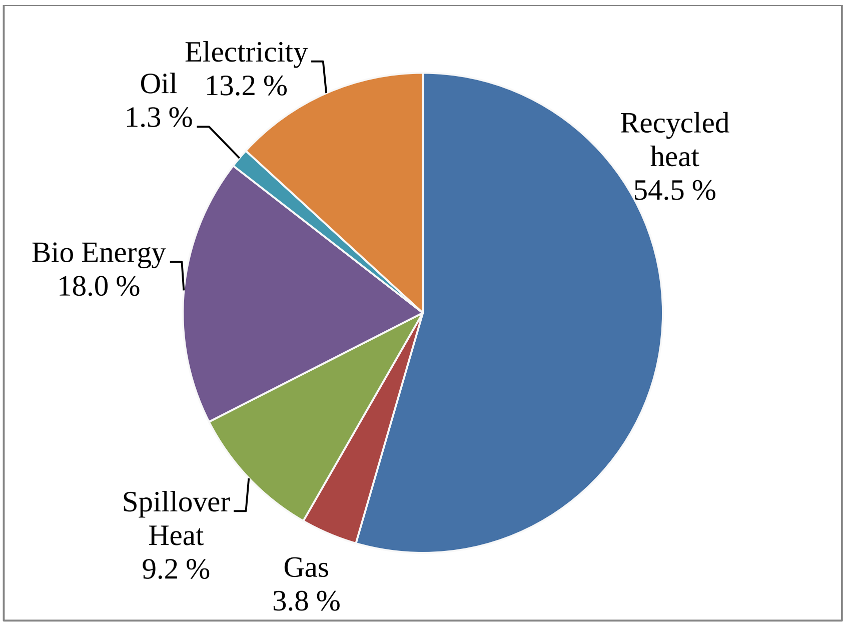
Figure 2.2 - Consumption of District Heating by Consumer Group



Source: (Statistics Norway, 2015a)

As previously discussed, district heating facilities use a variety of primary sources to operate plants. From figure 2.3 below, it is shown that the most frequently used approach in Norway in 2014 was the recycled heat method, where more than 50 per cent of the year's district heating supply (2.7 TWh) was produced from waste (Fjernkontrollen, 2015).

Figure 2.3 - Net Production of District Heating by Type of Heat Central: Norway



Source: (Fjernkontrollen, 2015; Statistics Norway, 2015a)

2.4 Legal Regulations on District Heating

The Norwegian district heating market is regulated by Norwegian law, namely by §5 in the Norwegian Energy Act of 1990. A central part of the act is the concession regulations. The act states that district heating cannot be built, owned or operated without concession (Energiloven, 1990). Concession rights refer to the right to use land or other property for a specific purpose, granted by a license from a government, a company or other controlling bodies. In addition, the act contains regulations for connection obligations, supply obligations, rules for shut down of facilities and for pricing.

Since this thesis will assess the pricing of district heating, the pricing regulations in enl. § 5-5 are most relevant. According to the paragraph, the charge for district heating shall not exceed the charge for electrical heating in the same supply area. This means that a supplier of district heating must provide a service that is at least as good as the consumer's alternative heating options. Since electricity is usually the best available alternative for heating, the price will be directly proportionate to electricity prices (Energiloven, 1990).

The act proposes different methods of pricing district heating. It suggests that the charge for district heating is calculated in the form of a connection fee, a fixed yearly charge and a charge for the heat that is used. The fixed connection fee is set out to cover the subscriber's proportion of the firm's initial investments into building the facility and the maintenance costs. The suggestive form of the pricing decision described is based on legislators' wish to allow for flexibility and freedom for firms themselves to determine the price based on local conditions. Further, the paragraph states that all prices are to be reported to the concession authorities (The Ministry of Petroleum and Energy). This is done to protect consumer interests, so that the concession authorities can intervene if necessary. This also functions as a way to keep track of the development in prices in the district heating market and to ensure transparency (Energiloven, 1990; Naas-Bibow & Martinsen, 2011).

2.5 Future Prospects for District Heating

Recent studies have shown that district heating can play an important role in the future of sustainable energy (Lund et al., 2014; Persson & Werner, 2011). Although future heat demands are projected to decrease in the future (Persson & Werner, 2011), there exists a considerable potential for continuous growth in the district heating market. This is much due to the environmentally friendly nature of district heating. To reduce climate effects and ensure energy security, many countries have implemented policies and targets aiming to increase the share of renewable energy resources in the energy mix and to increase energy efficiency. Enova identifies a considerable future potential for district heating in Norway. At present, one of the biggest issues in district heating is to spread distribution out of large cities, to more rural areas. By developing a market for local heating plants, less densely populated areas could also gain access to renewable heating in the future (Enova, 2015).

Lund et al. (2014) express the need for future district heating infrastructure to be designed for future energy systems, rather than for present systems. To do so, the future development of the industry requires technical advancements. In order to fulfill its role in future sustainable energy systems, district heating must address a number of challenges going forward. These include solutions for distributing heat resulting in less grid losses, building sustainable new buildings, renovating existing buildings to make them more energy efficient and to supply already existing buildings with more district heat (Lund et al., 2014).

In the report *Energy Roadmap 2050,* The European Commission (2012) assess the necessary strategies to achieve the EU’s target of an 80% reduction in annual GHG emissions by 2050 compared to 1990 levels. Reaching this target, the report recognizes that reducing emissions this drastically will put pressure on energy systems. To make the necessary transformations, nations need to be more politically ambitious by rethinking energy markets. One step in this process is to increase the share of district heating. In addition, the report shows that while prices are projected to rise until 2030, new energy systems can lead to lower prices later. Extensive regulation to bring down prices now should be avoided, since this can send the wrong message to markets, removing incentives for energy savings and low-carbon investments. This could hold back the transformations that will ultimately bring prices down in the long run (The European Commission, 2012).

By extending the use of district heating, local renewable resources can be used more efficiently by recycling some of the heat that is currently wasted. Thermal dynamic heat losses and losses from electricity production are the most common forms of energy losses. If district heating is implemented, some of these losses can be utilized for heating buildings, thus increasing the overall efficiency in global energy systems (Connolly et al., 2014). Increasing efficiency in this way could be particularly valuable for Norway as it has the highest power consumption per capita in the world. Expanding district heating in Norway can therefore lessen the country’s dependency on electric power (Gebremedhin, 2012).

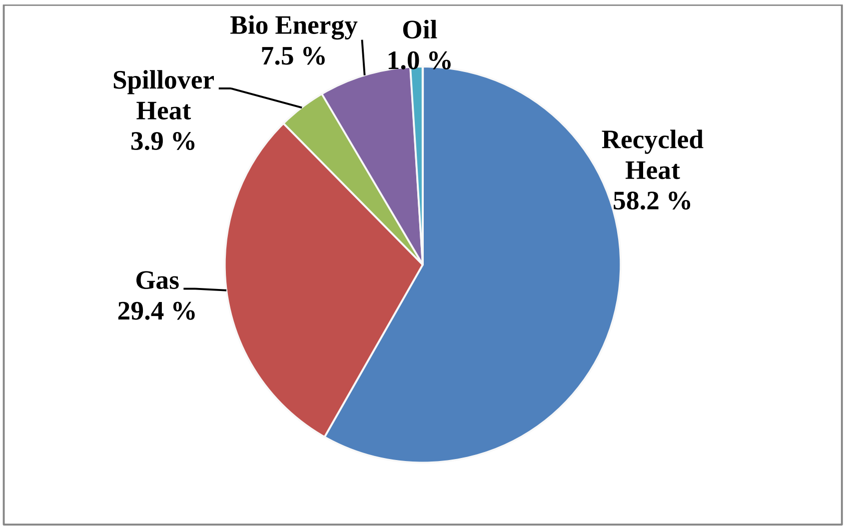
Going forward, governments should recognize the importance of district heating in terms of increasing energy efficiency and security of heat supply as well as reducing environmental impacts. This should therefore be focused on to ensure commitment to future energy sustainability. Henning and Gebremedhin (2012) therefore suggest that policy makers should focus on facilitating to increased investments and developments within the district heating sector. Through leading by example, firms in well-developed district heating countries have much knowledge that can promote district heating development elsewhere. Such agents can share their experiences and skills by assisting in the establishment of district heating facilities as well as systems for supply and distribution and contractual relations with customers. As the Nordic countries are in the forefront of the use and development of district heating, much of existing literature refers to these countries as examples of well-run district heating nations (Hellmer, 2013; Lund et al., 2010; McCormick & Neij, 2009).

2.6 Lyse Neo AS

Lyse Neo AS is a part of the Lyse Group, based in Stavanger in Norway, operating within the fields of energy, infrastructure and telecommunications. The group is owned by 16 municipalities in Rogaland, and has become the sixth largest provider of renewable energy in the Norwegian market. Lyse sells its products both nationally and regionally, with its main market being Southern Norway (Lyse Energi AS, 2015). Lyse Neo AS was established in 2000 and is responsible for developing and operating new energy solutions and products such as gas, biogas, district heating, district cooling, gas as fuel (CNG) and electricity in the transportation sector. Lyse Neo AS had annual revenues of NOK 352 million in 2014, with operating profits of NOK 25.7 million (Lyse Neo AS, 2015). In 2014, Lyse Neo AS supplied 120 GWh of district heating, compared to 132 GWh in 2013 (Lyse Energi AS, 2015).

As previously discussed, district heating facilities vary in which primary sources are used as inputs for heat production. For Lyse Neo AS, the dominant production input is recycled heat, making up 58.2% of total production for 2014, followed by gas at 29.4% of total production, as shown in figure 2.4. Lyse Neo currently operates four district heating facilities in the Stavanger region, located in Forus, Sandnes, Urban Sjøfront in Stavanger and in Risavika. The facility at Forus uses mainly recycled heat, while the other locations are based on bioenergy and gas. Lyse Neo AS is currently expanding their district heating network, and the Sandnes and Stavanger plants will be connected to the Forus network within 2018/2019 and 2020/2021, respectively (Fjernkontrollen, 2015).

Figure 2.4 - Net Production of District Heating by Type of Heat Central: Lyse Neo AS



Source: (Fjernkontrollen, 2015)

Lyse Neo's price for district heating consists of a variable and a fixed amount per kWh. The variable amount is the volume-based cost price for electricity in South-Western Norway (NO2) from Nord Pool Spot, changed monthly. The fixed amount consists of a base price per kWh and a fixed amount per month. These amounts vary according to customer type: *Privat* for households, *Varme* for firms consuming less than 144,000 kWh per year and *Varme Pluss* for firms consuming more than 144,000 kWh per year (Lyse AS, 2015b). This thesis will investigate the potential for Lyse Neo AS to implement other forms of pricing.

3. LITERATURE REVIEW

The majority of previous literature on the pricing of district heating has focused on pricing at marginal cost. However, several different pricing methods are used in practice. Many of the studies focus on consumers' propensity to switch to district heating from other forms of heating, on determinants of demand and on general consumer preferences towards district heating. In order to ensure fair and correct pricing, these aspects form an important basis for setting the right price. Assessing existing literature on the topic can help highlight key information and previous trends in these important fundamental aspects related to pricing.

3.1 Stated Preferences and Willingness to Pay

Yoon et al. (2015) assessed the willingness to pay (WTP) for district heating compared to individual heating in the Korean heating market. Consumers' economic valuation of convenience of the different heating systems was compared in a contingent valuation study. A double-bounded dichotomous choice method was used, presenting respondents with a price, asking them to answer "yes" or "no" on whether they were willing to pay the proposed amount under given scenarios. They found that households in affluent neighborhoods with higher income, higher heating costs during winter and higher education, collectively describing high living standard, assign higher value to district heating than to individual heating. These respondents also show more interest in non-economic factors, such as convenience, interest in energy efficiency and environmental aspects. In addition, results indicate that consumers are willing to use district heating even though prices were to increase. Among respondents currently using district heating, 78.5% reported that they were willing to continue using district heating if the price was equal to individual heating. Furthermore, among current district heating users, 74.5% were willing to continue as consumers if the price were to increase by 5%, and 54.2% would still prefer district heating with a 10% increase in price. This shows a large degree of consumer loyalty by Korean district heating users, and that factors other than price are important in consumer preferences towards district heating. Based on these results, Yoon et al. (2015) recognize that other factors than pure economic considerations need to be emphasized when analyzing consumer preferences for district heating. These considerations include comfort, usability, environmental friendliness and energy safety, which collectively can explain consumer preferences better than price alone.

On the contrary, Mahapatra and Gustavsson (2008) found that environmental aspects and convenience were given low priority by consumers. Their research estimated Swedish households' propensity to replace traditional heating systems with more energy efficient and environmentally friendly heating options, such as district heating. Rather, annual heating cost, functional reliability and indoor air quality were reported as the most important determinants for switching to district heating. Rouvinen and Matero (2012) found similar results for the Finnish heat market. They examined how different attributes affect homeowners' choice of heating system, including district heating, through a discrete choice experiment. The attributes respondents were questioned about included investment cost, annual operating costs, CO_2 emissions and required own work. The results showed that investment costs were an important factor in the choice of heating system, but non-financial attributes also had a considerable effect on the heating system decision. For district heating, functional reliability and fuel price reliability were highlighted as important determinants apart from the attributes respondents were questioned about.

Applying a slightly different approach, Braun (2010) estimated how German household's socio-economic and regional characteristics affect the choice of heating system in a discrete choice experiment, estimated with a multinomial logit model. She found that, unexpectedly, income had little effect on the choice of heating system. The minor role of income therefore provided little direction as to which income groups should be targeted with monetary incentives. However, the choice of heating system showed significant regional differences. With this, Braun (2010) concluded that policy decisions should be tailored to suit each region and be delegated to and enforced by regional authorities.

3.2 Price Responsiveness

District heating has shown to be relatively price inelastic (Hellmer, 2013; Haas & Biermayr, 2000), meaning that a percentage change in price produces a smaller percentage change in quantity demanded (McConnell, Brue, & Flynn, 2012). Using Swedish data, Ghalwash (2007) demonstrates the inelastic nature of district heating. Estimating the price responsiveness of consumers with a price increase as a result of environmental taxes, elasticity was calculated to -1.83, indicating that when the price of district heating increases due to a tax, demand for district heating will decrease. However, with a producer's increase in price, not triggered by a tax, elasticity is smaller, calculated at -0.43. The interpretation of this is that if the tax increases by 10%, demand for district heating will decrease by 18.3%. Furthermore, if the producer's price increases by 10%, demand for district heating decreases by 4.3%. This indicates that consumers are more sensitive to price changes with an environmental tax than with changes in a producer's price (Ghalwash, 2007).

Price responsiveness of district heating can also differ between types of buildings. Using data from Swedish district heating, Hellmer (2013) found that price elasticity for consumers living in small houses is generally greater than the elasticity for those in larger communal residential buildings. That is, consumers in smaller houses are more sensitive to fluctuations in price than consumers in larger buildings. One explanation for this could be that in small houses the consumers are responsible for metering themselves, while metering is done collectively in residential buildings. Consumers with individual metering therefore have immediate information available about their own usage and can react quicker to changes in price. Another explanation is that consumers in residential buildings to a larger extent are obliged to use district heating, while consumers in smaller buildings have more flexibility in switching between different heating systems as a response to varying prices (Hellmer, 2013). Rehdanz (2007) found similar results for Germany, also demonstrating the difference in flexibility between individual houses and larger residential buildings. The estimation of determinants for household heating expenditures found that individual households suffer less from price increases in district heating than consumers living in residential apartment buildings, who are to a larger degree obliged to use district heating (Rehdanz, 2007). Residents in larger buildings have less say about what type of heating system is utilized in the building, while individual homeowners have the opportunity to decide themselves whether to use district heating, switch systems and adjust to prices.

3.3 Pricing Mechanisms

Existing literature on pricing of district heating is mainly focused on two representative pricing policies – marginal cost pricing and cost-plus pricing. The main point of reference in selecting the appropriate pricing mechanisms is market characteristics. District heating is often characterized into two types of markets; regulated and deregulated markets (Li, Sun, Zhang, & Wallin, 2015). A regulated market is characterized by government intervention to change market outcomes. This typically involves regulation on prices, terms of service and market entry, not facilitating to a freely competitive market situation. A deregulated market on the other hand, involves less government intervention to allow for a larger degree of competitiveness in the market with prices derived in the market (Church & Ware, 2000). It is difficult to determine which situation is best for the district heating market. However, it is evident that the heating market cannot be fully regulated, nor fully deregulated. Rather, the consensus has become that there should be competition with some degree of control by government (Zhang, Ge, & Xu, 2013). The classification into regulated and deregulated markets reveals different methods of pricing. In a regulated district heating market, the cost-plus pricing method is most often utilized, while for a deregulated district heating market, marginal-cost pricing is the dominant method (Li et al., 2015).

3.3.1 Pricing in Regulated District Heating Markets

In regulated district heating markets, price is government regulated. The regulated price therefore orders the profit made by district heating suppliers. In such markets, the cost-plus pricing method is often used, where the price for district heating equals the sum of costs to be recovered and a reasonable profit for district heating supplier (Li et al., 2015). The key issue here is to determine the permitted profit a district heating supplier can earn. The benefits of using this method include simplicity, flexibility and ease of administration. However, in a regulated market situation, there are several restrictions imposed on the supplier. For instance, the district heating supplier is not permitted to compete with other heating solutions by adjusting their prices. Subsidies for district heating is therefore often needed in order to make district heating a competitive option compared to other heating alternatives (electric heating, boilers etc.). Subsidies on district heating systems are important to ensure stable energy prices, development of local energy systems, reduction of energy imports, reduced pollution and job creation. However, the cost-plus method normally uses historical data on real plants, containing uncertainties when used for predicting future situations (Li et al., 2015).

Li et al. (2015) also point on the unfavorable incentives created for district heating companies under regulated market control. “Under a cost-pricing mechanism, DH companies have incentives to increase profits by inflating costs, since permitted profits are usually related to costs. […] Consequently, the cost-plus pricing method undermines suppliers’ incentives to reduce cost and to upgrade their technology” (Li et al., 2015, p. 59). This can hinder future growth in the market and slow down development of district heating markets. Because of these incentives, companies that are efficient and manage to reduce their production costs, are punished with lower profits (Zhang et al., 2013).

3.3.2 Pricing in Deregulated District Heating Markets

To determine the price in a deregulated district heating market, pricing is most often done in accordance with marginal cost (Li et al., 2015, p. 59). A marginal cost is the cost of one additional unit of the product, in this case being the cost of generating one more unit of heat. The market price is obtained at the equilibrium point where total heat supply equals total heat demand. Facing an exogenous market price in a deregulated market, suppliers are motivated to set the price below market price in order to obtain a larger share of consumers and to achieve larger profits. In this way, all suppliers in the market will be motivated to increase efficiency, reduce costs and make profitable investments in equipment and infrastructure. Due to these incentives, marginal cost pricing will benefit not only district heating producers, but also the environment in terms of reduced emissions.

Sjödin and Henning (2004) suggest the marginal cost method as being the optimal choice for pricing district heating. The use of marginal cost for pricing allows for variation in peak and off peak seasons. During summer, when the demand for heating is lower, they find a lower marginal cost for district heating. It is therefore proposed that the marginal cost should be reflected in the price. In addition, they support the use of a fixed portion to be included in the total price, to eliminate some of the risk of the utility running at a loss. Combining the use of short-range marginal cost and a fixed cost "should be able to bring about a close to optimal resource-allocation" (Sjödin & Henning, 2004, p. 17).

Compared to the cost-plus pricing mechanism, the marginal cost approach is more complicated as it makes more factors into consideration. As a consequence, marginal-cost pricing is more difficult to apply in reality, as it is more challenging to precisely obtain all the relevant figures. Nevertheless, if figures are obtained, marginal-cost pricing provides a presentation of variations in production costs.

Recognizing that existing pricing methods for district heating, such as cost-plus pricing and marginal-cost pricing cannot simultaneously provide both high efficiency and sufficient investment cost return, Zhang et al. (2013) propose a new pricing model – Equivalent Marginal Cost Pricing (EMCP). This method incorporates both short- and long-run marginal costs. The method promotes efficiency in the district heating market, ensures investments and promotes efficient resource allocation. However, this method is based on a number of assumptions, making it less valid for practical use (Li et al., 2015).

3.4 District Heating as Natural Monopolies

The energy sector is capital intensive, requiring large initial and continuous investments. Such large installations provide economies of scale. Consequently, the energy sector tends to be dominated by few large suppliers with varying degrees of market power (Bhattacharyya, 2011). These suppliers are often government regulated and are commonly referred to as *public utilities*. The market situation these public utilities operate in is referred to as natural monopolies. A natural monopoly refers to a market consisting of a single firm that can produce the entire output of the market at a lower cost than if there were several involved firms (Pindyck & Rubinfeld, 2013). In a natural monopoly, monopoly is always more cost-effective than competition (Lipczynski, Wilson, & Goddard, 2009). Natural monopolies typically occur in two kinds of productions. Firstly, where there is a need for large infrastructure to begin the operation, and secondly in the presence of economies of scale (Mosca, 2008). The most common examples of natural monopolies are public utilities with large physical networks such as water distribution, telecommunications, electricity and district heating (Lipczynski et al., 2009; Rezaie & Rosen, 2012).

It is generally agreed that district heating networks are natural monopolies (Sjödin & Henning, 2004; Wissner, 2014; Zhang et al., 2013). However, there has been some discussion on whether the market should be characterized in such a way. Söderholm and Wårell (2010) argue that it is not completely clear whether the production of heat for district heating has large enough economies of scale to constitute a natural monopoly. Still, the distribution part of district heating constitutes a clear natural monopoly. The production of district heating may be subject to economies of scale relative to the market size it operates in. Also, the fact that district heating firms have exclusive access to the distribution grids and pipeline systems for district heating in the supply area, suggests that the district heating system as a whole can be viewed as a natural monopoly.

4. THEORETICAL FOUNDATIONS

“Understanding the economic environment in which pricing decisions are made is a first step towards making them effectively” (Nagle, 1984, p. 22). This is true for all product and service markets. It is therefore important to understand the characteristics of these markets as well as its consumers in order to make informed decisions about pricing. Pricing mechanisms are based on microeconomic theory. Microeconomic theory contains comprehension of behavior and interactions of individual firms and consumers. It reveals how industries and markets operate and evolve, while affected by government policies and the global economic environment (Pindyck & Rubinfeld, 2013). For district heating firms and consumers, these considerations are influenced by the monopolistic nature of district heating markets.

4.1 Consumer Theory

Theory of consumer behavior is a description of how consumers allocate incomes among different goods and services in order to maximize their well-being. The theory is based on individuals’ economizing problem, which is “the need to make choices because economic wants exceed economic means” (McConnell et al., 2012, p. 7).

4.1.1 Preferences and Utility

Economic theory builds on the presumption that individuals behave rationally and seek to maximize utility. Utility describes the satisfaction or benefit consumers derive from consuming goods and services. It is also assumed that consumers have clear preferences and are aware of how much additional utility can be derived from consuming additional units of each good – that is, the *marginal utility* of these goods. Limiting consumers’ opportunity to consume as much as desired is the budget constraint, given by consumers’ limited money income. The consumer’s budget constraint and the price of goods and services represent a scarcity problem. The consumer must make decisions on how to allocate scarce income to maximize utility (Nellis & Parker, 2002). In making these decisions, consumers will compare various market bundles, which are lists of specific quantities of one or more goods available. A rational consumer will combine bundles according to preference to maximize utility from total consumption. Microeconomic theory assumes that consumers know their preference sets, as well as the ordering of these preferences and that this can be represented by some utility function. In addition, it is assumed that a rational consumer will always choose the most preferred bundle from a set of feasible alternatives (Bhattacharyya, 2011).

The condition of rationality related to preferences is characterized by three properties or *axioms of rational choice*. Firstly, *completeness* assumes that the consumer is able to state whether he or she prefers bundle A or bundle B, or if they are equally preferred. Secondly, *transitivity* reveals that individual choices are internally consistent, so that if A is preferred over B and B is preferred over C, then A is preferred over C. Finally, *continuity* states that if A is preferred to B, then bundles sufficiently close to A will also be preferred over B (Snyder & Nicholson, 2008). Given these assumptions, a consumer's preferences can be expresses through a utility function. The utility function assumes that the consumer can choose among *n* number of goods $x_1, x_2, \dots, x_n$. All else equals, the utility *U* can be expressed as:

$$\text{Utility} = U(x_1, x_2, \dots, x_n) \tag{4.1}$$

A consumer will prefer good A to good B if the utility of A exceeds the utility of B. As the consumer is constrained by income, he or she will seek to maximize utility subject to a budget constraint:

$$\begin{aligned} &\text{Max } U(x_1, x_2, \dots, x_n) \\ &\text{s.t } I = p_1x_1 + p_2x_2 + \dots + p_nx_n \end{aligned} \tag{4.2}$$

Where $p_1, p_2, \dots, p_n$ refer to the prices of goods $x_1, x_2, \dots, x_n$ and I is income. Changes in prices and income will therefore affect an individual's utility (Snyder & Nicholson, 2008).

4.1.2 Utility of Discrete Choices

In the heating market, consumers have the opportunity to choose from different heating alternatives. This consumer decision is called a discrete choice, as the consumer is faced with a finite number of alternatives from which to choose. Some of the available alternatives for heating are district heating, electric heating, oil and wood pellets. Which alternative the consumer chooses will depend on the price of the heating source, the consumer's income and a number of other attributes. In addition, non-economic factors such as a consumer's preference for environmental friendliness, energy efficiency and required own work to operate the heating system must be accounted for (Rouvinen & Matero, 2012). The utility function for a heating consumer *i* from using a heating system *j* will then be:

$$U_{ij} = U(P_j, I_j, Z_j, \varepsilon_j) \quad \text{for } j = 1, 2, \dots J \tag{4.3}$$

The price of the heating alternative is denoted P, I is income, Z is the non-economic factors and ε is an error term that incorporates unobserved variables. For a consumer deciding on a heating system, the alternatives *j* can be replaced by:

U_1 = district heating U_3 = oil

U_2 = electric heating U_4 = wood pellets

The consumer will now choose the alternative yielding the highest utility. For instance, the consumer will choose district heating over electric heating if $U_1 > U_2$.

4.1.3 Random Utility Model (RUM)

Random utility theory is based on the notion that consumers will make choices based on the characteristics of a good (a deterministic component) along with some degree of randomness (a stochastic component). The random (stochastic) component occurs either because of randomness in preferences or that not all information about the consumer is known or taken into account. The model assumes that individuals consistently select the goods or services that gives their highest level of utility. With consumers facing discrete choices in the heating market, the consumer is faced with a finite set of alternative heating systems for their home or firm (Scarpa & Willis, 2010). The application of the random utility model is fit to analyze both individual household consumers and firms as consumers. For simplicity, the remainder of this section will focus on individual household consumers.

A consumer *i* is faced with a set of *J* alternatives *j* = 1,…, *J*. The consumer would obtain some level of utility from using each of the heating systems. The utility of consumer *i* related to an alternative *g* is given by:

$$U_{ig} = V_{ig} + \varepsilon_{ig} \tag{4.4}$$

Where V_{ig} is the deterministic component and ε_{ig} is the stochastic component, capturing any influences on individual choices that are omitted or unobservable. Further, a rational individual will choose alternative *g* if and only if the utility of alternative *g* is larger than for all the other options as follows (Perman, Ma, Common, Maddison, & McGilvary, 2011):

$$U_{ig} \geq U_{ij} \quad \forall j \neq g \tag{4.5}$$

Both the consumer and the researcher observe the same attributes for each choice of heating system, but only the consumer knows their own utility level from each choice. The known attributes are labeled x_{ij} and some attributes of the consumer are labeled s_i. The observed (deterministic) portion V_{ij} of the consumer's utility can now be estimated in a function, often called *representative utility* (Train, 2003):

$$V_{ij} = V(x_{ij}, s_i) \tag{4.6}$$

As shown in equation 4.6, $V_{ij} \neq U_{ij}$ because U_{ij} also contains the stochastic variable ε_{ij}. This component is therefore defined as the difference between the total utility and the deterministic component. The probability of a consumer *i* choosing alternative *g* can be estimated as:

$$\begin{aligned} P_{ig} &= \text{Prob}\,(U_{ig} > U_{ij}\ \forall\, j \neq g) \\ &= \text{Prob}\,(V_{ig} + \varepsilon_{ig} > V_{ij} + \varepsilon_{ij}\ \forall\, j \neq g) \\ &= \text{Prob}\,(\varepsilon_{ij} - \varepsilon_{ig} < V_{ig} - V_{ij}\ \forall\, j \neq g) \end{aligned} \tag{4.7}$$

In a heating system application, research can be conducted by a choice experiment where respondents state their preferred choice of heating system among two or more alternatives. The researcher can observe the levels of the attributes on monthly charge and investment costs. In some situations it is reasonable to define the observed part of utility to be linear in parameter with a constant. The alternative-specific constant captures the average effect on utility of all factors not included in the model. This is done by adding a constant to the observable part of the utility: $V_{ij} = x'_{ij}\beta + k_j$ for all *j*, where x_{ij} is a vector of variables that relate to alternative *j* by decision maker *i*. β are coefficients of these variables, and k_j is a constant that is specific to alternative *j*. When including alternative-specific constants, the unobserved portion of utility ε_{nj}, has zero mean. Realizing that there are other factors than investment cost and monthly charge influencing the consumer's utility and the choice between systems, the deterministic component of the utility function can be specified for a two-alternative case with the choice between district heating and electric heating:

$$V_{iD} = \alpha MC_{iD} + \beta IC_{iD} + k_D^0 + \varepsilon_{iD} \tag{4.8}$$

$$V_{iE} = \alpha MC_{iE} + \beta IC_{iE} + k_E^0 + \varepsilon_{iE} \tag{4.9}$$

Where MC_{iD} is the monthly charge for the consumer for using district heating and IC_{iD} is the investment cost for the consumer to connect the to district heating system, and similarly for electric heating. The parameters α and β can either be observed or estimated. Even if V_D were larger than V_E it would not necessarily mean that the consumer would prefer district heating to electric heating, since there can be several other unobserved factors influencing the decision. In order for the consumer to choose electric heating in such a situation (where $V_D > V_E$), the unobserved portion of utility for electric heating (ε_E) must be larger than the difference between the utility of each, to make up for the advantage district heating has in the observed or estimated component.

The difference between k_D^0 and k_E^0 is defined as *d*. Any model with the same difference in constants is equivalent, so if the difference between k_D^1 and k_E^1 in an equivalent equation is also *d*, this poses a problem for estimation because they will result in the same choice probabilities. One way to avoid this is to normalize one of the constants to zero. For instance, the constant for district heating can be normalized to zero:

$$V_D = \alpha MC_D + \beta IC_D + \varepsilon_{iD} \tag{4.10}$$

$$V_E = \alpha MC_E + \beta IC_E + k_E + \varepsilon_{iE} \tag{4.11}$$

With this normalization, the value of k_E is *d*, which is the difference in the original (unnormalized) constants. The constant for electrical heating can now be interpreted as the average effect of excluded factors on the utility of using electrical heating relative to using district heating. The probabilities described above applied to the choice of heating system can now be stated as follows (Train, 2003):

$$P_D = \text{Prob}\ (\varepsilon_E - \varepsilon_D < V_D - V_E) \tag{4.12}$$

and

$$\begin{aligned} P_E &= \text{Prob}\ (\varepsilon_E - \varepsilon_D > V_D - V_E) \\ &= \text{Prob}\ (\varepsilon_D - \varepsilon_E < V_E - V_D) \end{aligned} \tag{4.13}$$

4.2 Natural Monopoly Power

As discussed in chapter 3, district heating markets are characterized as natural monopolies. Natural monopolies occur when there are strong economies of scale, making competition uneconomical. If the market were to consist of several agents, they could not take advantage of economies of scale and unit costs, consequently inflating prices more than necessary. In a multiple-firm situation, each firm's lowest average total cost would be larger than for a single firm. Consequently, efficient, low-cost production requires one single producer (McConnell et al., 2012). This means that both average and marginal costs are declining over the entire range of output. Because of high fixed start-up costs and low or zero variable costs, economies of scale are also considered a barrier to entry (Mosca, 2008). Also, for natural monopolies, fixed costs make up a larger portion of total costs, compared to a competitive situation. Competition in such market situations tends to lead to wasteful use of infrastructure and delivery systems.

For district heating consumers, the monopolistic nature of the market means that they are tied to one heating supplier, and have only one option in selecting a district heating provider. District heating companies are allowed to make profits, and tend to increase costs for consumers. However, this does not automatically mean that district heating firms have complete monopoly power, as there exists several alternatives on the heating market. District heating firms do normally have monopoly power of district heating in their supply area, but do not have monopoly power over the entire heating market. However, the effect of market forces on district heating is weaker than for other utilities, such as electricity, because the heating networks are smaller in scale and are often owned by a single organization (Zhang et al., 2013). The availability of alternatives in the market, combined with high cross-price elasticity can reduce the power of a district heating supplier (Li et al., 2015).

4.2.1 Cross-Price Elasticity

Cross-price elasticity refers to the percentage change in the quantity demanded for a good that results from a 1-percent increase in the price of another good (Pindyck & Rubinfeld, 2013). These are often substitute goods, meaning that a price increase in one of the goods will lead to an increase in the quantity demanded of the other good. In the case of district heating, this relation can be shown as the elasticity of demand for district heating, relative to the price of an alternative heating source; electrical heating:

$$E_{Q_{DH}P_{EH}} = \frac{\Delta Q_{DH}/Q_{DH}}{\Delta P_{EH}/P_{EH}} = \frac{P_{EH}}{Q_{DH}} \frac{\Delta Q_{DH}}{\Delta P_{EH}} \tag{4.14}$$

In equation 4.14, Q_{DH} is the quantity of district heating and P_{EH} is the price of using electrical heating. Because district heating and electrical heating are substitute goods, the cross-price elasticity will be large and positive. Because these two products compete against each other in the market, an increase in the electricity price leads to an increase in demand for district heating, because the price increase will make district heating cheaper relative to electrical heating. This tends to cause consumers to switch from electrical heating to district heating, causing the demand for district heating to increase (Lipczynski et al., 2009). The two most important factors influencing the cross-price elasticity are the availability of an alternative heating source and the switch cost between different sources (Li et al., 2015).

4.2.2 Subadditivity and Barriers to Entry

Although economies of scale, implying decreasing average costs, act as a driving factor for the existence of a natural monopoly, it is not a sufficient condition. Instead, the concept of subadditivity of cost functions are used (Bhattacharyya, 2011). Natural monopoly exists if the cost function is subadditive over a range of output. A cost function is subadditive if it satisfies the following condition:

$$C(Q) = c(q_1+q_2) < c(q_1) + c(q_2) \tag{4.15}$$

This implies that it is more efficient for one firm to produce the entire market output (q_1+q_2) than it is for two firms to individually produce q_1 and q_2 quantities of the good. The cost function is therefore subadditive if the production of output with several firms result in a greater total industry cost than if the entire output were to be produced by one firm (Church & Ware, 2000). Thus, under natural monopoly conditions, the market is best served by one producer, leading to entry barriers.

District heating, as many other industries in the energy sector, require large infrastructural investments to start the production process. These investments are often sunk, meaning that they cannot be recovered. Entry may therefore be uneconomical, because a possible new entrant will not be able to cover their investments and fixed costs once there already is a firm in the market supplying the same industry. A new firm would therefore not be able to enter the market and obtain a large enough market share to be profitable (Lipczynski et al., 2009).

4.2.3 The Natural Monopoly Dilemma

Natural monopoly characteristics require a single firm to supply the entire market. However, in many situations it is undesirable for society to face the potential monopoly pricing (Bhattacharyya, 2011). Monopolists are price makers, meaning that the firm's output decisions will affect prices. Increasing prices will lead to lower sales, and decreasing prices will lead to higher sales. This gives the monopoly firm market power. The issue of monopoly is therefore that it opens up for abuse of market power through price setting (Church & Ware, 2000). Conversely, competitive firms are price takers, meaning that they are not able to affect the price by changing output. In order to limit monopolists' opportunity to abuse market power, the natural monopoly dilemma is often attempted solved by regulatory instruments. Regulation may therefore be seen as a substitute for competition in cases where competition reduces the natural monopolist's market share, and economies of scale cannot be fully utilized. Regulation is therefore required to prevent the monopolist from abusing its power (Lipczynski et al., 2009). The degree of regulation is an important basis in setting the most efficient price for a natural monopolist's products, and often dictates pricing.

4.3 Pricing District Heating

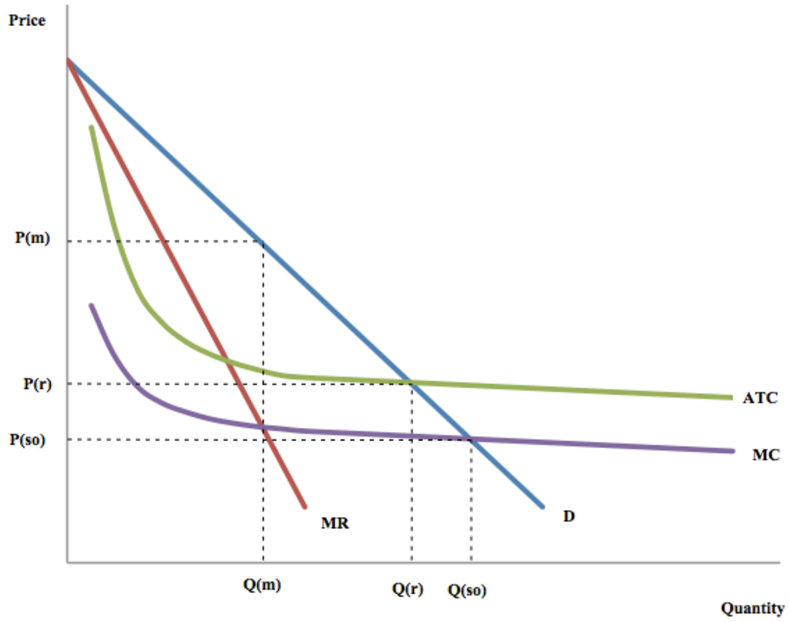
Price is the most important element affecting a firm's market share and profitability. Kotler and Armstrong (2014, p. 312) define price as "the sum of all the values that consumers give up to gain the benefits of having or using a product or service". Price is an element in the marketing mix, along with product, place and promotion. The marketing mix is a set of tactical marketing tools that a firm combines to produce the responses it wants form its target market. Of these elements, price is the most important, as it is the only element that produces revenue; all other elements produce costs. Pricing is therefore a strategic tool for creating and capturing consumer value (Kotler & Armstrong, 2014).

Perhaps the most decisive factor for a firm's pricing behavior is the degree of market competition. Thus, the market situation of a firm will guide their pricing method. Firms encountering little or no market competition will place more emphasis on long-term pricing strategies than firms with a large degree of competition. Long-term pricing policies smooth out fluctuations in costs and demand, making room for more predictable future projections (Àlvarez & Hernando, 2006). The following sub-sections will examine pricing in the case of a natural monopoly, and the different pricing mechanisms currently used for district heating. In the literature on district heating pricing, two representative methods are most common: marginal cost pricing and cost-plus pricing.

4.3.1 Pricing under Natural Monopoly Power

Figure 4.1 illustrates the relationship between demand, marginal revenue and the cost curves for a natural monopoly. The ATC curve represents the average total cost, MC is the marginal cost curve, D is the demand curve and MR is the marginal revenue curve. A rule of thumb for identifying a natural monopoly is that the demand curve intersects ATC while ATC is still downward sloping. What distinguishes a natural monopoly from a pure monopoly is that the ATC diminishes over a much larger range of output than for a regular monopoly. The ATC reaches its minimum point at some level of output far beyond the point of intersection between the demand curve and ATC. Thus, a natural monopoly experiences economies of scale on a much larger range of output that a regular monopoly would. Therefore, the natural monopoly must produce a much greater output that a regular monopoly in order to minimize its average total costs. Also, because average costs are declining, marginal cost is always below average cost (Welker, 2012).

Figure 4.1 - Natural Monopoly



Source: Adapted from Mosca (2008)

From figure 4.1, it is shown that the intersection of the demand curve and the marginal cost curve (MC=D=MB) gives an output of Q(so) and a price P(so), displaying the socially optimal quantity and price. In the absence of regulation, the natural monopoly would produce at output level Q(m) and receive a price of P(m), according to the profit maximization rule MR=MC. In such a case, the price P(m) will be larger that the socially optimal price of P(so), and the firm will produce less than what is socially optimal. This poses a dilemma: a natural monopoly exists in this market, but if this one monopoly firm is allowed to charge the price it wishes to charge in order to maximize its profits, it will restrict its outputs to Q(m) and charge a price that is much higher than what is socially desirable. This means that there will be an under-allocation of resources. They are now extracting surplus from consumers and transferring it as profit to the natural monopolist. To solve this problem, government intervention is required (Welker, 2012).

A combination of price controls and subsidies can contribute to achieve a more socially optimal level of output. These regulatory tools aim to incentivize natural monopoly firms to produce at the socially optimal level. However, at the social optimum, the price would not cover average total costs, and the firm will run at a loss. This happens because the firm must meet various levels of demand (peak and off-peak demand), and the firm therefore has substantial excess production capacity in periods where demand is stable (McConnell et al., 2012). There are several options a firm can utilize to solve this problem. One option is to be publically subsidized to cover the loss that marginal cost pricing would result in. Another is to use price discrimination to charge different prices to different consumers.

Recognizing that the socially optimal price leads to losses, regulatory agents impose the price P(r) to provide a fair rate of return to the monopolist. The best alternative is therefore to set the price at the minimum feasible price P(r), where average cost and demand intersect (McConnell et al., 2012).

4.3.2 Cost-Plus Pricing

The cost-plus pricing method is most commonly used for regulated district heating markets. With the method, the firm estimates or calculates average variable costs (AVC) and sets the price by marking up the AVC by a percentage. This mark-up takes the firm’s fixed costs and a profit margin into consideration (Lipczynski et al., 2009). The price is then calculated as:

$$P = AVC + \%\ \text{mark-up} \tag{4.16}$$

$$\text{or } P = (1+m)AVC \tag{4.17}$$

Where P is price, and the mark-up is 100×m percent. More specifically, for a regulated district heating market, the price for district heating equals the sum of costs to be recovered (the average variable costs) and a reasonable profit for district heating companies (the mark-up) (Li et al., 2015). The key issue in pricing district heating by cost-plus pricing is to determine the permitted profits a district heating company can make. This can be shown as:

$$Price_{DH} = OA + AD + PP \tag{4.18}$$

In equation 4.18, OA is operating costs, AD is annual depreciation, and PP is permitted profit. Permitted profits can among other ways be calculated rate of return on capital (ERO, 2009):

$$\text{PP} = \text{WACC} \times \text{RAB} \tag{4.19}$$

Where WACC is the weighted average cost of capital, and RAB is depreciated fixed cost, new investment and labor cost. Even though the aim of regulatory action is to prevent firms from abusing market power, issues related to the firm's incentives could arise. Since the permitted profits are related to the firm's costs, there is an incentive to inflate costs to gain larger profits. This can weaken district heating suppliers' motivation to introduce cost reducing initiatives such as technology updates. Consequently, the price will stay large or increase, undermining the purpose of regulatory intervention (Zhang et al., 2013).

4.3.3 Marginal Cost Pricing

For deregulated district heating markets, the most common pricing mechanism is the marginal cost method. In the case of district heating, the marginal cost refers to the additional cost of generating another unit of heat, usually measured in kWh. Due to cost considerations, a district heating firm using several production facilities will tend to run low-cost facilities before running high-cost facilities. The marginal cost is obtained from the facility with the highest operating costs (Li et al., 2015). Normally, marginal costs are divided into fixed and variable costs. Marginal cost is then the additional unit of variable costs plus the depreciations of fixed costs (Difs & Trygg, 2009). The marginal cost is calculated as follows:

$$\text{Marginal Cost} = \frac{\text{dVC}}{\text{dQ}} + \frac{\text{dFC}}{\text{dQ}} \tag{4.20}$$

Where VC are variable costs, FC are fixed costs and Q is production quantity. Since fixed costs are constant, regardless of production quantity, $\frac{dFC}{dQ}$ will be zero in the short run. The variable heat cost can be expressed by the energy balance:

$$\text{Heat} = \text{Fuel} \times \eta \tag{4.21}$$

Where η is the efficiency of the facility. When taxes are charged on fuels, carbon emissions and other pollutants, the cost can be written as:

$$\text{Heat} \times VC_{(\text{Heat-boiler})} = \text{Fuel} \times (\text{Cost}_{\text{fuel}} + \text{Tax}_{\text{carbon}} + \text{Tax}_{\text{energy}} + \text{Tax}_{\text{Sulphur}}) \qquad (4.22)$$

From equation 4.22,

$$VC_{(\text{heat-boiler})} = \frac{\text{Cost}_{\text{fuel}} + \text{Tax}_{\text{carbon}} + \text{Tax}_{\text{energy}} + \text{Tax}_{\text{Sulphur}}}{\eta} \qquad (4.23)$$

In equations 4.22 and 4.23, the component $\text{Cost}_{\text{fuel}}$ is the element subject to most variation, because the prices of fuels are subject to rapid change. The marginal cost of the facility will change in the same way as the fuel price. One of the greatest advantages of district heating is the availability of a range of different input fuels and it is common to use one type of fuel for base load production, and another for peak production. However, this may vary due to changing fuel prices. Low-cost fuels such as biomass and recycled heat are commonly used during summer, while more high-cost fuels are used during winter. This means that the marginal costs of district heating can vary seasonally during the year (Li et al., 2015).

The marginal cost of heat is closely related to the marginal cost of electricity. This is especially relevant for Norway, where the district heating price is linked to the electricity price by regulation, rather than to seasonal demand fluctuations. According to the Norwegian energy act §5-5, the charge for district heating cannot exceed the charge for electrical heating in the same supply area. This means that the electricity price will affect the marginal cost of district heating, and consequently the final price for consumers. The price for district heating must therefore be competitive with electricity prices (Naas-Bibow & Martinsen, 2011).

4.4 Price Discrimination

The characteristics of natural monopolies will in many cases facilitate the use of price discrimination. Price discrimination involves departing from a single-price and charging different prices to different consumers for similar goods or services. One of the necessary conditions for price discrimination is that the firm must have some degree of market power. A second necessary condition is that the firm must be able to distinguish between different consumers or groups of consumers according to their willingness or ability to pay. In addition, a third necessary condition is that resale must be prevented (McConnell et al., 2012). As opposed to using a single price, price discrimination is based on the consumer’s willingness to pay and the demand for a product, rather than on the production costs. Price discrimination is divided into three methods: first-, second-, and third-degree price discrimination.

4.4.1 First-Degree Price Discrimination

First-degree price discrimination implies that the firm charges a differentiated price to each individual consumer based on each consumer's maximum willingness to pay (WTP) for a good or service. However, it is unlikely that this can occur in practice, as the firm normally does not have this type of information. The most common practice is to estimate WTP and using a few different prices (Pindyck & Rubinfeld, 2013).

4.4.2 Second-Degree Price Discrimination

Second-degree price discrimination is the practice of charging different unit prices for different quantities of the same good or service, making the per unit price depend on the quantity purchased. As opposed to first-degree price discrimination, a firm considering second-degree price discrimination does not have enough information about each individual consumer to estimate WTP. Instead, the price does not depend on the identity of the consumer, but on how much each consumer is willing to purchase. A common form of second-degree price discrimination is discounts for bulk purchases (Lipczynski et al., 2009). In a district heating situation, second-degree price discrimination can be applied by charging different prices for consumers depending on their annual average heat use. For instance, consumers using more that a certain quantity of heat get a discounted price after reaching this pre-set level.

4.4.3 Third-Degree Price Discrimination

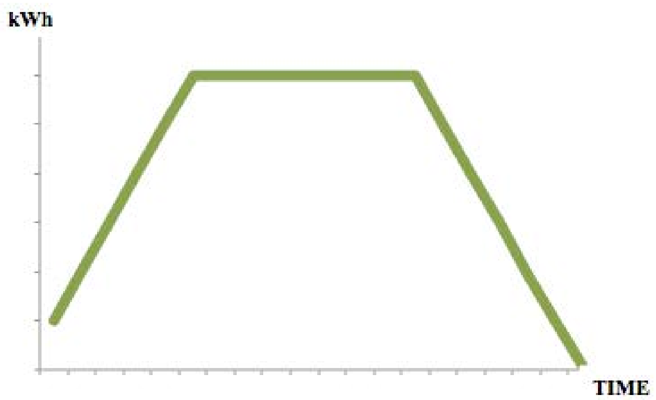
Third-degree price discrimination involves making the price of a good depend on the identity of the consumer. This implies dividing consumers into segments with separate demand curves and charging different prices for each group. The firm charges the same price for each consumer belonging in each group, but differentiates the between groups or markets. For district heating, this can be done by dividing the consumer base into groups according to distinct characteristics. This can be done by separating into groups such as households and firms, or according to the building type such as industrial buildings, apartment buildings and individual houses, and charge different prices to each group.

4.4.4 Peak-Load Pricing

Demand for certain energy products shows significant daily and seasonal variations, as different amounts of energy is demanded at different times. Marginal costs are higher during peak periods due to capacity constraints. Demand and marginal costs show strong time dependence and can vary between hours, days, weeks and seasons. The variability of demand relative to production capacity brings about a peak-load problem. The problem arises when output is not storable. The peak-load problem also arises when the firm produces in a number of time periods, and demand over these periods is cyclical. While demand fluctuates from period to period, it does so in a predictable pattern. (Church & Ware, 2000, p. 802):

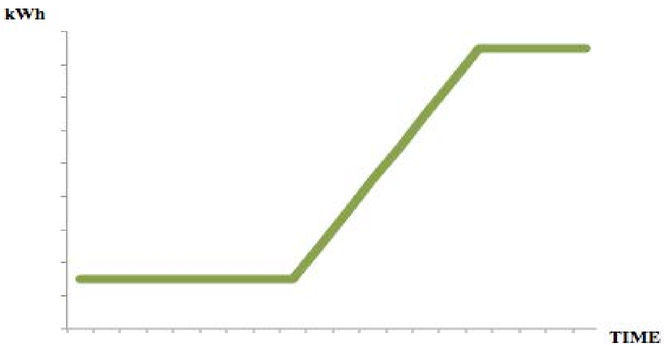
The plot of heat demand for a 24-hour period is called a daily load curve. The curve shows the variation of heat demand during a day (Bhattacharyya, 2011). The daily load curve is different for firms and households, varying inversely. During peak hours of heat use in households, the use will usually be lower for firms, and vice versa. Figure 4.2 shows a typical daily load curve for a firm. It shows that demand for heat increases during the morning, reaching a steady peak at mid-day, and decreases at the evening and during the night.

Figure 4.2 - Firms' Daily Load Curve



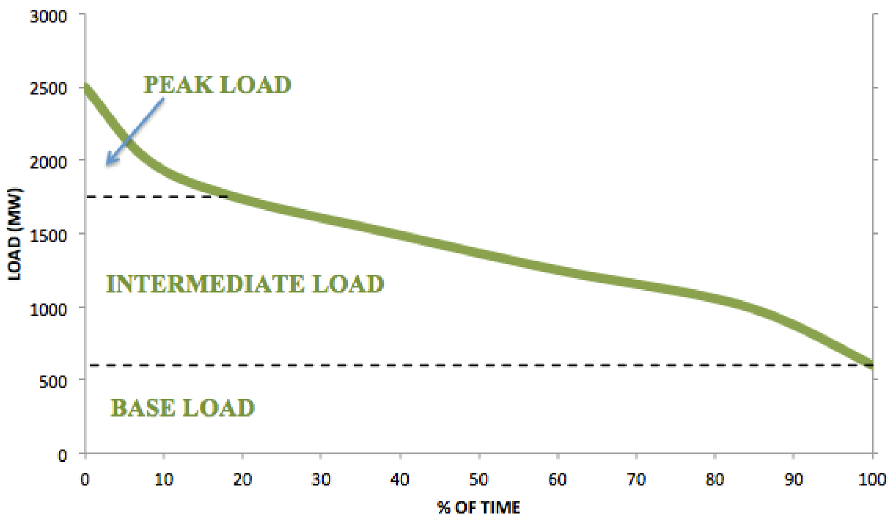
As figure 4.3 shows, households will demand little heat in the mornings and during the day, and will increase towards a peak in the afternoon and the evening. During weekends, the daily load curves will be low throughout the day for firms, and steadily fluctuating for households.

Figure 4.3 – Households' Daily Load Curve



Information from daily load curves is often times collected over a year, where the frequency of occurrence of different loads can be determined. A plot of such a cumulative frequency distribution is illustrated in a load duration curve. The plot describes the percentage of time at which each level of load is demanded. This is shown in figure 4.4:

Figure 4.4 - Load Duration Curve

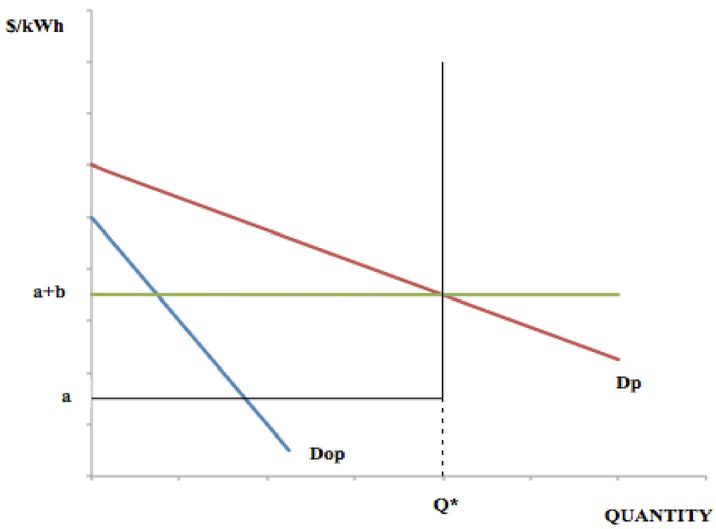


Source: Adapted from Bhattacharyya (2011)

The load duration curve consists of three periods; base load, intermediate load and peak load. The base load is the minimum level of demand on a district heating system, which always exists. This is operated by the most efficient facility available. Next, in the intermediate period, demand gradually increases towards the peak period. The peak period is when demand is at its highest and typically occurs less than 20% of the time. When demand exceeds the base load capacity, other facilities are utilized. These facilities are more expensive to start up and run, increasing the marginal production cost. Continuously meeting demand therefore requires modifying supply according to which demand period the system is in. To smooth system operations, suppliers need to operate three types of facilities. Firstly, there must be facilities running continuously throughout the year, covering base load. Secondly, to cover the intermediate period, there is a need for facilities that can fluctuate with demand. Finally, facilities for running only during peak load periods are required (Bhattacharyya, 2011).

The difference in peak and off-peak demand lays the foundation for peak-load pricing. This involves charging different prices at different points in time, namely charging a higher price during the peak periods, when capacity constraints cause marginal costs to be high. Instead of capturing consumer surplus, the goal of peak-load pricing is to increase economic efficiency by setting a price that is closer to marginal cost at that point in time (Pindyck & Rubinfeld, 2013). The aim of peak load pricing is to find a solution to the following dilemma: the firm must install the necessary capacity to meet demand in all periods, but this capacity is not used in off-peak periods. This is costly to the firm in the off-peak periods where there are no revenues from the excess capacity. On the other hand, reductions in capacity result in congestion problems in peak periods. This means that some consumers will not be provided with demanded heat in peak periods. This will impose costs on the firm in form of lost revenues. The peak load problem is therefore a trade off between the cost of increasing capacity and revenue loss. The pricing decision is shown in figure 4.5.

Figure 4.5 - Peak-Load Pricing



Source: Adapted from Bhattacharyya (2011)

With larger demand during peak the period, there exist two demand curves, Dp for demand during the peak period, and Dop for off-peak demand. The short-run marginal cost curve at *a*, is assumed constant until capacity is exhausted at Q*. In the short run, no further output is possible beyond this point. The fixed cost is set at *b*, which added with *a* gives the long-run marginal cost. In the off-peak period there is an under-utilization of capacity, and price is therefore set at marginal cost *a*. In the peak period, supply is constrained. If the price were set equal to marginal cost here, demand would exceed supply. Price would therefore be set at long-run marginal cost *a+b*, taking into account the cost of adding capacity. The result yields two prices: a lower one set according to short-run marginal cost and a higher one to combine higher demand and capacity constraints in the peak period. For consumers, this means that those who use district heating during peak periods should bare the full responsibility of the capacity cost and the operating costs, while those who only demand heat during off-peak periods should be charged only for the short-run marginal cost (Nellis & Parker, 2002).

5. SURVEY METHODOLOGY AND DESIGN

This chapter will describe the survey methodology used for the empirical examination, focusing mainly on stated preference methods. Further, the chapter will describe the research design and how the surveys were designed.

5.1 Stated Preference and Revealed Preference Data

Stated preference techniques are based on survey data that enable measurement of use and non-use values. Use values refer to individuals' value of resources they physically interact with or their valuation of having the resource available in the future. Conversely, non-use values are the benefits an individual derives from resources without physically interacting with them, nor intending to do so, while still appreciating their existence (Perman et al., 2011). On the other hand, revealed preference methods relate to actual choices by measuring use values only. These are observations of choices and preferences through observed actions. The major advantage of obtaining revealed preference data is that it reflects actual choices. However, these data are historical, and therefore only useful after the choice is made. Often, researchers will want to determine how people respond to situations that currently do not exist, to predict future behavior. In such a case, stated preference data can replace or compliment revealed preference data (Train, 2003).

Stated preference data is collected from survey or experimental methods where respondents state their preferred choice from hypothetical scenarios. Two or more options are described with attributes, and the respondent is instructed to choose the most preferred option if they were to make the choice in real life. The answer a respondent gives is that respondent's stated choice (Train, 2003). Stated preference data can be used to identify trade-off behavior between competing alternatives. A limitation of stated preference data is, however, that there can arise hypothetical bias, where stated choices might not be consistent with actual choices (Buryk, Mead, Mourato, & Torriti, 2015). The most used stated preference techniques are contingent valuation (CV) and choice experiments (CE) (Perman et al., 2011).

5.1.1 Contingent Valuation

The contingent valuation method is a much-used technique within environmental valuation. Respondents are asked directly to express preferences, based on hypothetical scenarios. The researcher can in this way obtain monetary measures of individuals' value of environmental goods, where the lack of real markets for environmental quality prevents the use of other valuation techniques. Government departments often use CV methods in cost-benefit analysis to determine how various projects impact different aspect of the environment. However, it has been debated whether CV studies give sufficient information to be included in government policy decisions (Carson, Flores, & Meade, 2001). The debate springs from the several limitations of the method. For instance, hypothetical bias, as explained earlier, information bias, where WTP reflects the respondent's limited knowledge of the topic and other factors that can restrict the adequacy of the results. However, most of the limitations can be detected and corrected for with a well-designed survey and careful testing (Perman et al., 2011).

5.1.2 Choice Experiments

Another form of stated preference analyses is choice experiments (CE). This method is employed within several disciplines, including the transportation sector and environmental valuation. With the CE method, respondents are presented with a finite number of discrete alternatives and asked to choose their preferred alternative in a sequence of choices. The choices involve hypothetical scenarios of several competing compositions. Each alternative is presented with different attributes, with different levels, displayed in choice menus. The levels refer to the measurement unit and its size for each attribute (Buryk et al., 2015).

One of the major advantages of choice experiments is that the researcher can include as many attributes as needed and can vary the levels of each attribute as is appropriate for the research purpose (Train, 2003). Choice experiments can give useful insights and information to policy makers. The fact that choice experiments include scenarios that currently do not exist enables the researcher to develop and test the viability of suggested policies. A drawback of choice experiments is that it places a strain on the respondents' cognitive abilities. The problem arises when respondents simplify the way they choose their preferred alternative. In this way, respondents limit their decision-making by focusing solely on one or a few of the attributes, without assessing the alternative in its entirety. Such respondents are said to display lexicographic preferences (Perman et al., 2011). Also, designing the choice experiment in a way that leads the respondents to favor one alternative over another can cause lexicographic preferences. For instance, labeling the choices "status quo" or "the environmentally friendly option" could cause respondents to favor one alternative over others, without regarding the attributes. The lexicographic preferences problem is best solved by designing choice experiments that are simple and easily understood by all respondents and by avoiding persuasive language (Perman et al., 2011).

5.2 Validity

Validity refers to the issue of whether or not an indicator or a set of indicators included in a research measures what they intend to measure. Validity is separated into *internal* and *external* validity. Internal validity is concerned with whether a conclusion that incorporates a causal relationship between two or more variables is reasonable. External validity on the other hand refers to questions of whether results from a research can be generalized beyond the scope of the specific research context (Bryman & Bell, 2011). In a choice experiment, the planning process involving developing, testing and optimizing of a measurement instrument (survey, interview etc.) is important for the success and the validity of the results. Validity is classified into three main types: *content validity, criterion validity* and *construct validity*.

5.2.1 Content Validity

Content validity refers to the degree to which a measure covers the entire scope of the concept of interest. This also concerns whether the research goes beyond what is intended to be measured. Choice experiments can rarely include all the relevant attributes affecting a choice, but it is essential to include the most important ones that are relevant to the majority of respondents. If the most important attributes are omitted, respondents can make assumptions of the excluded attributes, which can affect the validity of the experiment (Kløjgaard, Bech, & Søgaard, 2012). Content validity is therefore concerned with the need to avoid under-measuring or over-measuring (Zikmund, Babin, Carr, & Griffin, 2010).

5.2.2 Criterion Validity

Criterion validity addresses questions of whether the research and results are valid in practice. It refers to the ability of a measure to correlate with other standard measures of similar constructs or established criteria. Criterion validity is classified as either *concurrent validity* or *predictive validity*, depending on the time sequence of the correlation. Concurrent validity is concerned with current situations, while predictive validity tests is used to test validity for future conditions and behavior (Zikmund et al., 2010). For choice experiments this will concern whether the results are usable in reality, and whether the results are measured in the time frame that is appropriate for the research objective.

5.2.3 Construct Validity

Construct validity considers both the theory and the instrument used to measure a concept in determining whether measures truthfully represent a unique concept, avoiding biases that may affect the results. In order for a measure to be construct valid, the measure must correspond with empirically grounded theory. At a minimum, the measure must demonstrate *face validity*, which is an intuitive process of determining whether the intended concept is in fact being addressed. In practice this is done by consulting other individuals, preferably with some experience on the topic, about whether the concept is being reflected properly (Bryman & Bell, 2011). In a choice experiment, this refers to whether the experiment includes the factors that are relevant in order to address the research aim. More specifically, this involves the extent to which the true utility of the attributes included are reflected (Kløjgaard et al., 2012)

5.3 Reliability

Reliability is concerned with the consistency of a measured concept. This involves three factors: *stability*, *internal reliability* and *inter-observer consistency*. Stability entails asking whether a measure is stable over time, not fluctuating between different points in time. Internal reliability deals with questions of homogeneity of measures, by measuring consistency between different indicators to ensure that each indicator converges to a common meaning. Lastly, inter-observer consistency deals with issues of subjective judgment regarding the recording and categorizing of data, where the involvement of several people could lead to inconsistency in decisions (Bryman & Bell, 2011).

5.4 Research Design

The research design is determined by the purpose of a research, and acts as an overall framework or plan for the study. In addition, it guides the research in terms of collecting and analyzing data (Iacobucci & Churchill, 2010). A *descriptive design* in chosen for this research to address the study's main objective – to identify preferences and attitudes towards different forms of district heating pricing. A descriptive design is used to shed light on the relationship between two or more variables of interest or to predict future conditions (Brandimarte, 2011). This is done by combining empirical analysis with prior knowledge of the concept. The use of hypotheses guides the research in specific directions, allowing for measurement of relations between variables (Iacobucci & Churchill, 2010).

For this research, the descriptive design is quantitative in nature, meaning that results are represented by assigning numbers in an ordered and meaningful way (Zikmund et al., 2010). The study focuses particularly on how environmental and system benefits affect choices of preferred pricing method for heating. Measuring how different attributes affect the preferred choice of pricing method for heating suggests that a research design based on choice experiment design is appropriate, as it allows for comparisons between different attributes at varying levels. The research design is not a full choice experiment, but resembles the design and procedure for designing a full choice experiment.

5.5 About the Surveys

Two different surveys were conducted for this research, one directed to households and the other to firms. For both surveys, the target populations were restricted to households and firms in Southern Rogaland. Due to the time restrictions for the thesis, the firm survey functions as a pilot survey. The survey was therefore used as a supplement to the household survey to identify some general trends among the surveyed firms compared to households.

In order to efficiently obtain sufficiently large samples within the time frame of the thesis, it was decided to develop web-based self-administered surveys. Due to technological advancement and ease of use, web-based surveys have become the preferred method of survey administration in recent years (Hoyos, 2010). Web-surveys have the advantage of obtaining fast and complete responses with few unanswered questions and are therefore efficient when large samples are required. Furthermore, web-surveys are flexible in design, both in terms of appearance and functions such as automatic redirection and randomization of questions (Bryman & Bell, 2011).

5.6 Overall Survey Design

The surveys were designed based on inspiration from pervious research and from advise by Lyse Neo AS. Drawing on previous research on choice experiments done within the energy sector (not exclusively studies done on district heating) provided a nuanced impression of how the final surveys could be designed to obtain the information needed. Receiving additional advise from representatives at Lyse Neo AS, who have expert knowledge on the topic, also helped form the design of the survey.

The surveys were constructed with the online survey instrument SurveyMonkey. The website provides the ability to customize surveys and obtain summary statistics as well as complete datasets. This provides good data accuracy, as potential errors in manual data entry are avoided. The datasets can be converted to different formats for more sophisticated data analyses. For this research, the dataset was analyzed using the statistical software programs STATA and SPSS.

5.6.1 The Household Survey

The household survey consisted of three sections: the introduction section, the choice experiment and the final section. The introduction section was used to warm up the respondents to think about energy use and included questions about political positioning, household energy use as well as attitudes and behavior towards the topic. The introduction section was used to gather *basic information* related to the topic of research (Iacobucci & Churchill, 2010). The choice experiment was presented in the next section. The section initiated by providing information about district heating and asking respondents about their previous knowledge and attitudes towards district heating. Following this, the choice sets were presented in a table format, describing the pricing alternatives by their attributes and levels, after which respondents were asked to choose their preferred alternative. Lastly, the final section identified *classification information*, such as socio-economic and demographic characteristics of the respondents. The section was included to enable a comparison of how different respondents' attitudes and preferences are affected by these factors.

5.6.2 The Firm Survey

The firm survey also contained three sections similar to the household survey, but was presented in a slightly different order. Firstly, in the introduction section, the respondents were asked to identify their position in the firm along with other characteristics of the firm, acting as socio-economic and demographic factors (*classification information)* of the firm. Further, the second section was constructed to identify the firms' position on environmental and energy efficiency issues (*basic information*). The last section contained information about district heating along with a question about the respondents' opinions on district heating, as in the household survey. Lastly, the choice sets were presented, asking respondents to select their preferred pricing alternatives.

5.7 Question Design

For both surveys, close-ended multiple-choice questions were used, where respondents chose between pre-set alternatives. The next subsections will describe the choices regarding question design for the introduction, concept related and demographic questions. The choices made when designing the choice experiment will be dealt with in greater detail in the next section.

5.7.1 Basic Information

The introduction section for the household survey included the basic information, where respondents answered questions about energy consumption and expenditures as well as attitudes and preferences towards the research topic. Most of these questions were multichotomous, with fixed alternatives where the respondent were asked to choose the alternative that most closely described their position on the subject. To measure the intensity of respondents' feelings about different aspects related to energy use, the Likert Scale was used. The scale is typically used when measuring agreement, frequency, importance and likelihood. The Likert Scale assumes equal distance between the points on the scale and that the score for each respondent is assumed to be a proxy for the respondents true attitude (Barua, 2013). An example from the household survey is the question "How important is it for your household to be energy efficient?", where respondents are asked to rate their answer on a 5-point interval scale ranging from "entirely unimportant" to "very important".

For the firm survey, the basic information was included in the second section. This section also included questions on energy consumption and expenditures along with questions set out to measure the firm's position on and commitment to environmental friendliness and climate issues. The section included a branching question in which the respondent was redirected according to their answer. Respondents answering "yes" to whether the firm had adopted any strategies aimed at reducing climate emissions, were directed to a follow-up question concerning the content of these strategies. Answering any of the other options directed the respondent to skip the follow-up question and proceed with the survey.

Prior to the choice sets, both surveys included information about district heating. Following the information, respondents were asked to state their position on the concept on a 5-point scale ranging from very negative to very positive. The household respondents were also asked about their degree of previous knowledge of district heating.

5.7.2 Classification Information

The classification information was included in the final section of the household survey and the first section of the firm survey. For the household survey this included age, gender, level of education and household income. For the firm survey this included questions about which industry the firm operates in, annual revenue, number of employees and location. The purpose of these socio-economic and demographic questions was to get an indication of the representativeness of the sample as well as to analyze how choices were affected by these factors.

5.8 Designing a Choice Experiment

Each respondent was presented with two choice sets. Each choice set presented three different pricing options with associated attributes and levels in a table format, where respondents were instructed to assess the information in the table and choose the preferred pricing alternative. The pricing alternatives were *Fastpris* (*Fixed Price*), *Tidsavhengig Brukspris* (*Time of Use Price*) and *Effektpris* (*Peak-Load Price*).

The *Fixed Price* charges the same price per kWh of heat used over a set period of time. The price remains the same during all hours of the day and all days and seasons during the year. The *Time of Use Price* has pre-set high-priced on-peak periods and low-priced off-peak periods. This involves periods during the day, where the price is higher for periods of high use and lower during remaining hours, defined to approximate market conditions. A more precise resemblance of actual market conditions is achieved with the *Peak-Load Price*. In this pricing method, during a pre-set number of days at peak hours of the day, the price is increased significantly, compensated by a lower price during all remaining days, hours and seasons during the year. Customers are notified shortly in advance regarding which days will be affected. This allows for both daily and seasonal variations to be reflected.

To determine the effect of environmental and system benefits, respondents were randomly divided into two sub-samples, with environmental and system benefits associated with each pricing alternative randomly presented to one of the sub-samples. Designing the survey in Survey Monkey allowed for randomization between which respondents received the survey version with the benefits, and which received the version without the information. Providing this treatment to a randomized group of respondents enabled measurement of how environmental and system benefits impact the decision of preferred pricing method.

Designing a CE survey involves careful consideration of which types of questions to include. A natural point of departure is to design the choice sets first and then proceed to determine what type of background information is needed about the respondents. This allows the researcher to consider the chosen attributes and levels when deciding on what background information is necessary. Apart from typical socio-economic and demographic questions such as age, income and level of education, topic relevant questions are included. The topic relevant questions sought to identify respondents' use of and attitudes towards the topic of research. Also, some information was provided about the topic to make sure the respondents were sufficiently informed about the topic and the choices they would face in the upcoming choice sets. The choice experiment itself requires careful consideration of design and content. Typically, this involves four main steps (Perman et al., 2011):

Figure 5.1 - Designing a Choice Experiment

1. **Identify relevant attributes**
   - Normally more than 4 to 5 attributes
2. **Select the levels for each attribute**
   - At least two different levels
   - Continuous values or discrete values
3. **Construct choice sets**
   - Full factorial design
   - Fractional factorial design
4. **Consider how many choice experiments to include in survey**

Source: Perman et al. (2011)

5.8.1 Identifying Relevant Attributes

The first step in creating choice sets involves identifying relevant attributes. Normally more than 4 to 5 attributes are used. The key is to find a balance between including enough attributes to gain a complete picture of the alternative, while avoiding the use of too many attributes that can over-complicate the choice set and discourage respondents. It is also essential to include attributes that most correctly describe the entire concept to ensure content validity. The choice sets in this research included the following attributes: a written description of each pricing option, a graphical description, required behavior change to get savings, potential bill increase with no behavioral change, and environmental and system benefits. The attributes used were chosen based on previous research (Buryk et al., 2015; Rouvinen & Matero, 2012) and from advise by Lyse Neo AS.

5.8.2 Selecting Levels for Each Attribute

The second step is to select levels for each attribute. There should be at least two levels for each attribute to be able to measure a change in behavior when levels are changed. Further, it should be decided whether these levels should take continuous or discrete values. Continuous values are used when an attribute can take any given value. With discrete values, the respondent chooses only one of the given alternatives, so the alternatives must be mutually exclusive, meaning that choosing one alternative involves *not* choosing the other alternatives. Further, the choice set must be exhaustive and finite, in that all possible alternatives are included and there is a limited amount of alternatives presented to the respondent (Train, 2003). The selection of attributes was based on previous research, as well as on advise from Lyse Neo. Given the complexity of multi-attribute choice experiments, only the levels for the attribute *Potential Bill Saving With Behavioral Change* (the monetary attribute), outlined in red in table 5.1, were varied in each choice set. The household and firm surveys were identical, with the exception of the time of the price increase. For households, the time frame for increased price was 14:00 – 20:00, while it was 09:00 – 15:00 for firms. The changed level was displayed as a percentage discount on the monthly heating bill. Table 5.1 summarizes the levels and attributes used in the final choice sets.

Table 5.1 - Attributes and Levels

	Fixed Price	**Time of Use Price**	**Peak-Load Price**
Written Description	A fixed price per kWh of heat all hours of the day and all days during the year.	<u>*Household:*</u> **50% higher** than fixed price **6 hours** during the day (14:00-20:00). *<u>Firm:</u>* **50% higher** than fixed price **6 hours** during the day (09:00-15:00). Price is **25% lower** than fixed price all other times.	<u>*Household:*</u> Price is **8 times higher** than fixed price **6 hours** during the day (14:00-20:00) **10 days** during the year. *<u>Firm:</u>* Price is **8 times higher** than fixed price **6 hours** during the day (09:00-15:00) **10 days** during the year. Price is **25% lower** than fixed price all other times.
Graphical	Graph of price (y-axis) against time of day (x-axis).		
Required Behavior Change to get Savings	None	Adjust thermostat down by **1°C**. **Reduce** the use of hot water.	Adjust thermostat down by **2.5°C**. **Reduce** the use of hot water.
Potential Bill Increase with No Behavior Change	**0%**	**0% to 5%**	**0% to 5%**
Potential Bill Saving with Behavior Change	**0%**	**15%** **20%**	**2%** **10%**
Environmental and System Benefits from Switching from Fixed Price	None	**Reduced** water and air pollution. **Increased** use of renewable resources. **Increased** energy efficiency. **Increased** functional reliability. **Reduced** increase in electricity prices.	**Reduced** water and air pollution. **Increased** use of renewable resources. **Increased** energy efficiency. **Increased** functional reliability. **Reduced** increase in electricity prices.

5.8.3 Constructing Choice Sets

The third step deals with the construction of choice sets. The *full factorial design* is used to find all the possible combinations of attributes to make up choice sets. In a choice experiment with 3 attribute levels and 4 attributes, the full factorial design would be $3^4 = 81$ possible combinations of attribute levels. These could then be randomly combined into different choice sets to determine a finite number of alternatives. This approach is usually impractical. An alternative is to use a *fractional factorial design*, where only a subset of all possible combinations of attribute levels is considered. Statistical software can be used to determine which subsets to include. Another method of obtaining choice sets is to copy or slightly modify the experimental design used by other researchers (Perman et al., 2011)

Due to the complexity and impracticality of the full factorial design, the construction of choice sets for this choice experiment was done by combining a fractional factorial design and drawing from previous research. The choice sets ultimately included in the survey were chosen by the researcher.

5.8.4 Deciding on the Amount of Choice Sets to Include in Survey

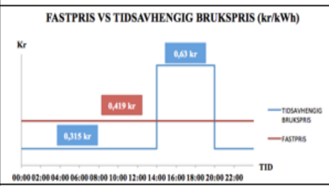
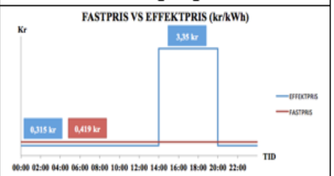
Lastly, the forth step considers how many choice experiments to include in the survey. This involves balancing the researchers desire to obtain as much information as possible from respondents by adding as many choice sets as possible with the consideration of maintaining the interest of respondents. Including too many choice sets can have damaging effects on responses as the survey or interview might become tedious, leading respondents to rush through the survey and give imprecise answers. Therefore it was decided to include a total of four choice sets in the survey, of which only two would be presented to each respondent. Since the choice sets were to be randomized between respondents, there was a need to include four choice sets. The decision to present each respondent with no more than two choice sets was taken with the choice sets' complexity in mind. Since the choice sets included a considerable amount of information, including too many choice sets could potentially have negative effects on the respondents' attentiveness and could lead to discouragement.

5.8.5 The Final Choice Sets

When the first choice set was presented to respondents, instructions were provided on how to assess the upcoming information. The decision to do so was taken from pre-test respondents suggesting more information be given prior to the actual choice sets. The information stated that the upcoming table consisted of three choices, whereby the respondents were instructed to assume they currently had the fixed price alternative as their heating price. Further, they were instructed to read the information thoroughly and decide whether they would like to keep the fixed price alternative or switch to any of the other two alternatives.

When receiving the second choice set, respondents were informed that the upcoming table consisted of the same information as the former table, with the exception of the row *Potential Bill Saving with Behavior Change*, where he actual percentage change was specified in the information text as well as in the information table. This allowed respondents to consider the change without having to read the information in detail again to decide which price method was preferred after the change. An example of a choice set included in the final survey is shown in figure 5.2. This choice set was used in the household version and includes the environmental and system benefits.

Figure 5.2 - Example of Choice Set

Prisalternativ:	Fastpris	Tidsavhengig Brukspris	Effektpris
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (14:00 - 20:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastprisalternativet.	*Prisen er 8 ganger høyere enn fastprisalternativet 10 dager i året i 6 timer (fra 14:00 til 20:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (14:00-20:00):** *Justere ned termostat 1°C på vinteren *Redusere bruk av varmtvann	**Endringer ved høypristider på dagen (14:00-20:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Redusere bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	15%	2%
Miljø- og systemfordeler	*Ingen	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris

5.9 Pre-Testing

To assess how the surveys would be understood under actual conditions, they were pre-tested to detect any faults, confusion or ambiguities. The household survey was pre-tested by a focus group of four students at the University of Stavanger, two of which received the survey version without information about environmental and system benefits, and two with the information. The test was conducted in a personal interview setting to be able to observe how questions were answered and at which questions the test respondents were confused or needed more information. Each respondent received a paper copy of the survey and interacted with the researcher throughout the completion of the survey. The pre-test respondents commented on some minor linguistic issues and expressed the need for additional information in the explanation section prior to the choice sets, in order to better understand the upcoming choice.

The firm survey was also pre-tested in a personal interview setting, by a divisional manager at a large firm in the Stavanger area. This pre-test revealed the need for some minor adjustments. The pre-test respondent expressed the need to reformulate certain questions to avoid ambiguities as well as suggesting additional alternatives to some questions.

Furthermore, the surveys were assessed by an expert on survey methodology, as well as by Lyse Neo, who are experts on district heating. The combination of expert advise on design and on content provided a comprehensive impression of how the surveys would look once they were to be implemented. The testing and assessment process was completed in order to ensure face validity, in that pre-test respondents and experts commented on and confirmed that the surveys reflected the objective of the study in a logical way. After completing the pre-tests, the necessary modifications were made and the surveys were revised before implementation.

6. SURVEY IMPLEMENTATION AND DESCRIPTIVE STATISTICS

6.1 Implementing the Surveys

The household survey was distributed by handing out upwards of 1500 flyers containing information about the survey along with a web-link to the online survey (see appendix E). The flyers had the title “Energibruk og varme i hjemmet ditt: Hva synes du?” and contained information about the purpose of the survey and how to participate. In order to incentivize prospective respondents to participate, it was informed that all respondents had the opportunity to enter the draw for a VISA gift card. The flyers were handed out at locations where there are usually gathered large crowds people. More specifically, the flyers were handed out at the shopping centers Kvadrat, Amfi Ålgård and Norwegian Outlet Stavanger, at the University in Stavanger and in Sandnes City Center. After handing out the flyers, the household survey got a total of 205 respondents. This kind of survey distribution often has low response rates. Therefore, the low response rate of 14% for this survey was as expected.

The firm survey, which aimed to be used as a pilot survey, required fewer respondents. The survey was therefore sent by e-mail to about 30 firms from the researchers extended network. The total number of respondents who completed the survey was 16, making the response rate 53%.

6.2 Sample

When conducting any research it is desirable to obtain responses from a sample that can most closely be generalized to represent the conditions of a chosen population. This however, is subject to constraints on time and budget (Hoyos, 2010). The sample is therefore a subset of the population and is based either on a probability or a non-probability approach. Probability sampling is a technique in which every member of the population has a known, nonzero probability of being selected for the sample. On the other hand, a non-probability sample is a technique in which members of a sample are selected based on personal judgment or convenience, where the probability of being chosen is unknown (Zikmund et al., 2010). For this research, the sampling technique most closely fits the description of non-probability sampling. The samples for each of the surveys in this research were set out to reflect the larger population in question: households and firms in Southern Rogaland.

6.3 Descriptive Statistics

Descriptive statistics are used to get an overview of the sample and to summarize and describe the data in a simple and understandable manner. Descriptive statistics are distinguished from inferential statistics, which seek to make conclusions that extend beyond the simple nature of descriptive statistics (Zikmund et al., 2010). In the following sections, descriptive statistics will be presented for the firm and household surveys. Because the firm survey is a pilot test, only the descriptive statistics will be presented from its results. Inferential statistics for the household survey will be explored in chapter 7.

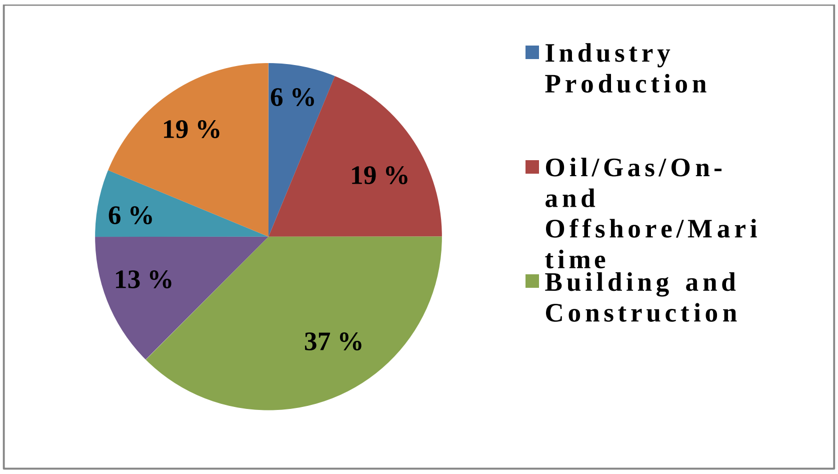
6.3.1 The Firm Survey

The firm survey had a total of 16 responses, completed by a representative at each firm. It is common practice in business and management research to have one respondent completing a survey on behalf of an organization. One of the advantages of gathering data from a single representative is that it enables a larger number of firms to be surveyed, without having to survey multiple people within each firm (Bryman & Bell, 2011). Based on the small sample for the firm survey, it is to be emphasized that the results cannot be generalized to represent the population of all firms in Southern Rogaland, but will function as a means for identifying some prevailing trends or patterns. A summary of the results can be found in appendix D.

6.3.1.1 Demographics

Among the surveyed firm representatives, 37.5% were senior managers, 43.8% were managers and 18.8% were employees. Within the sample, 37.5% work in sales and marketing, 25% in management and 37.5% work in production. The sectors represented in the sample, and their shares, are shown in figure 6.1.

Figure 6.1 - Represented Sectors



The figure shows that building and construction firms are represented with the largest share, with 38% of the sample, followed by oil/gas/on-offshore/maritime and other sectors, both at 19%. The firms represented in the sample are relatively evenly spread out in size, both in terms of annual revenues and number of employees, as shown by figures 6.2 and 6.3. Figure 6.2 shows the revenue distribution, revealing a large spread between the firms. The majority of the firms (31.25%) lie in the revenue category 6-20 million. The firms' size in terms of employees is also relatively balances, where the upper and lower bounds are represented equally, as shown in figure 6.3.

Figure 6.2 - Revenue Distribution

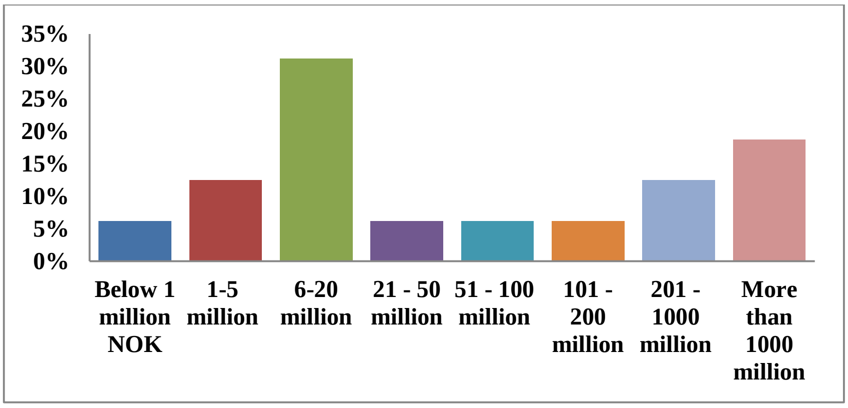


Figure 6.3 - Number of Employees

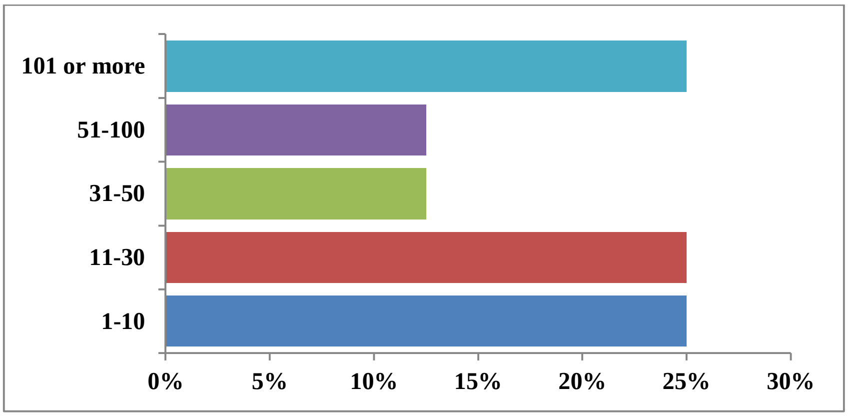
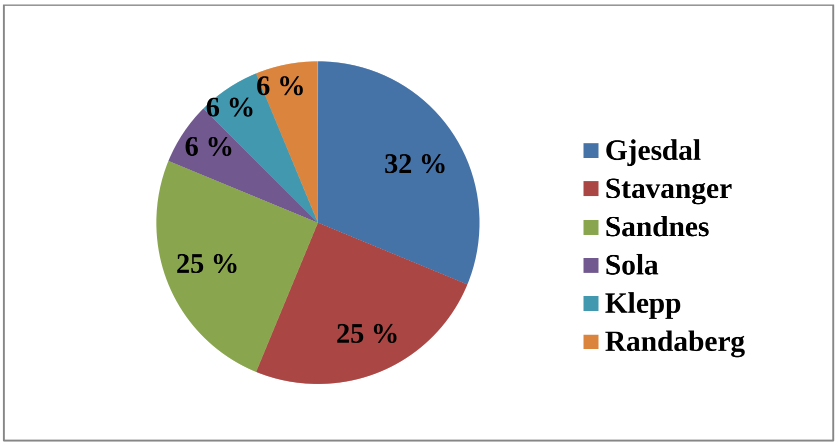


Figure 6.4 shows the location of the surveyed firms. The research was based on firms in Southern Rogaland, and the municipalities Gjesdal, Stavanger, Sandnes, Sola, Klepp and Randaberg were represented in the sample. The municipality Gjesdal had the largest share of participation, with 32%, while Stavanger and Sandnes were both represented with 25% each.

Figure 6.4 - Location



6.3.1.2 Heating Sources

The firms were asked to state which heating sources were currently used, along with which heating source is the most important for the firm. From this, 68.75 % of respondents reported that they use electricity as a heating source. Furthermore, 56.25% report that electricity is the most important heating source, followed by central heating systems at 25%. Apart from electricity and central heating systems, heat pumps, solar panels, firewood and oil are used by the firms in the sample.

6.3.1.3 Electricity Use and Expenditures

To get a picture of the firm's energy consumption, respondents were asked about the firm's monthly electricity use and expenses. The reported electricity use in the sample ranges from 500 kWh to more than 10,000 kWh a month, with the larges share of responses at the lower and upper alternatives, at 13% each. As expected, the results for electricity expenses follow a similar pattern, where the highest and the lowest ranges are most frequently selected, ranging from the categories 0 – 1,000 NOK up to more than 20,000 NOK. For both questions, a relatively large share of respondents reported that they did not know the electricity usage and expenses of their firm: 44% and 27% respectively.

6.3.1.4 Climate- and Energy Efficiency Commitments

Of the surveyed firms, the majority of respondents (62.5%) reported that their firm had no adopted plan or strategy for climate emission abatement, while 6.25% of firms were in the process of implementing one. 18.75% of respondents reported that their firm had committed to a plan or strategy. These respondents were directed to a follow-up question regarding the content of these strategies. The results from this question revealed that the most commonly adopted measures were energy efficiency (75%), conversion to environmentally friendly fuels (25%), using low-emitting transportation modes (50%), and other measures (50%). In general, climate challenges were reported to have little significance in deliberation of firm strategies, with 75% of respondents stating that it was not important or just somewhat important for the firm's decision process. The same results were evident for the question concerning energy efficiency's role in firm decisions, also revealing that 75% of firms regarded energy efficiency as not important or somewhat important when making firm decisions.

Respondents were also instructed to rank the importance of being energy efficient according to several driving forces. The results are summarized in table 6.1. The results indicate that the firms generally put less emphasis on energy efficiency than climate issues, as addressed above. This is shown by the frequent choice of the neutral alternative, as well as a low response rate to the very important category. However, 50% of firms reported that it was important for them to reduce energy expenditures and 37.5% regarded reliability of supply as important. This can indicate that considerations for their own business are more important than external concerns.

Table 6.1 - Motivations for Energy Efficiency

	Entirely unimportant	**Unimportant**	**Neutral**	**Important**	**Very Important**
Reduce energy expenditures	6%	0%	31%	50%	12.5%
Environmental considerations	12.5%	19%	37.5%	31%	0%
Reliability of supply	6%	6%	50%	37.5%	0%
Contribute to reduce society's energy scarcity	6%	12.5%	62.5%	19%	0%

Similarly, respondents were asked to specify the importance of a number of elements related to the motivation to invest in climate friendly measures, shown in table 6.2. As can be seen from the table, the elements most frequently selected as very important were government requirements and improved financial profitability. However, most respondents stated that the given factors are important, where a good reputation in the local community was most prominent, selected by 53% of respondents. Selection of the entirely unimportant choice is low, as can be expected because these elements are generally seen to be important to firms. It is therefore expected that most firms will appoint some level of importance to each of the elements, even though they might not have adopted a plan or strategy.

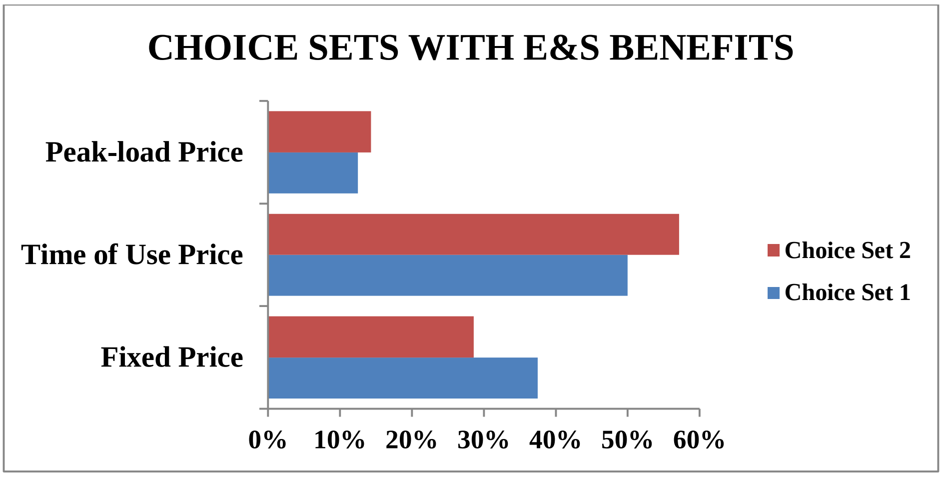
Table 6.2 - Motivations for Climate Friendliness

	Entirely unimportant	Unimportant	Neutral	Important	Very important
Government requirements	7%	13%	7%	40%	33%
Improved financial profitability	7%	0%	13%	47%	33%
Good reputation among customers	7%	13%	20%	40%	20%
Good reputation among existing and prospective employees	7%	20%	27%	40%	7%
Good reputation in the local community	13%	7%	20%	53%	7%
Good reputation among investors	7%	40%	27%	20%	7%
Competitive advantage from having an environmentally friendly organizational profile	7%	20%	40%	27%	7%

6.3.1.5 Choice of Pricing Alternative

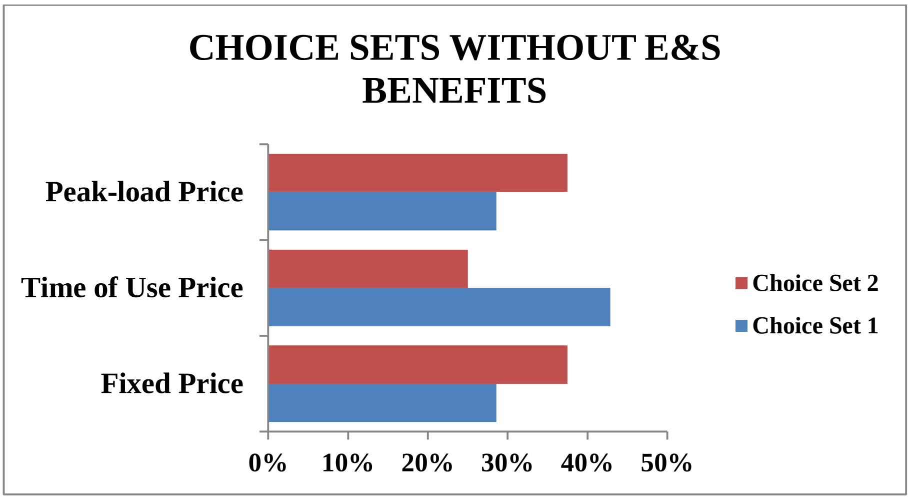
In the last part of the survey, respondents were given information about district heating and were asked to state their attitude towards it on a 5-point scale ranging from very negative to very positive. Upwards of 80% of respondents claimed to be positive or very positive to district heating. Following this question, the choice sets were presented. 9 of the 16 surveyed firms received the environmental and system (E&S) benefits treatment, and 7 received the survey version without the treatment. Figures 6.5 and 6.6 compare the preferences for each pricing alternative for the choice sets with E&S benefits and without E&S benefits, respectively. As can be seen in figure 6.5, there is evidence of a slight preference for the time of use pricing alternative for respondents receiving E&S information. This is apparent for both choice sets answered by each respondent, where savings increased from the first to the second choice set. Before the savings increase, 50% of respondents reported that the time of use price was preferred, while this portion was increased to 57% for the second choice, where savings increased. This suggests that the rate at which respondents change their preferred alternative as a result of the increased savings from choice set 1 to choice set 2 is low.

Figure 6.5 - Choice Sets with E&S Benefits



For the respondents not given the E&S benefits treatment, the distribution is slightly more spread out, with time of use price preferred in the first choice set, at 43%. For the second choice, there is an equal preference for fixed price and peak-load price, at 37.5% each, as can be seen in figure 6.6.

Figure 6.6 - Choice Sets Without E&S Benefits



In summary, the results suggest that respondents given information about E&S benefits selected the time of use price at a higher rate than respondents without the information. This indicates that the E&S benefits are slightly affecting the preferences for the given pricing alternatives.

6.3.2 The Household Survey

The following sub-sections will outline the descriptive statistics for the household survey. The sample consists of 205 respondents.

6.3.2.1 Demographic and Socio-Economic Variables

Table 6.3 contains descriptive statistics of the respondents. The table contains the number of respondents, N, minimum and maximum values for the variable as well as mean and standard deviation values. Certain variables have minimum values of 0 and maximum values of 1, indicating that they are dummy variables. For instance, the variable DOWN will have a value of 1 for respondents owning their own home, and a value of 0 otherwise. The table also shows the standard deviation for the variables. The standard deviation is a measure of spread, that is, how the variables deviate from the mean (Wooldridge, 2014).

Table 6.3 - Descriptive Statistics of Sample

Variable	N	Min	Max	Mean	Std. Dev.
DFEMALE	205	0	1	.57	.47
AGE	205	20	80	31.60	12.50
AGE^2	205	400	6400	1154	1093
EDUC	205	10	18	15.15	2.01
$EDUC^2$	205	100	324	233.45	58.73
DUNIEDUC	205	0	1	.58	.49
DFULLTIME	205	0	1	.42	.50
DSTUDENT	205	0	1	.29	.45
DHINC	205	0	1	.26	.44
DLINC	205	0	1	.28	.45
DDOMESTIC	205	0	1	0.58	.50
DDETACHED	205	0	1	.40	.49
HHSIZE	205	1	6	2.66	1.20
DOWN	205	0	1	.57	.50
ELUSE	205	0	4500	1617	903
DHELUSE	205	0	1	.04	.21
DLELUSE	205	0	1	.24	.43
ELBILL	205	500	5500	1499	1064
DHBILL	205	0	1	.05	.23
DLBILL	205	0	1	.47	.50

Certain questions contained answer options formatted as intervals, which led to the need for conversion into single answers in order to ease interpretation. The conversion was carried out by recoding each of the intervals to its middle value. This was applied for the variables age, household income and average monthly electricity expenses. In addition, the education variable was converted to reflect the number of years of completed education, as opposed to the formal level of education completed, as was asked in the survey.

From table 6.3 it can be seen that 57% of respondents are women, while 43% are men. The age of the respondents range between 20 and 80 years old, with an average age of just below 32. Among the respondents, 58% were in domestic partnerships or married, meaning that they most likely have at least a 2-person household. The household size ranges from 1 to more that 5 (which for simplicity has been set to six). The mean household size is just below 3 people. Further, 40% of respondents live in a detached house. This is interesting to look at because these houses are more likely to use more heat and electricity than for instance a smaller apartment. The variable DOWN indicates whether the respondent owns his or her own home or if he or she rents or lives with family, where a value of 1 indicates home ownership. Table 6.3 indicates that 57% of respondents own their own home.

Furthermore, table 6.3 shows that the majority of the respondents in the sample are highly educated. The respondents' years of education ranges from 10 to 18 years, with mean years of education at 15. This is again confirmed by the variable DUNIEDUC, showing that 58% of respondents have higher education from university or college. Furthermore, 42% of respondents are full time workers and 29% are students.

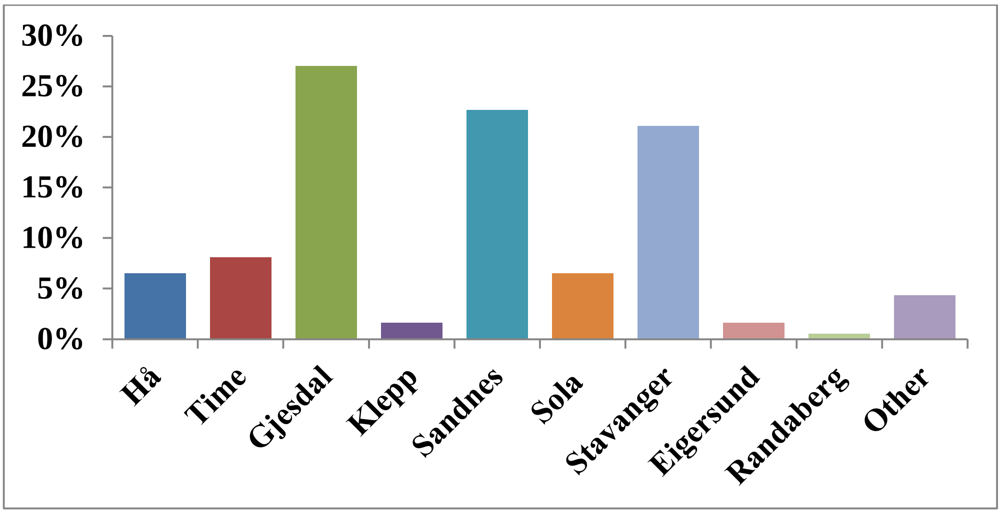
The variable DHINC is a dummy variable indicating whether respondents have a high household income. In this case, high income is defined to all income levels over 1 million NOK. Similarly, the variable DLINC is a dummy variable for respondents with low household income, defined as income levels below 500,000 NOK. From figure 6.3, it can be seen that 26% of the sample are in the higher income category, while 28% are classified as low-income households.

The variable ELBILL is a measure of the households' average monthly electricity expenditures. It is shown that this ranges from 500 to 5500 NOK, with a mean of 1499 NOK. DHBILL and DLBILL are dummy variables indicating high and low electricity bills, respectively. A high electricity bill is defined as being more than 4000 NOK, while a low bill is a below 1000 NOK. Figure 5.4 reveals that 5% of respondents have a high monthly bill, while 47% have a low bill. As expected, the average monthly electricity use follows a similar pattern. ELUSE shows that electricity use ranges from 0 to 4500 kWh monthly, with a mean use of 1617 kWh. DHELUSE describes high electricity use, and is defined to be more than 3000 kWh, which is shown to apply to 4% of the sample. Low electricity use, less than 1000 kWh a month, is reflected through DLELUSE and is shown to be the case for 24% of respondents.

6.3.2.2 Municipalities

This research aims to capture the attitudes and preferences for district heating for the Southern Rogland area. It was therefore interesting to inspect which municipalities were represented in the sample. From figure 6.7 it is seen that the highest shares of participation are among the municipalities Gjesdal, Sandnes and Stavanger, with 27%, 23% and 22% respectively.

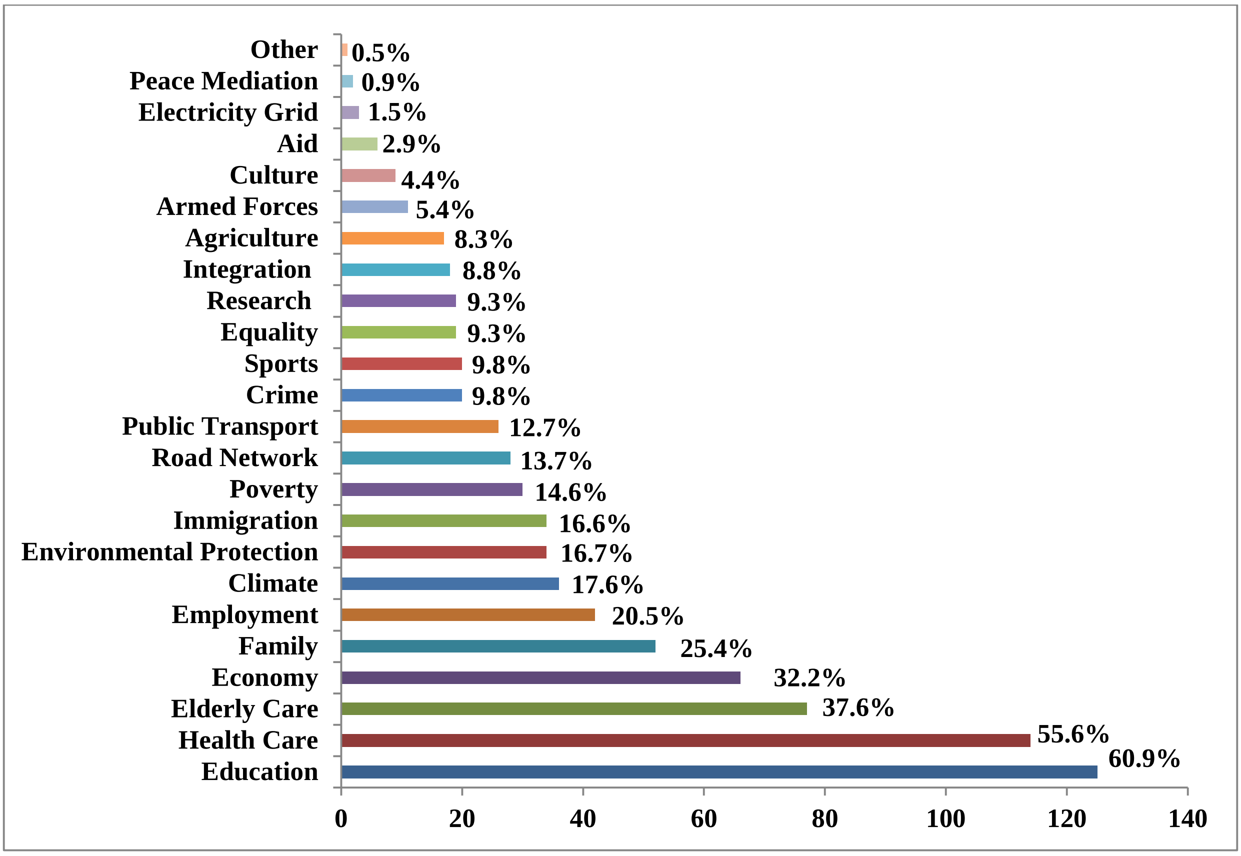
Figure 6.7 - Municipalities



6.3.2.3 Political Preferences

The first question in the survey, asked respondents to specify their preferences for political causes they believed should be prioritized in national budgets. The respondents could choose up to 4 of the given alternatives.

Figure 6.8 - Political Preferences

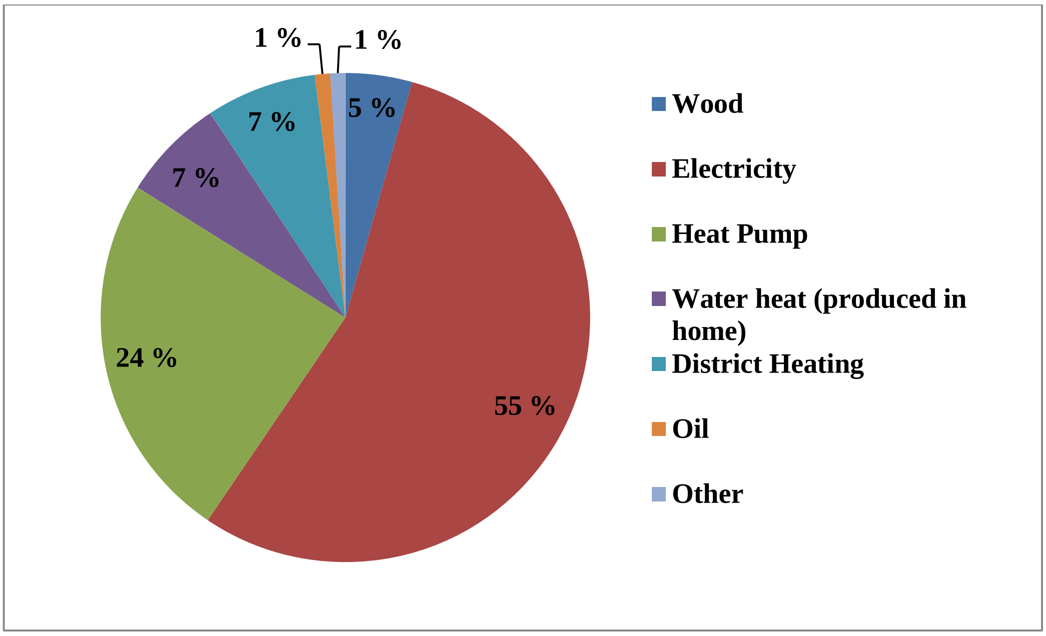


As illustrated in figure 6.8, education and health care were considered by respondents to be the most important political priorities.

6.3.2.4 Heating

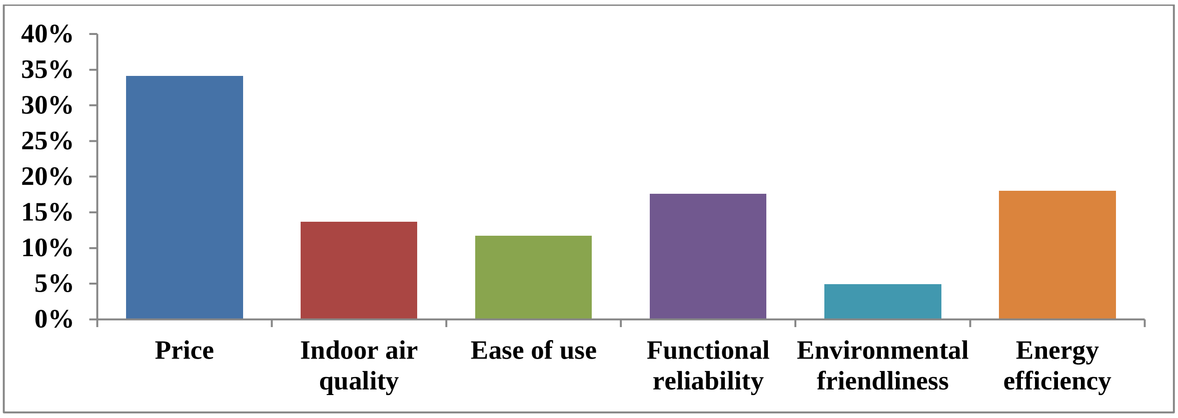
Respondents were asked a series of questions about current heating use and about what factors are important to them when it comes to heating. It can be seen in figure 6.9 that the most frequently used heating source by respondents is electricity, with 55% stating that this is their home's most important source of heating, followed by heat pumps at 24%.

Figure 6.9 - Most Important Heating Source



Further, respondents were to state the importance of a number of factors relating to the heating and hot water supply in their homes. Here, price was revealed to be the most important aspect for respondents, with 34%. The second most important factors were energy efficiency and functional reliability at 18%, as shown in figure 6.10.

Figure 6.10 - Important Factors



The same factors were also to be assessed by respondents in terms of importance, on a 5-point scale ranging from entirely unimportant to very important. The distribution is shown in table 6.4. Generally, it can be seen that respondents placed great importance to all of the given factors. In particular, the price factor is ranked with high importance, where 85.8% of respondents regarded it as important or very important. This is consistent with the results in figure 6.10 above, where price was seen as most important. Also following the distribution in figure 6.10, are the results indicating that environmental friendliness is considered the least important factor by respondents.

Table 6.4 - Importance of Various Factors

	Entirely unimportant	**Unimportant**	**Neutral**	**Important**	**Very important**
Price	1%	1.5%	11.7%	52.6%	33.2%
Indoor air quality	1.5%	1.5%	16%	59.5%	21.5%
Ease of use	1.5%	2.4%	20.6%	57.5%	18%
Functional reliability	1%	0.5%	17.1%	52.7%	28.7%
Environmental friendliness	3.4%	6.3%	31.3%	49.7%	9.3%
Energy efficiency	1%	1.5%	24.4%	49.7%	23.4%

As explained earlier, respondents were asked about their level of previous knowledge of the concept of district heating, followed by a written and illustrative description, whereafter they were to state their attitude towards district heating. Results reveal that as many as 48.8% of respondents had little or no knowledge of the concept, and only 12.2% were familiar with or very familiar with district heating. After having read the information, 73.7% of respondents reported that they were positive or very positive to district heating. Only 1.5% of respondents claimed to be negative or very negative to the concept.

Following these descriptive statistics it is interesting to investigate how these relate to the choice of pricing method in the choice experiment. In particular, it will be interesting to investigate how the combination of high importance put on price and relatively low importance put on environmental friendliness will reveal itself through choice of heating price analyzed in the next chapter.

7. ANALYSIS AND RESULTS

This chapter describes the results from the econometric analysis. Section 7.1 describes the variables used in the analyses; section 7.2 describes the hypothesis, followed by detailed descriptive statistics of choice frequencies, switching behavior and a binary logistic regression analysis in section 7.3. Lastly, the results from the multinominal logistic regression and alternative-specific conditional logit models are presented and compared in section 7.4.

7.1 The Variables

Table 7.1 describes the variables used for the econometric analysis. The dependent variables are labeled Y_1 and Y_2, while the independent variables are labeled X_1 through X_{25}. The dependent variable Y_1 describes respondents' choice between the three heating price alternatives and is used in the multinomial logistic regression and in the alternative-specific conditional logistic regression. Y_2 is a dependent dummy variable indicating whether a respondent switches his or her preferred pricing alternative from fixed price to time of use price or peak-load price between the first and second choice set, and is used for the binary logistic regression. The table also includes a description of the expected signs on the coefficients for the multinomial logistic and alternative-specific conditional logistic regressions.

Table 7.1 - The Variables

Variable:		Description:	Time of Use	Peak-Load
			H_A	H_A
Y_1	**CHOICE**	Respondents choice of pricing alternative (1=Fixed, 2=Time of Use, 3 = Peak-Load)		
Y_2	**DSWITCH**	Respondent switches pricing alternative from fixed to time of use or peak-load (1,0)		
X_1	**DFEMALE**	Respondent is female (1,0)	> 0	> 0
X_2	**AGE**	Respondent's age	> 0	> 0
X_3	**AGE^2**	Respondent's age squared	< 0	< 0
X_4	**EDUC**	Respondent's education in years	> 0	> 0
X_5	**$EDUC^2$**	Respondent's education in years squared	< 0	< 0
X_6	**DFULLTIME**	Respondent works full time (1,0)	> 0	> 0
X_7	**DSTUDENT**	Respondent is student (1,0)	< 0	< 0
X_8	**INC**	Household income in NOK	> 0	> 0
X_9	**INC^2**	Household income squared in NOK	< 0	< 0
X_{10}	**DDOMESTIC**	Respondent is married or in a domestic partnership (1,0)	$\neq 0$	$\neq 0$
X_{11}	**DDETACHED**	Respondent lives in a detached house (1,0)	> 0	> 0
X_{12}	**HHSIZE**	Household size	$\neq 0$	$\neq 0$
X_{13}	**DOWN**	Respondent owns own residence (1,0)	> 0	> 0
X_{14}	**DHELUSE**	Respondent has high monthly electricity use (1,0)	> 0	> 0
X_{15}	**DLELUSE**	Respondent has low monthly electricity use (1,0)	< 0	< 0
X_{16}	**DHBILL**	Respondent has high monthly electricity bill (1,0)	> 0	> 0
X_{17}	**DLBILL**	Respondent has low monthly electricity bill (1,0)	< 0	< 0
X_{18}	**DENVIRONMENT**	Environmental protection to be prioritized in public budgets (1,0)	> 0	> 0
X_{19}	**DCLIMATE**	Climate issues to be prioritized in public budgets (1,0)	> 0	> 0
X_{20}	**DIMPEE**	Energy efficiency is important (1,0)	> 0	> 0
X_{21}	**DIMPRICE**	Price is most important aspect of heating (1,0)	> 0	> 0
X_{22}	**SAVE_ALT2**	Amount saved for Time of use Price in NOK	> 0	< 0
X_{23}	**SAVE_ALT3**	Amount saved for Peak-Load Price in NOK	< 0	> 0
X_{24}	**COST**	The cost associated with each choice	< 0	< 0
X_{25}	**DTREATMENT**	Respondent received E&S information treatment (1,0)	> 0	> 0

7.2 Hypotheses

The variables above are set up based on their possible impact on respondent's choice of heating price alternative. In the analyses that follow later in this chapter, the probabilities of choosing the time of use and peak-load pricing alternatives relative to the fixed price alternative are estimated. In order to investigate the relationships between the choice probabilities and the independent variables, hypotheses are used as statements to establish the expected signs for each of the coefficients on the variables, as shown in table 7.1.

The expected effects on the probability of choosing each pricing alternative are based on intuition, existing literature and on economic theory. Another important consideration is the *ceteris paribus* assumption that will be applied throughout the analyses, stating that all factors other than those being considered are held constant when explaining their relationship to the dependent variable.

In table 7.1, the socio-economic variables (X_1 through X_{19}) address **research question 2**, concerning which socio-economic factors will affect the choice of heating price alternative. The savings and cost variables address **research question 3**, regarding how appropriate price discrimination is for heating. The variable SAVE_ALT2, explaining the potential savings associated with time of use price, is expected to be positive for the time of use estimation and negative for the peak-load price estimation. This is a reasonable expectation because as savings increase for time of use price, it is expected that the probability of choosing this alternative will increase, and therefore decrease for peak-load pricing. This relation is predicted to be equivalent for the SAVE_ALT3 variable, which is the savings for choosing peak-load pricing. The COST variable will be expected to have the opposite effect, where an increase in the cost of each alternative will be expected to decrease the probability of choosing each of the pricing alternatives.

Lastly, the dummy variable for received treatment relates to **research question 1**, about environmental considerations related to the choice of heating price method. The variable is expected to have a positive relation to both the time of use and peak-load prices. The environmental and system benefits received by the treated individuals will presumably increase the likelihood of choosing the time of use and peak-load prices, compared to keeping the fixed price alternative with no benefits.

Based on the expected signs on the coefficients described in table 7.1, some hypotheses will be looked into in greater detail and will be focused on more explicitly for the remainder of the analyses and discussion of the results. The hypotheses are explained in table 7.2.

Table 7.2 - Hypotheses

Hypothesis	Variable	Description
1	DTREATMENT	Receiving the information treatment will increase the likelihood of choosing the time of use or peak-load prices, relative to the fixed price alternative.
2	INC	As household income increases, the probability of choosing the time of use or peak-load pricing alternatives, relative to the fixed price alternative, will increase.
3	DDETACHED	Living in a detached house will increase the likelihood of choosing the time of use or peak-load prices, relative to the fixed price alternative.
4	DHBILL	Respondents with high monthly electricity bill will be more likely to choose the time of use or peak-load prices, relative to the fixed price alternative.
5	DHELUSE	High monthly electricity use will increase the likelihood of preferring the time of use or peak-load prices, relative to the fixed price alternative.

Hypothesis 1 is related to research question 1, which deals with the impact of environmental considerations of district heating. Respondents receiving the information treatment were shown the environmental and system benefits associated with the time of use and peak-load pricing alternatives. It can therefore be expected that these two pricing alternatives will be preferred over the fixed price alternative, which has no identified environmental and system benefits. It is therefore expected that DTREATMENT will be positive for both the time of use and the peak-load prices.

Hypothesis 2 relates to research question 2, involving socio-economic factors of respondents and their impact on preferences for district heating pricing. From previous research on district heating assessed in chapter 3, it is evident that there are varying results on the impact income has for decisions regarding household heating (Braun, 2010; Yoon et al., 2015). It is therefore interesting to look at the income variable for this sample to determine whether there exists a relationship between income and the choice of heating price alternative.

The choice sets explain that by choosing the time of use price, the price is 50% higher than fixed price during certain times, while the rest of the time the price is 25% lower than the fixed price. The peak-load price will be 8 times higher at certain times, and 25% lower than fixed price the remainder of the time. Keeping this in mind, households with high income may be able to take the risk of the elevated prices at these peak times. It is therefore expected that the variable INC will be positive.

Hypothesis 3 also addresses research question 2. The type of housing has been seen to have an effect on the household's heating decisions (Hellmer, 2013). Consumers in detached houses have a greater deal of control over their own use than those who live in larger apartment buildings. Because metering is done individually in detached homes, consumers have immediate information about their usage and have the opportunity to react quicker to fluctuations in price. The required behavioral change described in the choice sets are therefore more feasible for those who live in detached homes where they have a greater deal of control over monthly usage and can adjust use accordingly. It is therefore expected that the coefficient on the variable DDETACHED will be positive.

Hypothesis 4 also addresses research question 2. As households with higher electricity and heating bills can expect a large amount saved with the proposed saving rates, they are expected to prefer the time of use and peak-load prices compared to the fixed price alternative. With a high bill (associated with high usage), these households might have incentive to complete the necessary behavioral changes to get the savings. The coefficient associated with the variable DHBILL is therefore expected to be positive.

Following hypothesis 4, hypothesis 5 states that there is an expected relationship between high electricity use and choice of pricing alternative. High monthly electricity use is expected to increase the likelihood of preferring the time of use or peak-load prices, relative to the fixed price. The coefficient for the variable DHELUSE is therefore expected to be positive.

7.3 Choice Frequencies and Switching Patterns

7.3.1 Descriptive Results

Each respondent was faced with two choices, of which they selected the preferred pricing alternative in each. Among the 205 respondents, 111 (54%) received the survey version without the information treatment, while 94 (46%) respondents received the environmental and system benefits information. Table 7.3 shows the choice frequencies for the three pricing alternatives for the treated and non-treated sub-samples in each of the two choices C_1 and C_2. From the table, it can be seen that for the sub-sample with no information treatment in the first choice, there was an apparent preference for the fixed price option, with nearly half of respondents selecting the alternative. For the second choice, however, the highest rate of selection shifts to the time of use alternative with 40.6% of responses. The peak-load alternative was the least preferred in both choices for the no-treatment group.

The clearest difference in the treated group versus the non-treated group is the preference distribution for the fixed price alternative. With no treatment, the fixed price alternative was frequently selected, but for the treated sub-sample the time of use alternative is favored in both choices. For the first choice, the fixed price alternative had the second largest selection, with peak-load price a great deal lower. For the second choice, peak-load price was the second most preferred alternative, closely followed by the fixed price alternative.

Table 7.3 - Choice Frequencies

		No information treatment N = 111		**With information treatment N = 94**	
		C_1	**C_2**	**C_1**	**C_2**
Pricing Alternative	**Fixed**	48.7%	35.1%	35.1%	27.7%
	Time of Use	28.8%	40.6%	41.5%	43.6%
	Peak-Load	22.5%	24.3%	23.4%	28.7%

The distribution of frequencies in table 7.3 also indicates some switching activity between alternatives from C_1 to C_2 for both the treated and non-treated groups. Tables 7.4 and 7.5 describe the switching activity in greater detail. The observations of switching are highlighted in blue in the tables. Generally, among the individuals not receiving treatment, 33% switch their preferred alternative from C_1 to C_2, while the switching rate for the treated group is 28%. The switching pattern for the non-treated sub-sample is shown in table 7.4. It can be seen that 31.5%, 21.6% and 13.5% of respondents did not switch and chose the fixed price, time of use price and peak-load price alternatives in both choices, respectively.

The most frequently occurring switch was from fixed price to time of use from the first choice to the second choice. This corresponds to a savings change from 0% to 20%. Also, switching from peak-load in the first choice to time of use in the second choice was evident for 9% of respondents. In terms of potential savings, this switch would increase the savings from 2% to 20%.

Table 7.4 - Switching: No Treatment

No E&S Benefits N = 111		**Choice 2**			Total:
		Fixed	Time of Use	Peak-Load	
Choice 1	Fixed	31.5%	10%	7.2%	48.7%
	Time of Use	3.6%	21.6%	3.6%	28.8%
	Peak-Load	0%	9%	13.5%	22.5%
	Total:	35.1%	40.6%	24.3%	100%

Table 7.5 - Switching: Treatment

E&S Benefits N = 94		**Choice 2**			Total:
		Fixed	Time of Use	Peak-Load	
Choice 1	Fixed	24.5%	7.4%	3.2%	35.1%
	Time of Use	2.1%	30.9%	8.5%	41.5%
	Peak-Load	1.1%	5.3%	17%	23.4%
	Total:	27.7%	43.6%	28.7%	100%

Similarly, for the sub-sample receiving information about environmental and system benefits, table 7.5 shows how the two choices each respondent was faced with related to one another. The frequency with which respondents chose to remain with the same alternative in both choice sets was 24.5%, 30.9% and 17% for the fixed price, time of use price and peak-load alternatives, respectively.

The most frequent switch for this sub-sample was observed for the switch from time of use in the first choice to peak-load price in the second choice, at 8.5%. This is a quite surprising switch, as it corresponds to a savings decrease from 15% to 10%. Further, the switch rate from fixed price in C_1 to time of use price in C_2 was 7.4%, associated with a savings increase from 0% to 20%. Observed switching for the other configurations is relatively low.

In general, it can be seen that switching from time of use price or peak-load price towards the fixed price was uncommon for this sample. This was to be expected because savings decreased by making this switching decision. In addition, the respondents with the information treatment would also be "giving up" the environmental and system benefits by choosing to switch. The low switching percentage for the switch to fixed price (shown by the two blue cells in the leftmost columns) in both tables 7.4 and 7.5, are therefore as expected according to economic theory.

7.3.2 Binary Logistic Regression

Also interesting to investigate are the factors affecting the respondents' switching decisions. To do so, a binary logistic regression was run to identify any variables impacting switching behavior. A binary logit model has a two-category dependent variable, indicating whether an event has occurred or not. In this case, the dependent variable is DSWITCH, indicating whether respondents switch their preferred pricing alternative from the fixed price alternative in choice 1 to the time of use or peak-load prices in choice 2. A value of 1 for the dependent variable will be the target group, meaning that the switch occurs, and 0 if the switch does not occur. The probability of a respondent *i* switching his or her preferred pricing alternative is expressed in equation 7.1.

$$\text{Prob(Switch)} = \frac{\text{Exp}(X_i\beta)}{1+\text{Exp}(X_i\beta)} \qquad (7.1)$$

Equation 7.1 can also be expressed as:

$$\text{Log}\left[\frac{\text{Prob (switch)}}{\text{1-Prob (switch)}}\right] = \beta_0+\beta_1X_1+...+\beta_nX_n+\varepsilon_i \qquad (7.2)$$

Where prob (switch) is the probability that a respondent switches preferred pricing alternative from fixed price in the first choice to time of use or peak-load price in choice 2, β_0 is the intercept and the other βs are coefficients associated with the independent X variables, and ε_i is a disturbance term (Ezebilo & Animasaun, 2011). The results from the binary logistic regression model are shown in table 7.6. The table reports the coefficient for the independent variables in the β – column, indicating the direction of the probability. The p-value reports on the statistical significance of the estimate, and the exp (β) reports the odds ratio.

The odds ratio explains the amount of change in odds of switching for every one-unit increase in the predictor variables. If a coefficient β is positive, the odds ratio will be larger than one, if the coefficient is equal to zero, the odds ratio will be one and if a coefficient is negative, the odds ratio will be less than one but still positive.

Table 7.6 - Binary Logistic Regression

	β	P-value	Exp(β)
Constant	-44.197	.004	
DTREATMENT	-.794	.024	.452
AGE	-.109	.352	.897
AGE^2	.001	.443	1.001
INC	.000	.027	1.000
INC^2	.000	.019	1.000
EDUC	5.869	.005	353.894
$EDUC^2$	-.193	.006	.825
DFEMALE	.046	.893	1.047
DDOMESTIC	.320	.471	1.378
DFULLTIME	.449	.335	1.567
DSTUDENT	-.155	.772	.857
DOWN	-1.004	.024	.366
DDETATCHED	.364	.379	1.439
HHSIZE	.003	.989	1.003
DHELUSE	.032	.972	1.033
DLELUSE	-1.016	.027	.362
DHBILL	-19.515	.998	.000
DLBILL	.272	.522	1.312
DENVIRONMENT	.007	.987	1.007
DCLIMATE	-.075	.857	.928
DIMPRICE	-.443	.228	.642
DIMPEE	-.604	.088	.547
Prob>Chi^2	.000		
N	205		

Positive values for the coefficients indicate that an increase in the predictor variable will increase the likelihood of switching. With a negative value, the likelihood of falling into the reference group is decreasing as the score on the predictor variable increases. This is true for the continuous variables. For the dummy variables, a positive coefficient will imply that the group coded 1 for that variable will be more likely to switch, and a negative value will indicate that this group will be less likely to switch.

For overall fit of the model, the chi^2 test reports on the statistical significance of the model, compared to a model including only the constant. As seen in table 7.6, the model is statistically significant in terms of the low chi^2 value of .000, meaning that the model fits significantly better than a model with no predictor variables. The model also reported pseudo r^2 values. The Cox & Snell r^2 was .140, while the Nagelkerke r^2 was .251. These values represent an analogy to the r^2 values typically obtained in OLS regression. These two values can therefore be interpreted to say that the model explains approximately 14% to 25.1% of the variation in the model outcome.

From the results, it is seen that the variables DTREATMENT, INC, INC^2, DOWN and DLELUSE are significant at the 5% level, while the variable DIMEE is significant at the 10% level. Further, the variables EDUC and $EDUC^2$ are statistically significant at the 1% level. The variable DTREATMENT has a negative coefficient; meaning that a person receiving the environmental and system benefits information treatment is less likely to switch preferred pricing alternative from fixed price in the first choice to time of use or peak-load in the second choice, compared to those who did not receive the treatment. The odds ratio is .452, meaning that respondents receiving the treatment are approximately 55% less likely to make the switch.

The EDUC variable has a positive coefficient, while $EDUC^2$ is negative. This indicates that an increase in respondents' years of education will have a positive effect on the probability of switching, but only up to a certain point. Beyond this point, the $EDUC^2$ variable indicates that the probability of switching no longer increases with increased education, but starts to decrease. The model also shows some income effects, with positive coefficients on INC and INC^2. This indicates that as income increases by a unit, the probability of switching will increase. The income-squared variable indicates that this relationship may not be linear, and can change in direction at some level of income.

The variable for home ownership has a negative coefficient, meaning that homeowners are less likely than those who are not homeowners to switch from the fixed price to any of the two other alternatives. The odds ratio of .366 indicates that homeowners are approximately 63% less likely to make the switch. Further, the variable indicating low monthly electricity use had a negative coefficient. This means that those who use less electricity are less likely to switch from fixed price to the time of use price or the peak-load price. The odds ratio of .362 reveals that those with low electricity use are roughly 64% less likely to switch than those who are not in the low electricity category.

Lastly, the variable DIMPEE, indicating whether respondents regard energy efficiency as important for their household, is negative. This indicates that they are less likely to make the switch from fixed price to one of the other pricing alternatives. The odds ratio indicates that those who regard energy efficiency are about 45% less likely to make the switch than those who do not regard energy efficiency as important to their household.

7.4 Choice Probabilities

In order to determine how the independent variables affect the probability of choosing each of the pricing alternatives, two regressions were run: a multinomial logistic regression and an alternative-specific conditional logistic regression. These models produce the choice probabilities for each price alternative, relative to a chosen base category. The fixed price alternative was set as the base category in both models. As defined and made clear in the survey, the fixed price alternative was the status quo option in each of the choice sets respondents were faced with, and they were to choose if they wished to keep the fixed price or switch to any of the other two alternatives. The fixed price alternative was therefore the natural choice for base category.

The multinomial logit model and the alternative-specific conditional logit model are similar in that they both explain the relationship between a dependent variable with more than two categories and a set of independent variables. However, the conditional model is slightly more complicated as it incorporates two different forms of independent variables: alternative-specific and case-specific variables. These will be explained in greater detail later. In addition, the alternative-specific logit model requires several observations per individual in order to explain different portions of the respondents' choices.

The multinomial logit model aims to describe how an individual's characteristics affect their likelihood of choosing an alternative, relative to the base alternative. Age, gender, political positioning, household income or other socio-economic and demographic characteristics are commonly used for this purpose (Perman et al., 2011). These independent variables, being characteristics of an individual or household, are constant over the alternatives. With X_i representing the characteristics of individual *i*, the probability that individual *i* will choose *j* out of the *J* alternatives, given the individual's characteristics is given by equation 7.3.

$$\text{Prob}\left(\text{Y}_{ij}|\text{X}_{ij}\right)= \frac{\exp(\beta'_j)}{\sum_{j=1}^{\text{J}} \exp(\beta'_i X_i)} \tag{7.3}$$

Here, Y_i is the choice of pricing alternative made by individual *i* and β are regression coefficients to be estimated (Greene, 2000). Table 7.7 shows the results from the multinomial logistic regression.

Table 7.7 - Multinomial Logistic Regression

	Time of Use Price			Peak-Load Price		
	β	**P-value**	**Exp(β)**	**β**	**P-value**	**Exp(β)**
Intercept	-3.770	.654		-44.794	.000	
SAVE_ALT2	-.002	.370	0.998	-.001	.760	0.999
SAVE_ALT3	.004	.109	1.004	.004	.099	1.004
DTREATMENT	.403	.116	1.496	.307	.301	1.359
AGE	-.045	.567	0.956	.049	.634	1.050
AGE^2	.001	.557	1.001	-.001	.468	0.999
INC	.000	.867	1.000	.000	.615	1.000
INC^2	.000	.948	1.000	.000	.755	1.000
EDUC	.470	.679	1.614	6.047	.000	422.843
$EDUC^2$	-.015	.699	0.985	-.200	.000	0.819
DFEMALE	.525	.042	1.690	.536	.078	1.709
DDOMESTIC	.126	.696	1.134	-.021	.959	0.979
DFULLTIME	.323	.342	1.381	-.198	.605	0.820
DSTUDENT	.186	.645	1.204	-.193	.676	0.824
DOWN	-.706	.041	0.494	-.051	.901	0.950
DDETATCHED	-.034	.915	0.967	.217	.549	1.242
HHSIZE	.235	.083	1.265	.127	.427	1.135
DHELUSE	-2.341	.039	0.096	-.096	.893	0.908
DLELUSE	.249	.427	1.283	-.257	.503	0.773
DHBILL	1.071	.353	2.918	1.493	.175	4.450
DLBILL	.023	.956	1.023	.517	.261	1.677
DENVIRONMENT	-.178	.599	0.837	.038	.924	1.039
DCLIMATE	.376	.261	1.456	.591	.112	1.806
DIMPRICE	-.131	.627	0.877	-.084	.792	0.919
DIMPEE	.263	.326	1.301	-.142	.644	0.868
Prob>chi^2	.000					
Pseudo R-Square	.217					
N	205					

The table reports the β coefficients, the p-value and the exponential of β (the odds ratio). The overall fit of the model is statistically significant with a chi^2 value of .000. This means that the predicted model has a significantly better fit than a model including the intercept only. The pseudo r^2 is .217, meaning that 21.7% of the variance in the outcome is explained by the model.

In order to measure a monetary contributor to the probability of choosing each alternative relative to the fixed price alternative, the variables SAVE_ALT2 and SAVE_ALT3 were included in the model. These variables represent how much each respondent had the opportunity to save by choosing the time of use (alternative 2) and peak-load (alternative 3) prices. It was expected that the savings variables would be positive and significant within their own alternative (own-saving), and negative for the competing alternative (substitute saving). Thus, it was expected that when the savings for the time of use alternative increased, the probability of choosing this alternative would increase, and that when savings for the competing alternative increases the probability of choosing this alternative would decrease. However, this is not the case for this model. In the time of use section of the model, the savings variables were not statistically significant, meaning that they cannot be said to have an effect on the probability of choosing the time of use alternative, relative to the fixed price. A possible explanation for this lack of savings effects for the time of use price could be that the potential savings were not large enough. The magnitude of the savings might not have been sufficiently large enough to compensate for the necessary actions required to obtain the savings.

However, some savings effects are identified for the peak-load price section, where the savings variables have the expected signs. SAVE_ALT2 is negative, meaning that as savings increase for the time of use price, the probability of choosing peak load price, relative to fixed price, will decrease. Following this, the SAVE_ALT3 variable is positive and statistically significant at the 10% level, indicating a greater probability for selecting peak-load price when the savings for this alternative increases.

Most of the other variables in the model have the expected signs, as hypothesized in table 7.1. However, some of the variables did not have the expected signs. For both pricing alternatives these include INC^2, DOWN, DLBILL and DHELUSE. In addition, some of the variables had the expected signs for one of the pricing alternatives, but not for the other. These included AGE, AGE^2, DFULLTIME, DSTUDENT, DDETATCHED, DLELUSE DENVIRONMENT and DIMPEE. Additional results from the multinomial logistic regression will be described in relation to the results from the alternative-specific conditional model.

The alternative-specific conditional logit model allows for estimation of choice probabilities for choice models including several choices by each respondent, requiring multiple observations for each individual. Each observation describes a portion of the choice being made by each individual. The model allows for two forms of independent variables: case-specific and alternative-specific variables. The case-specific variables are characteristics of the individuals and are constant across choices. Examples include gender and income, which remain unchanged for each individual, regardless of which portion of the choice is considered. Alternative-specific variables on the other hand, vary across cases and alternatives due to the characteristics of each choice alternative. For this estimated model, the cost of choosing each of the pricing alternatives is the alternative-specific variable. The variable is calculated based on each individual's current monthly electricity bill and the percentage savings for each alternative in each choice. The cost variable estimates how the cost attributes of the choices affect the likelihood of selecting each alternative, relative to the base category. As for the multinomial logit model, the fixed price option is used as the base category.

The alternative-specific conditional logit model can be expressed as the probability of individual *i* choosing pricing alternative *j* among J number of alternatives, given the alternative-specific and case-specific conditions:

$$\text{Prob}\left(Y_{ij} \middle| X_{ij}, Z_{ij}\right) = \frac{\exp(X'_{ij}\beta)\exp(X'_{ij}\gamma)}{\left[\sum_{j=1}^{J} \exp(X'_{ij}X\beta)\right]\exp(Z'_{ij}\gamma)} \tag{7.4}$$

In equation 7.4 the dependent choice variable, indicating the choice of heating price alternative is denoted Y_{ij}. The X_{ij} variables are alternative-specific, while Z_{ij} are the case-specific variables and β and γ are regression coefficients (Chen, Yang, Liu, & Zhang, 2016).

The estimated model shown in table 7.8 is divided into alternative-specific and case-specific variables. From the model, it can be seen that the overall fit of the model is statistically significant with a chi^2 of .0214. This means that the model fits significantly better than a model with no predictor variables. The number of observations is 1,230, where each observation explains a part of each of the 205 respondents' choices.

The variable COST is seen to have the expected negative sign on the coefficient. However, the predictor is found to not be statistically significant, meaning that according to this model the cost of each pricing alternative cannot be said to have a significant effect on the probability of choosing each of the pricing alternatives. A possible explanation for this could be that the potential savings were too low to trigger a significant response from the surveyed households.

Most of the other variables in the model had the expected relation to the dependent variable. However, some variables did not have the expected signs. For both pricing alternatives these include DOWN, DHELUSE, DLBILL and DIMPRICE. In addition, some of the variables had the expected signs for one of the pricing alternatives, but not for the other. These include AGE, AGE^2, DFULLTIME, DSTUDENT, DDETATCHED, DLELUSE, DENVIRONMENT and DIMPEE. The signs on the coefficients are therefore seen to be similar to those in the multinomial logistic regression.

Table 7.8 - Alternative-Specific Conditional Logistic Regression

Variable:	β	P-Value	Exp(β)	β	P-Value	Exp(β)
Alternative-Specific:						
COST	-.001	.624	.999			
		Time of Use			**Peak-Load**	
Case-Specific:						
Constant	-4.252	.607		-47.320	.000	
DTREATMENT	.384	.131	1.468	.332	.255	1.394
AGE	-.035	.651	.965	.046	.652	1.047
AGE^2	.001	.636	1.001	-.001	.481	.999
INC	.000	.557	1.000	.000	.481	1.000
EDUC	.432	.700	1.541	6.072	.000	433.689
EDUC^2	-.013	.724	.986	-.201	.000	.817
DFEMALE	.505	.048	1.658	.559	.063	1.750
DDOMESTIC	.149	.642	1.160	-.009	.981	.990
DFULLTIME	.319	.342	1.377	-.195	.608	.822
DSTUDENT	.192	.625	1.211	-.177	.692	.837
DOWN	-.659	.055	.517	-.035	.930	.964
DDETATCHED	-.061	.843	.940	.223	.529	1.250
HHSIZE	.234	.080	1.263	.128	.414	1.136
DHELUSE	-2.281	.042	.102	-.050	.943	.951
DLELUSE	.278	.371	1.321	-.288	.449	.749
DHBILL	.390	.693	1.477	1.518	.048	4.565
DLBILL	.227	.539	1.255	.426	.249	1.531
DENVIRONMENT	-.181	.593	.834	.034	.930	1.035
DCLIMATE	.388	.243	1.475	.569	.122	1.768
DIMPEE	.227	.391	1.255	-.158	.604	.925
DIMPRICE	-.105	.694	.900	-.077	.806	.853
Prob>chi^2	.0214					
Observations	1,230					

The gender variable was also found to be statistically significant and positive for both pricing alternatives in both models, indicating that females are more likely than men to choose the time of use and peak-load prices, relative to fixed price. The variable has large odds ratios in both models, reflecting that women are considerably more likely than men to choose the time of use and peak-load prices, relative to the fixed price.

Home ownership and household size are statistically significant for the time of use price in both models. Home ownership is a dummy variable, so the negative coefficient means that homeowners are less likely than those who are not homeowners to choose the time of use price, relative to the fixed price. The odds ratios in both models show that homeowners are approximately 50% less likely to choose the alternative, relative to the fixed price alternative, than those who are not homeowners. Household size is a continuous variable, indicating that as household size increases the likelihood of choosing the time of use price relative to the fixed price will increase. The odds ratios for the variable reveal that as household size increases by a unit, there will be a 26% increase in the probability of choosing the time of use price relative to the fixed price.

There was also identified some educational effects on the choice of pricing alternative. The continuous education variables EDUC and $EDUC^2$ were statistically significant at the 1% level for the peak-load price in both models. EDUC was positive, indicating that for an increase in years of education, the likelihood of choosing the peak-load price relative to the fixed price increases. However, $EDUC^2$ was seen to be negative in both cases, reflecting that at some level of education, the positive relation between choice and education will become negative.

Monthly electricity usage and expenditures also showed to have statistically significant effects in both models. Particularly for the time of use price, high electricity use had negative effects in both models. This means that those with high electricity use seem to be less likely to choose the time of use price relative to the fixed price option. Odds ratios of .096 and .10 indicate that those who have a high monthly electricity use are about 90% less likely to choose the time of use price relative to the fixed price. It can also be seen that respondents with high monthly electricity expenditures, are significantly more likely to choose the peak-load price relative to the fixed price in the conditional regression model.

8. DISCUSSION

The main objective of this research has been to identify preferences and attitudes towards district heating. In particular, it was focused on households' and firms' preferences towards different forms of district heating pricing. After reviewing existing literature on the pricing of district heating, economic theory and an empirical analysis, the research questions established in chapter 1 can be addressed. Through two surveys based on choice experiment design, results were obtained describing preferences for three forms of district heating price configurations. Due to time restrictions, the results from the firm survey were analyzed by simple descriptive statistics, as the survey aimed to function as a pilot test. The results from the household survey were therefore the main focus for the empirical analysis and the discussion in this chapter.

8.1 Treatment Effects (Research Question 1)

The importance of environmentally friendly aspects of district heating was assessed by analyzing the effect of the information treatment. The sample was randomly split into two sub-samples where 94 respondents received the survey version with information about environmental and system benefits, while 111 respondents received the version excluding the information. From descriptive analysis of choice frequencies, it was seen that household respondents receiving the information treatment preferred the time of use price in both choices, while the non-treated respondents preferred the fixed price in the first choice and the time of use in the second choice. This indicates that the information treatment had some effect on the choice of pricing alternative. This expectation was also confirmed through the regression models, where the treatment variable had positive coefficients related to the choice of time of use and peak-load prices, relative to the fixed price option. However, the effects were not statistically significant in either of the models. This means that the effect was not seen to be significantly different from zero. Hypothesis 1, predicting that the treatment will have a statistically significant positive effect on the choice of pricing alternative can therefore not be confirmed by the results, and the null hypothesis that there was a negative or no effect of the information treatment fails to be rejected.

This conflicts with the results by Buryk et al. (2015), who found statistically significant relations between choice of pricing alternative and environmental and system benefits treatment for electricity pricing. However, other studies focusing specifically on district heating have found that environmental considerations associated with district heating were given less priority by consumers (Mahapatra & Gustavsson, 2008).

To summarize research question 1, it can therefore be said that there is no statistical evidence that the environmental friendliness of district heating has an effect on the choice of pricing alternative. However, descriptive results from the sample indicate that there was identified some response when the environmental and system benefits were highlighted. The results from the attitude and perception questions indicate that respondents are concerned with environmental friendliness, climate effects and energy efficiency. Among the respondents, 16.7% and 17.6% select environmental protection and climate issues to be prioritized in national budgets. Further, 59% of respondents consider environmental friendliness to be important or very important properties of their household's heating and hot water supply. Energy efficiency also scored high in this respect, with 73% of respondents regarding it as important or very important in relations to their household's heating and hot water supply. It is therefore important to recognize that environmental friendliness, climate concerns and energy efficiency can have some impact on consumers' heating decisions and should be clearly communicated.

8.2 Socio-Economic Factors (Research Question 2)

Research question 2 addresses the socio-economic characteristics of the individuals and households in relations to the choice of preferred pricing alternative. Hypothesis 2 examined the effects of income. Income was expected to have a positive effect on choosing the time of use and peak-load prices, relative to the fixed price. The variable was positive, as expected, but was not statistically significant in either of the models, meaning that income cannot be said to have a significant effect on the choice between the pricing alternatives. The null hypothesis that income has zero or a negative effect on the probability of choosing the time of use and peak-load prices, relative to the fixed price, fails to be rejected.

Through hypothesis 3, it was also expected that respondents living in detached houses were more likely to choose the time of use or peak-load prices, relative to the fixed price. The variable DDETATCHED had the expected positive coefficient sign for the peak-load price, but not for the time of use price. The variable was not statistically significant. The null hypothesis that the variable had zero or a negative effect on the likelihood of choosing the time of use and peak load prices fails to be rejected.

From hypothesis 4 it was expected that having a high monthly electricity bill would affect the probability of choosing the time of use and peak-load prices, relative to the fixed price. The variable DHBILL was shown to be statistically significant at the 5% level for the peak-load price in the alternative-specific conditional logit model. It is therefore estimated that having a high monthly electricity bill will increase the probability of preferring the peak-load price, relative to the fixed price. Selecting the peak-load price gave savings of 2% and 10% for the two choices. These were smaller than those for the time of use price. However, the fact that the peak-load price only increased in price 10 days during the year, and had a price 25% lower than fixed price for the rest of the time, households with high bills had the opportunity to save a great deal without much effort other that during these 10 days. Even during these days, the price is manageable through completing the necessary actions. The null hypothesis that DHBILL had zero or a negative impact on the pricing alternative choice is rejected.

From Hypothesis 5 it was expected that the variable DHELUSE would have a positive effect on the likelihood of choosing the time of use and peak-load prices, relative to the fixed price. However, the coefficient for the variable was estimated to be negative for both pricing alternatives in both models. The variable was statistically significant for time of use price in both models, meaning that the probability decreased for those who had high monthly electricity use, compared to those who did not have high electricity use. The null hypothesis that high monthly electricity use will have a negative or no affect on the likelihood of choosing the time of use and peak-load prices therefore fails to be rejected. This is a surprising result, as one would expect there to be increased incentive for households that have high use to reduce use due to the potential savings involved with the time of use and peak load prices, compared to the fixed price.

Apart from the variables that were focused on in the hypotheses, there were identified several other socio-economic factors that had statistically significant effects on the choice of heating price alternative. These included gender, education, house ownership and household size. Firstly, females were seen to be more likely than men to select both the time of use and the peak-load prices, relative to the fixed price. Secondly, as years of education increased, the likelihood of choosing one of these alternatives increased. Thirdly, home-owners were estimated to be 50% less likely to choose the time of use price, relative to the fixed price. Lastly, it was estimated that as household size increase, the likelihood of choosing the time of use price, relative to the fixed price increased.

8.3 Price Discrimination in District Heating (Research Question 3)

The third research question addresses the potential to use price discrimination for pricing district heating. As discovered in the empirical analysis on consumer preferences, there exists preference for the time of use and peak-load prices. Departing from a linear, single-price strategy can therefore be seen to have potential in district heating markets.

Since the district heating market in Southern Rogaland can be characterized as a natural monopoly, using price discrimination based on time can be a feasible alternative. As described in chapter 4, price discrimination is a tool natural monopoly firms can utilize to cover the losses associated with excess capacity. Heating use in residential and commercial sectors varies greatly during different times of the day and different seasons, so it is essential that supplying firms provide the needed heat at all demand levels. To do so, the supplier must run multiple facilities covering capacity for all stages of demand. The facilities required for intermediate and peak load demand periods are associated with high startup costs and marginal costs. Price discrimination based on time will therefore be better able to cover the costs of these facilities at the necessary times, taking into account the cost of increasing capacity. Since heat demand is somewhat predictable ahead of time, charging differentiated prices at set times can increase the predictability of revenues for the supplying firm. By informing consumers about the peak times and what necessary modifications are required, the consumer has some degree of control over use, and ultimately the cost of heating. With this control, the consumer will likely perceive the pricing to be fair.

In addition, one of the necessary conditions for price discrimination is that the firm must be able to distinguish between different consumers. The empirical results indicate that there is potential for price discrimination by dividing consumers into groups according to monthly use. In addition, price discriminiation can be applied by charging different forms of prices according to consumer characteristics, such as separating between different types of buildings or between households and firms.

The Norwegian Water Resources and Energy Directorate (NVE) recently issued a statement presenting peak-load pricing as a planned future pricing policy for electricity in Norway. With increased demand for electricity in years to come, the plan aims to incentivize consumers to shift use from periods of peak demand to periods with less demand. With this, the plan intends to reduce the need for investments by suppliers and to reduce consumers' electricity bill, while ensuring balance within the electricity grid. The plan is set to be implemented by 2019 (The Norwegian Water Resources and Energy Directorate, 2016). Due to the regulations in the Norwegian Energy Act §5-5, stating that the charge for district heating shall not exceed the charge for electrical heating, the pricing of district heating must follow the patterns of the electricity market. Therefore, there exists a potential for district heating pricing to follow the electricity sector in dynamic pricing policies in the future.

8.4 Research Limitations

Due to time constraints on completing the research, some compromises were made in the design and completion of the research. For instance, the choice experiment was not designed as a full choice experiment. An ideal choice experiment would be designed applying a full factorial design or a fractional design, where all possible configurations of savings are considered and ultimately a randomly selected portion of these are presented to respondents (Perman et al., 2011). For this research, attributes and levels were constructed by the researcher, based on expert advise, previous research, and intuition. It is common practice to complete choice experiments in this way, but it is not ideal in terms of randomization and complete accuracy in the result (Perman et al., 2011). Full choice experiments typically include more than two choice sets, while this research was based on only two choices in order to correspond with the scope of the study.

The sample size of 205 respondents can be considered to be too small from which to draw generalized conclusions for the desired population. The sample was not completely representative of the population of households in Southern Rogaland, which had implications for the ability to conclude something about the true preferences for different forms of district heating pricing. A larger sample could potentially give a more precise estimation of true preferences, but would require considerably more time and funding to complete. The small sample size could be seen to result from the sampling method used for this research. Handing out invitation flyers was time-consuming and resulted in a low response rate. However, keeping the sample limitations in mind, the obtained sample results can contribute by approximating some of the expected effects that could be obtained with a larger sample.

The firm survey also had some limitations in terms of sampling. By having one respondent answer the survey on behalf of the entire organization, it was not guaranteed that the respondent had sufficient information to answer the questions accurately. This was seen in the survey, where the "I don't know" option was frequently used, especially for the electricity usage and expenditure questions. The problem often arises when the respondent is a lower-level employee with limited information. In addition, it is important to note that higher-level employees and managers can also distort the accuracy of the results. These respondents might feel inclined to present their firm in a favorable way, displaying over-positive answers (Bryman & Bell, 2011). This could be the case for this survey, where respondents were asked about environmental and energy efficiency attitudes and commitments. However, this limitation is reduced somewhat by clearly communicating anonymity.

8.5 Suggestions for Further Research

Research on consumer preferences for different types of pricing alternatives for district heating is lacking in existing academic research. Based on the value these types of studies can have for policy makers and suppliers' pricing decisions, the topic is worth investigating on a larger scale. Exploring the preferences for different pricing policies for district heating based on a larger representative national sample could bring about more sufficient information that could be useful in making informed pricing decisions.

Applying a full choice experiment could potentially incorporate additional forms of pricing alternatives as a supplement to the fixed, time of use and peak-load prices investigated in this thesis. A full choice experiment design could also facilitate the use of more than two choice sets and additional attributes and levels for each choice. As the empirical results for this research show, the savings and cost attributes were not seen to have significant effects on the choice of pricing alternative. It could therefore be interesting to investigate similar experiments with larger saving potentials and larger savings increase between choices.

9. CONCLUSIONS

This thesis has examined various pricing strategies for district heating. Attitudes towards district heating and preferences for different forms of pricing were investigated through a discrete choice experiment approach targeting households and firms in Southern Rogaland. Three competing heating price alternatives were presented to respondents, whereby they were to state their most preferred choice of heating price alternative. The three alternatives, *fixed price*, *time of use price* and *peak-load price*, were presented to respondents in labeled choice menus describing attributes of each alternative. The fixed price was stated as the status quo option, and respondents were asked to indicate whether they would continue applying the fixed price or switch to any of the other two alternatives.

In order to examine whether environmental considerations impacted the choice of preferred heating price alternative, an environmental and system benefits attribute for the time of use and peak-load prices was randomly presented to about half of the respondents. The results from two regression models showed that the effect was not a statistically significant predictor explaining the probability of choosing each of the pricing alternatives. However, descriptive results from the household sample indicate that when environmental benefits are highlighted, there was an increased preference for the time of use and peak-load prices, and decreased preference for the fixed price compared to when the environmental benefits were not shown. Results from the attitude and perception questions also indicate that environmental friendliness, climate concerns and energy efficiency are regarded as important properties of households' heating and hot water supply. Similar results were found among firm respondents.

The probabilities of choosing each of the pricing alternatives were also examined based on the impact of several socio-economic and demographic variables. Differences in preferences for pricing alternatives were identified for home ownership, gender and household size. Increasing years of education was also estimated to increase the probability of choosing the time of use or peak-load prices. In addition, monthly electricity use and expenditures were found to effect the choice of heating price alternative.

The results of the research suggest that there is a potential for other forms of pricing than the fixed linear prices that are currently used is most district heating markets. However, further investigation into the concept is necessary to determine true preferences for dynamic pricing strategies in district heating.

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11. APPENDICES

Appendix A – Household Survey

Appendix B – Household Survey Results

Appendix C – Firm Survey

Appendix D – Firm Survey Results

Appendix E – Invitation Flyers

APPENDIX A: HOUSEHOLD SURVEY

FJERNVARME

Om denne undersøkelsen

Din mening er viktig!

Takk for at du hjelper med denne undersøkelsen som er en del av ressursøkonomisk forskning ved Universitetet i Stavanger. Svarene du gir vil hjelpe oss med å få bedre innsikt i folks preferanser og betalingsvillighet for energieffektive oppvarmingsløsninger. Fokuset er spesielt på bruk av fjernvarme.

Det tar ca.10 minutter å fylle ut hele skjemaet. Du som deltar i denne undersøkelsen vil være helt anonym. Vi er bare interessert i sammenfatninger av svarene over alle deltakerne. Vi gir ikke individuell informasjon til tredjeparter til noe som helst formål.

Skulle du ha problemer med å fylle ut skjemaet eller ha spørsmål angående undersøkelsen kan du kontakte oss på e-post eller telefon.

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1

FJERNVARME

Introduksjonsspørsmål

* 1. Hvilke politiske saker er det viktigst at blir prioritert i offentlige, nasjonale budsjetter?
(Velg opp til 4 saker som er viktige for deg og din husholdning)

- [ ] Miljøvern
- [ ] Strømnett
- [ ] Økonomi
- [ ] Klima
- [ ] Eldreomsorg
- [ ] Kollektivtransport
- [ ] Fattigdom
- [ ] Landbruk
- [ ] Forsvaret
- [ ] Innvandring
- [ ] Kultur
- [ ] Veinett
- [ ] Annet (vennligst spesifiser):
- [ ] Utdanning
- [ ] Sysselsetting
- [ ] Likestilling
- [ ] Bistand
- [ ] Helse
- [ ] Kriminalitetsbekjempelse
- [ ] Forskning
- [ ] Fredsmekling
- [ ] Familie
- [ ] Idrett
- [ ] Integrering

2

FJERNVARME

Varmebruk

2. Hvilke oppvarmingskilder benyttes i hjemmet ditt?
(Kryss av de alternativene som er relevante for deg)

- [ ] Ved
- [ ] Elektrisitet
- [ ] Varmepumpe
- [ ] Vannbåren varme produsert i hjemmet
- [ ] Vannbåren varme (Fjernvarme)
- [ ] Solcelle
- [ ] Olje
- [ ] Annet

FJERNVARME

Varmebruk

3. Hva er den VIKTIGSTE oppvarmingskilden i hjemmet ditt?

- ◯ Ved
- ◯ Elektrisitet
- ◯ Varmepumpe
- ◯ Vannbåren varme produsert i hjemmet
- ◯ Vannbåren varme (fjernvarme)
- ◯ Solcelle
- ◯ Olje
- ◯ Annet

4

FJERNVARME

Varmebruk

4. Hvor fornøyd er du med din nåværende oppvarmingskilde?

- ◯ Veldig misfornøyd
- ◯ Misfornøyd
- ◯ Nøytral
- ◯ Fornøyd
- ◯ Veldig fornøyd

5

FJERNVARME

Varmebruk

5. Har du planer om å bytte oppvarmingskilde i ditt hjem i løpet av de neste 4 årene?

- ◯ Ja
- ◯ Nei
- ◯ Vet ikke

6

FJERNVARME

Varmebruk

6. Hva er den viktigste egenskapen ved din boligs oppvarming og varmtvann for deg?

- ◯ Pris
- ◯ Inneklima
- ◯ Brukervennlighet
- ◯ Funksjonell pålitelighet
- ◯ Klimavennlighet
- ◯ Energieffektivitet

FJERNVARME

Varmebruk

7. Hvor viktig er hver av disse egenskapene ved oppvarming og varmtvann i din bolig for deg?

	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig
Pris	◯	◯	◯	◯	◯
Inneklima	◯	◯	◯	◯	◯
Brukervennlighet	◯	◯	◯	◯	◯
Funksjonell pålitelighet	◯	◯	◯	◯	◯
Klimavennlighet	◯	◯	◯	◯	◯
Energieffektivitet	◯	◯	◯	◯	◯

FJERNVARME

Energibruk

8. Hvor viktig er det for din husholdning å være energieffektive?

- ◯ Helt uviktig
- ◯ Uviktig
- ◯ Nøytral
- ◯ Viktig
- ◯ Veldig viktig

FJERNVARME

Energibruk

9. Vennligst gi ditt beste anslag på din husholdnings gjennomsnittlige månedlige strømforbruk.

- ◯ 0 kWh
- ◯ 200 kWh
- ◯ 400 kWh
- ◯ 600 kWh
- ◯ 800 kWh
- ◯ 1 000 kWh
- ◯ 1 200 kWh
- ◯ 1 400 kWh
- ◯ 1 600 kWh
- ◯ 1 800 kWh
- ◯ 2 000 kWh
- ◯ 2 200 kWh
- ◯ 2 400 kWh
- ◯ 2 600 kWh
- ◯ 2 800 kWh
- ◯ 3 000 kWh
- ◯ 3 200 kWh
- ◯ 3 400 kWh
- ◯ 3 600 kWh
- ◯ 3 800 kWh
- ◯ 4 000 kWh
- ◯ Mer enn 4 000 kWh

FJERNVARME

Energibruk

10. Vennligst gi ditt beste anslag på hvor mye din husholdning betaler i gjennomsnitt i strøm per måned.

- ◯ 0 - 500 kr
- ◯ 500 - 700 kr
- ◯ 700 - 900 kr
- ◯ 900 - 1 100 kr
- ◯ 1 100 - 1 300 kr
- ◯ 1 300 - 1 500 kr
- ◯ 1 500 - 1 700 kr
- ◯ 1 700 - 1 900 kr
- ◯ 2 100 - 2 300 kr
- ◯ 2 300 - 2 500 kr
- ◯ 2 500 - 2 700 kr
- ◯ 2 700 - 2 900 kr
- ◯ 3 100 - 3 300 kr
- ◯ 3 300 - 3 500 kr
- ◯ 3 500 - 3 700 kr
- ◯ 3 700- 3 900 kr
- ◯ 3 900 - 4 100 kr
- ◯ 4 100 - 4 300 kr
- ◯ 4 300 - 4 500 kr
- ◯ 4 500 - 4 700 kr
- ◯ 4 700 - 4 900 kr
- ◯ 4 900 - 5 100 kr
- ◯ 5 100 - 5 300 kr
- ◯ 5 300 - 5 500 kr
- ◯ Mer enn 5 000 kr

FJERNVARME

Fjernvarme

11. Hva er din nåværende kjennskap til fjernvarme?

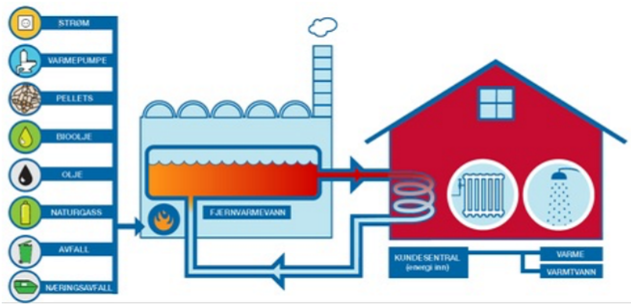
- ◯ Liten eller ingen kjennskap
- ◯ Noe kjennskap
- ◯ God kjennskap
- ◯ Meget god kjennskap

FJERNVARME

Fjernvarme Informasjon

VENNLIGST LES FØLGENDE INFORMASJON

Et fjernvarmeanlegg er et sentralt anlegg som brukes til å varme opp vann til varmt tappevann og oppvarming av bygninger. Fra fjernvarmeanlegget distribueres vannet til næringsbygg, offentlige bygg og boliger gjennom nedgravde isolerte rør. Hos kunden er det installert en kundesentral med varmevekslere hvor energien overføres fra fjernvarmevannet til kundens varme- og tappevannsanlegg. Herfra transporteres det varme vannet videre i boligen. Slik som for elektrisk oppvarming styrer kunden varmen med termostater og forbruket registreres med energimålere. Bildet nedenfor illustrerer denne prosessen.



Fjernvarmeanlegg benytter ulike energikilder som gjenvunnet varme, bioenergi, olje, gass og elektrisitet. I Rogaland benyttes hovedsakelig gjenvunnet varme fra industriproduksjon, avfallsforbrenning og annen restvarme som ellers ville gått til spille. Å ta vare på og gjenvinne denne varmen, som ellers ville bli sluppet ut i omgivelsene, er fjernvarmens hovedtanke. Å gjenvinne varme på denne måten er samtidig klimavennlig og energieffektivt.

12. Basert på overståede informasjon, hvordan stiller du deg til fjernvarme?

- ◯ Veldig negativ
- ◯ Negativ
- ◯ Nøytral
- ◯ Positiv
- ◯ Veldig positiv

FJERNVARME

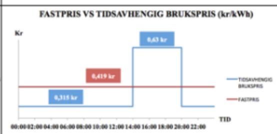
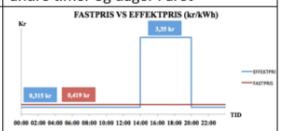
Informasjon om pris

Nedenfor er det presentert tre prisalternativ for varme: *Fastpris*, *Tidsavhengig Brukspris* og *Effektpris*.

Ved *fastpris* menes det at du betaler en fastsatt pris per kWh varme brukt per måned. Ved *tidsavhengig brukspris* betales det en høyere pris for noen timer av dagen og lavere pris resten av dagen. *Effektpris* går ut på at du betaler en høyere pris noen timer av dagen kun noen utvalgte dager i året. Resten av timene og dagene betales det en lavere pris.

Anta at det første alternativet *Fastpris* er din nåværende varmeavtale. De andre to alternativene tilbyr deg å spare på varmekostnadene ved å redusere varmebruk i perioder med høy varmepris.

Vennligst les gjennom informasjonen nøye og velg om du vil bytte til et nytt prisalternativ, eller om du vil beholde fastprisalternativet.

Prisalternativ:	Fastpris	Tidsavhengig Brukspris	Effektpris
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (14:00 - 20:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastprisalternativet.	*Prisen er 8 ganger høyere enn fastprisalternativet 10 dager i året i 6 timer (fra 14:00 til 20:00). Det vil blir varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
Nødvendig endring	Ingen	**Endringer ved høypristider på dagen (14:00-20:00):** *Justere ned termostat 1°C på vinteren *Redusere bruk av varmtvann	**Endringer ved høypristider på dagen (14:00-20:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Redusere bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	15%	2%

13. Hvilket prisalternativ foretrekker du?

- ◯ Beholde fastpris
- ◯ Tidsavhengig brukspris
- ◯ Effektpris

14

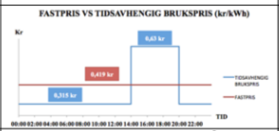
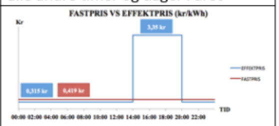
FJERNVARME

Informasjon om pris

Nedenfor er den samme tabellen som på forrige side, med unntak av nederste rad *potensiell sparing ved gjennomføring av nødvendig endring.*

Sparing ved *tidsavhengig brukspris* er nå økt fra 15% til 20% og fra 2% til 10% ved *effektpris.*

Vennligst ta stilling til endringen og velg hvilket prisalternativ du nå foretrekker.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (14:00 - 20:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastprisalternativet.	*Prisen er 8 ganger høyere enn fastprisalternativet 10 dager i året i 6 timer (fra 14:00 til 20:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
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Potensiell sparing ved gjennomføring av nødvendig endring	0%	20%	10%

14. Hvilken prisalternativ foretrekker du nå?

- ◯ Beholde fastpris
- ◯ Tidsavhengig brukspris
- ◯ Effektpris

FJERNVARME

Informasjon om pris

Nedenfor er det presentert tre prisalternativ for varme: *Fastpris*, *Tidsavhengig Brukspris* og *Effektpris*.

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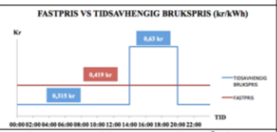
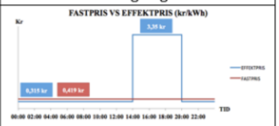
Anta at det første alternativet *Fastpris* er din nåværende varmeavtale. De andre to alternativene tilbyr deg å spare på varmekostnadene ved å redusere varmebruk i perioder med høy varmepris. I tillegg medfører disse alternativene økte miljø- og systemfordeler.

Vennligst les gjennom informasjonen nøye og velg om du vil bytte til et nytt prisalternativ, eller om du vil beholde fastprisalternativet.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (14:00 - 20:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastprisalternativet.	*Prisen er 8 ganger høyere enn fastprisalternativet 10 dager i året i 6 timer (fra 14:00 til 20:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (14:00-20:00):** *Justere ned termostat 1°C på vinteren *Redusere bruk av varmtvann	**Endringer ved høypristider på dagen (14:00-20:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Redusere bruk av varmtvann
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Potensiell sparing ved gjennomføring av nødvendig endring	0%	15%	2%
Miljø- og systemfordeler	*Ingen	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris

15. Hvilket prisalternativ foretrekker du?

◯ Beholde fastpris

◯ Tidsavhengig brukspris

◯ Effektpris

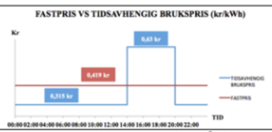
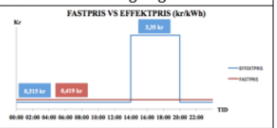
FJERNVARME

Informasjon om pris

Nedenfor er den samme tabellen som på forrige side, med unntak av raden *potensiell sparing ved gjennomføring av nødvendig endring.*

Sparing ved *tidsavhengig brukspris* er nå økt fra 15% til 20% og 2% til 10% ved *effektpris.*

Vennligst ta stilling til endringen og velg hvilket prisalternativ du nå foretrekker.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (14:00 - 20:00) i av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastprisalternativet.	*Prisen er 8 ganger høyere enn fastprisalternativet 10 dager i året i 6 timer (fra 14:00 til 20:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
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Miljø- og systemfordeler	*Ingen	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusere økning i strømpris	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusere økning i strømpris

16. Hvilken prisalternativ foretrekker du nå?

◯ Beholde fastpris

◯ Tidsavhengig brukspris

◯ Effektpris

FJERNVARME

Bakgrunnsinformasjon

Til slutt trenger vi bakgrunnsinformasjon om deg og de andre deltakerne for å forsikre oss om at data fra undersøkelsen er representativt for befolkningen.

17. Er du mann eller kvinne?

- ◯ Mann
- ◯ Kvinne

FJERNVARME

Bakgrunnsinformasjon

18. Hva er din alder?

- ◯ Under 18år
- ◯ 18 - 21 år
- ◯ 22 - 25 år
- ◯ 26 - 29 år
- ◯ 30 - 39 år
- ◯ 40 - 49 år
- ◯ 50 - 59 år
- ◯ 60 - 69 år
- ◯ 70 - 79 år
- ◯ 80 år eller eldre

FJERNVARME

Bakgrunnsinformasjon

19. Hva er din sivilstatus?

- ◯ Gift/ Registrert partner
- ◯ Samboer
- ◯ Parforhold
- ◯ Singel
- ◯ Skilt
- ◯ Enke/Enkemann
- ◯ Annet

21

FJERNVARME

Bakgrunnsinformasjon

20. I hvilken kommune bor du?

- ◯ Hå
- ◯ Time
- ◯ Bjerkreim
- ◯ Gjesdal
- ◯ Klepp
- ◯ Sandnes
- ◯ Sola
- ◯ Stavanger
- ◯ Eigersund
- ◯ Randaberg
- ◯ Annen kommune

FJERNVARME

Bakgrunnsinformasjon

21. Hva slags bolig bor du i?

- ◯ Enebolig
- ◯ Rekkehus
- ◯ Leilighet
- ◯ Hybel

FJERNVARME

Bakgrunnsinformasjon

22. Inkludert deg selv, hvor mange mennesker (barn og voksne) er det i din husstand?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ Flere enn 5

FJERNVARME

Bakgrunnsinformasjon

23. Eier du ditt eget hjem eller leier du?

- ◯ Eier
- ◯ Leier
- ◯ Bor med familie/slekt
- ◯ Ingen av delene

FJERNVARME

Bakgrunnsinformasjon

24. Hva er ditt høyeste fullførte utdanningsnivå?

- ◯ Grunnskolenivå
- ◯ Videregåendenivå
- ◯ Fagbrev/Fagskole
- ◯ Universitets- og høyskolenivå, 1 - 3 år
- ◯ Universitets- og høyskolenivå, 3 - 5 år
- ◯ Universitets- og høyskolenivå, mer enn 5 år

25. Hvilke alternativ beskriver best din nåværende arbeidssituasjon?

- ◯ Arbeider fulltid
- ◯ Arbeider deltid
- ◯ Ikke-lønnet/frivillig arbeid
- ◯ Student
- ◯ Pensjonert
- ◯ Hjemmeværende
- ◯ Svangerskapspermisjon (midlertidig permisjon)
- ◯ Selvstendig næringsdrivende
- ◯ Er ikke i arbeid på nåværende tidspunkt
- ◯ Annet (vennligst spesifiser):

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Bakgrunnsinformasjon

26. Vennligst oppgi omtrentlig årlig brutto inntekt i din husstand. Det vil si all samlet inntekt i husstanden før skatt er trukket fra.

- ◯ 0 – 100 000 kr
- ◯ 100 001 – 200 000 kr
- ◯ 200 001 – 300 000 kr
- ◯ 300 001 – 400 000 kr
- ◯ 400 001 – 500 00 kr
- ◯ 500 001 – 600 000 kr
- ◯ 600 001 – 700 000 kr
- ◯ 700 001 – 800 000 kr
- ◯ 800 001 – 900 000 kr
- ◯ 900 001 – 1 000 000 kr
- ◯ 1 000 001 – 1 100 000 kr
- ◯ 1 100 001 – 1 200 000 kr
- ◯ 1 200 001 – 1 300 000 kr
- ◯ 1 300 001 – 1 400 000 kr
- ◯ 1 400 001 – 1 500 000 kr
- ◯ 1 500 001 – 1 600 000 kr
- ◯ 1 600 001 – 1 700 000 kr
- ◯ 1 700 001 – 1 800 000 kr
- ◯ 1 800 001 – 1 900 000 kr
- ◯ 1 900 001 – 2 000 000 kr
- ◯ Mer enn 2 000 000 kr

FJERNVARME

Takk for at du deltok i denne undersøkelsen!

27. Har du andre kommentarer til denne undersøkelsen som du ønsker å dele med oss?

28. Ønsker du å delta i trekningen av et VISA gavekort pålydende 1 000 kroner?

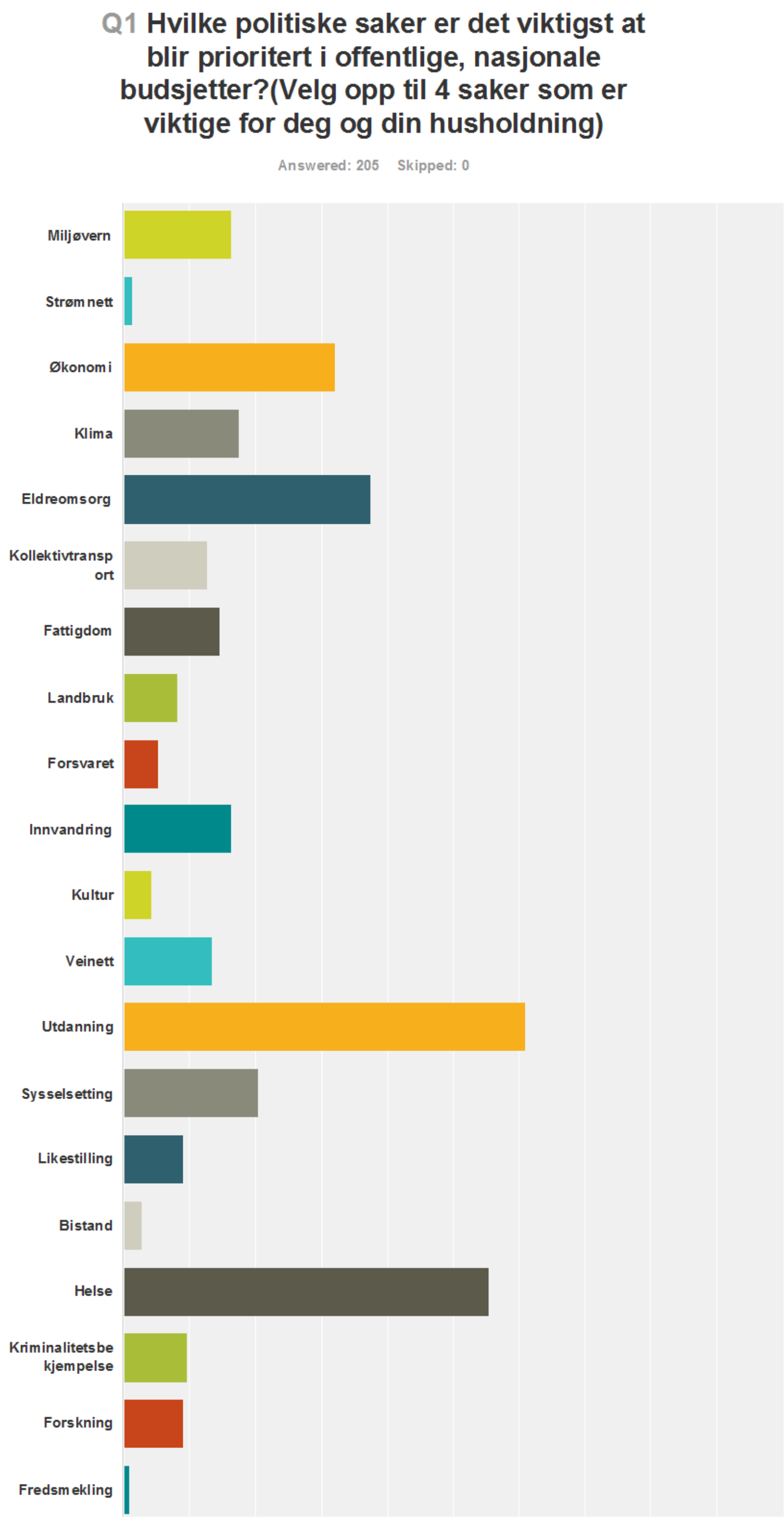
Mobiltelefon

E-post

29

APPENDIX B: HOUSEHOLD SURVEY RESULTS

FJERNVARME



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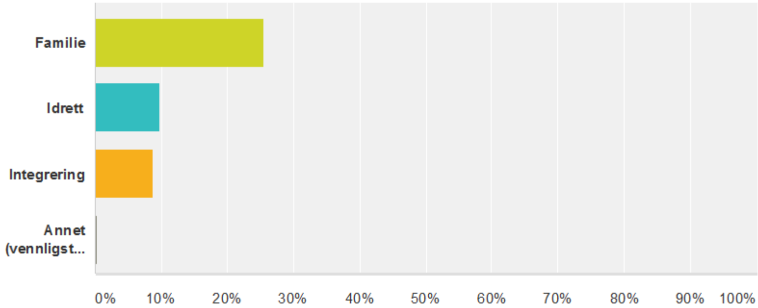
FJERNVARME

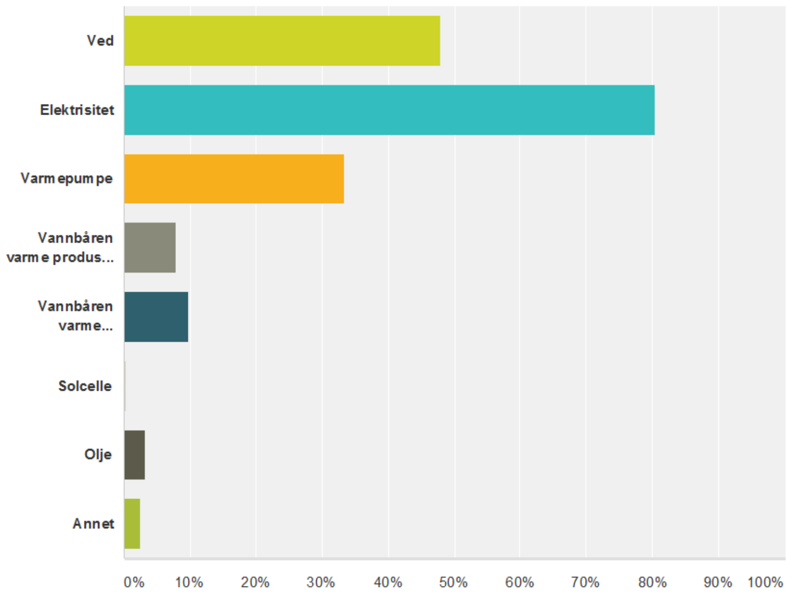


Answer Choices	Responses	
Miljøvern	16.59%	34
Strømnett	1.46%	3
Økonomi	32.20%	66
Klima	17.56%	36
Eldreomsorg	37.56%	77
Kollektivtransport	12.68%	26
Fattigdom	14.63%	30
Landbruk	8.29%	17
Forsvaret	5.37%	11
Innvandring	16.59%	34
Kultur	4.39%	9
Veinett	13.66%	28
Utdanning	60.98%	125
Sysselsetting	20.49%	42
Likestilling	9.27%	19
Bistand	2.93%	6
Helse	55.61%	114
Kriminalitetsbekjempelse	9.76%	20
Forskning	9.27%	19
Fredsmekling	0.98%	2
Familie	25.37%	52
Idrett	9.76%	20
Integrering	8.78%	18
Annet (vennligst spesifiser):	0.49%	1
Total Respondents: 205		

Q2 Hvilke oppvarmingskilder benyttes i hjemmet ditt?(Kryss av de alternativene

som er relevante for deg)

Answered: 204 Skipped: 1

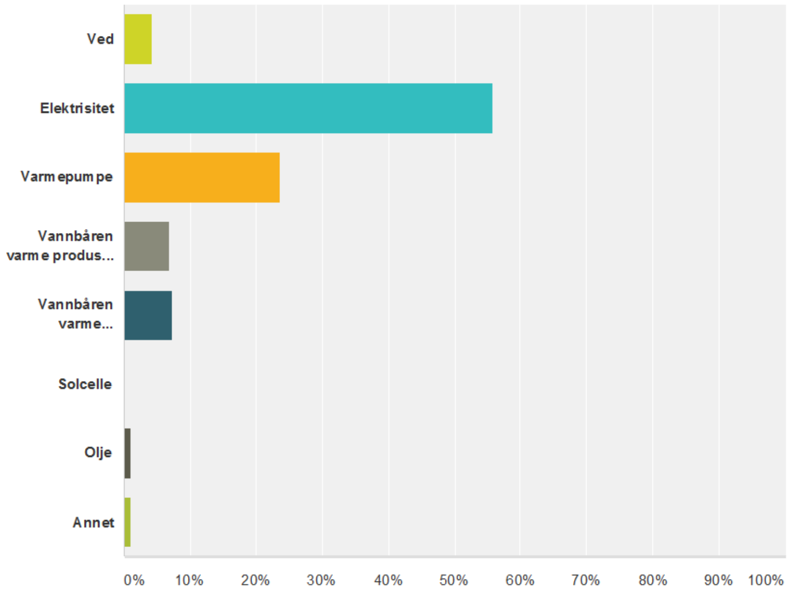


Answer Choices	Responses	
Ved	48.04%	98
Elektrisitet	80.39%	164
Varmepumpe	33.33%	68
Vannbåren varme produsert i hjemmet	7.84%	16
Vannbåren varme (Fjernvarme)	9.80%	20
Solcelle	0.49%	1
Olje	3.43%	7
Annet	2.45%	5
Total Respondents: 204		

Q3 Hva er den VIKTIGSTE oppvarmingskilden i hjemmet ditt?

Answered: 203 Skipped: 2

FJERNVARME

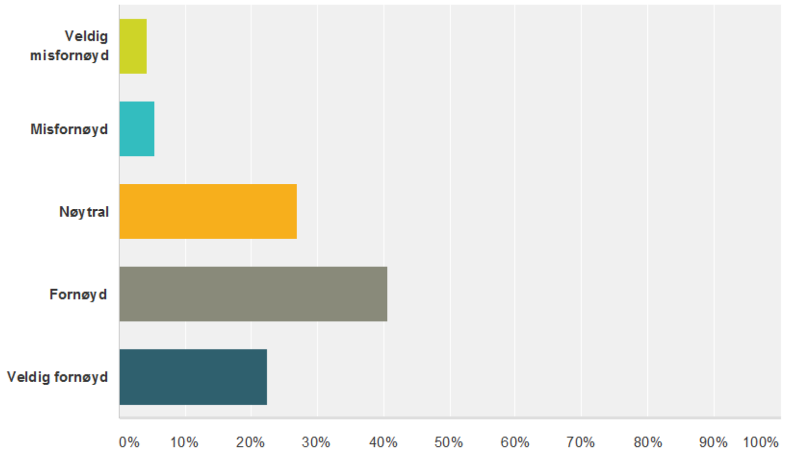


Answer Choices	Responses	
Ved	**4.43%**	9
Elektrisitet	**55.67%**	113
Varmepumpe	**23.65%**	48
Vannbåren varme produsert i hjemmet	**6.90%**	14
Vannbåren varme (fjernvarme)	**7.39%**	15
Solcelle	**0.00%**	0
Olje	**0.99%**	2
Annet	**0.99%**	2
Total		**203**

Q4 Hvor fornøyd er du med din nåværende oppvarmingskilde?

Answered: 204 Skipped: 1

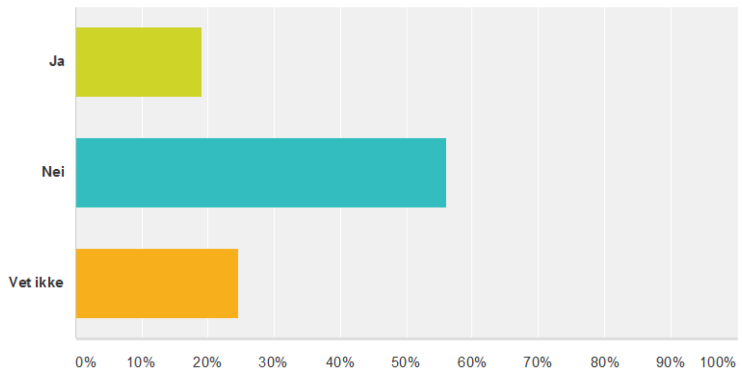
FJERNVARME



Answer Choices	Responses	
Veldig misfornøyd	4.41%	9
Misfornøyd	5.39%	11
Nøytral	26.96%	55
Fornøyd	40.69%	83
Veldig fornøyd	22.55%	46
Total		**204**

Q5 Har du planer om å bytte oppvarmingskilde i ditt hjem i løpet av de neste 4 årene?

Answered: 203 Skipped: 2

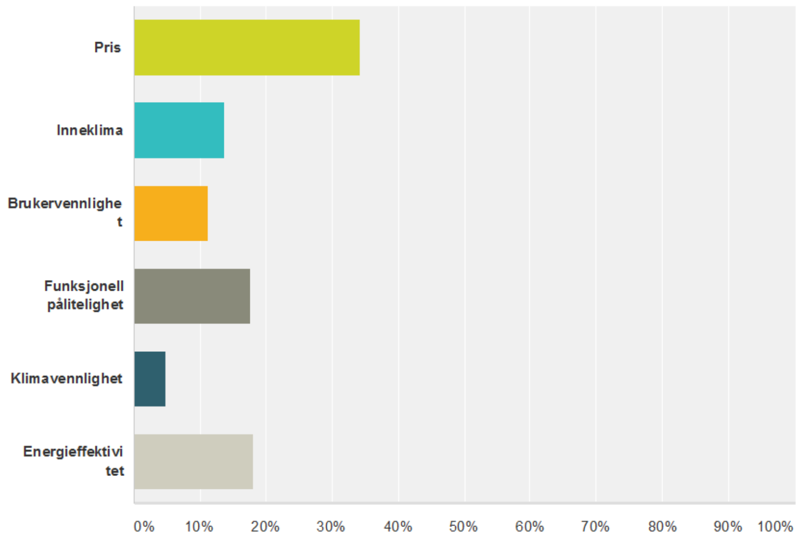


Answer Choices	Responses	
Ja	19.21%	39
Nei	56.16%	114

Vet ikke	24.63%	50
Total		203

Q6 Hva er den viktigste egenskapen ved din boligs oppvarming og varmtvann for deg?

Answered: 204 Skipped: 1

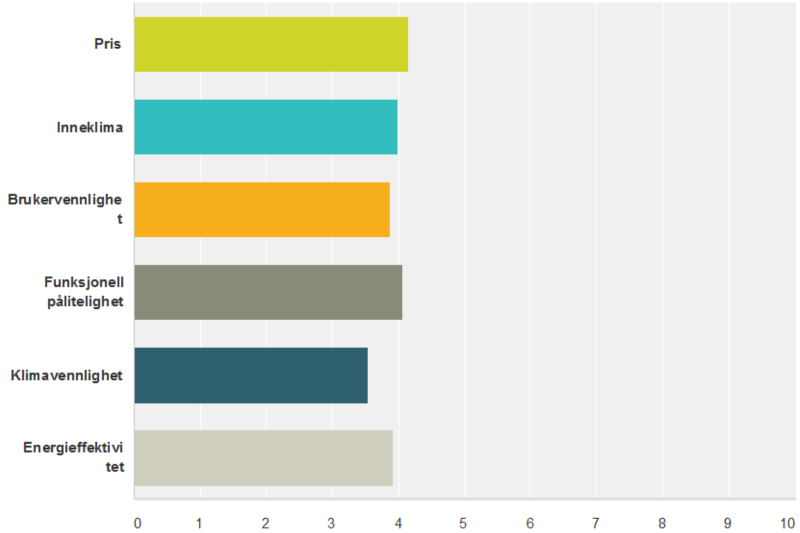


Answer Choices	Responses	
Pris	34.31%	70
Inneklima	13.73%	28
Brukervennlighet	11.27%	23
Funksjonell pålitelighet	17.65%	36
Klimavennlighet	4.90%	10
Energieffektivitet	18.14%	37
Total		204

Q7 Hvor viktig er hver av disse egenskapene ved oppvarming og varmtvann i din bolig for deg?

Answered: 203 Skipped: 2

FJERNVARME

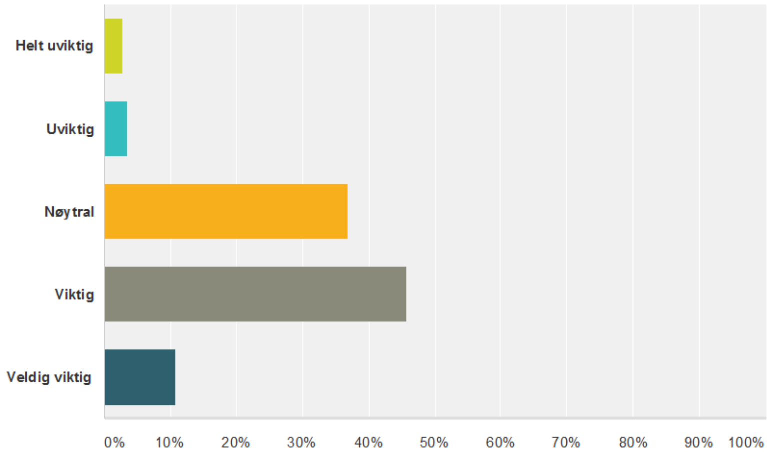


	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig	Total	Weighted Average
Pris	1.01% 2	1.51% 3	12.06% 24	51.26% 102	34.17% 68	199	4.16
Inneklima	1.50% 3	1.50% 3	16.50% 33	58.50% 117	22.00% 44	200	3.98
Brukervennlighet	1.51% 3	2.51% 5	21.11% 42	56.28% 112	18.59% 37	199	3.88
Funksjonell pålitelighet	1.01% 2	0.51% 1	17.68% 35	51.01% 101	29.80% 59	198	4.08
Klimavennlighet	3.50% 7	6.50% 13	32.00% 64	48.50% 97	9.50% 19	200	3.54
Energieffektivitet	1.01% 2	1.51% 3	25.13% 50	48.24% 96	24.12% 48	199	3.93

Q8 Hvor viktig er det for din husholdning å være energieffektive?

Answered: 203 Skipped: 2

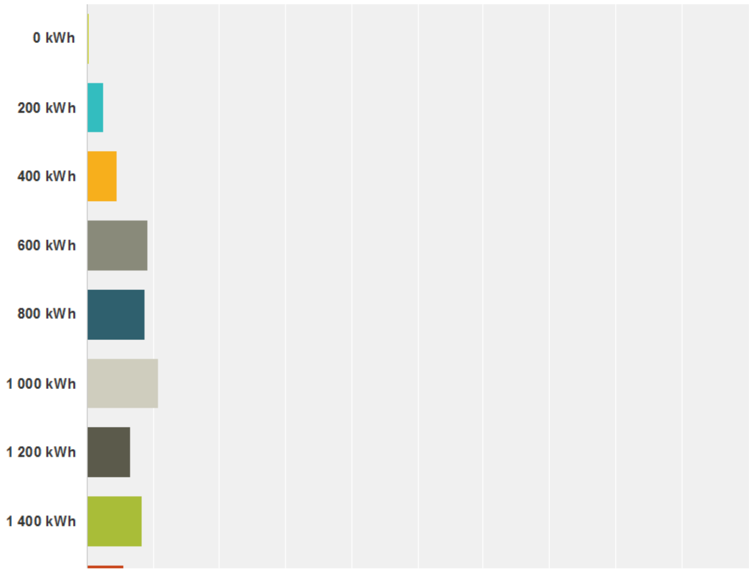
FJERNVARME



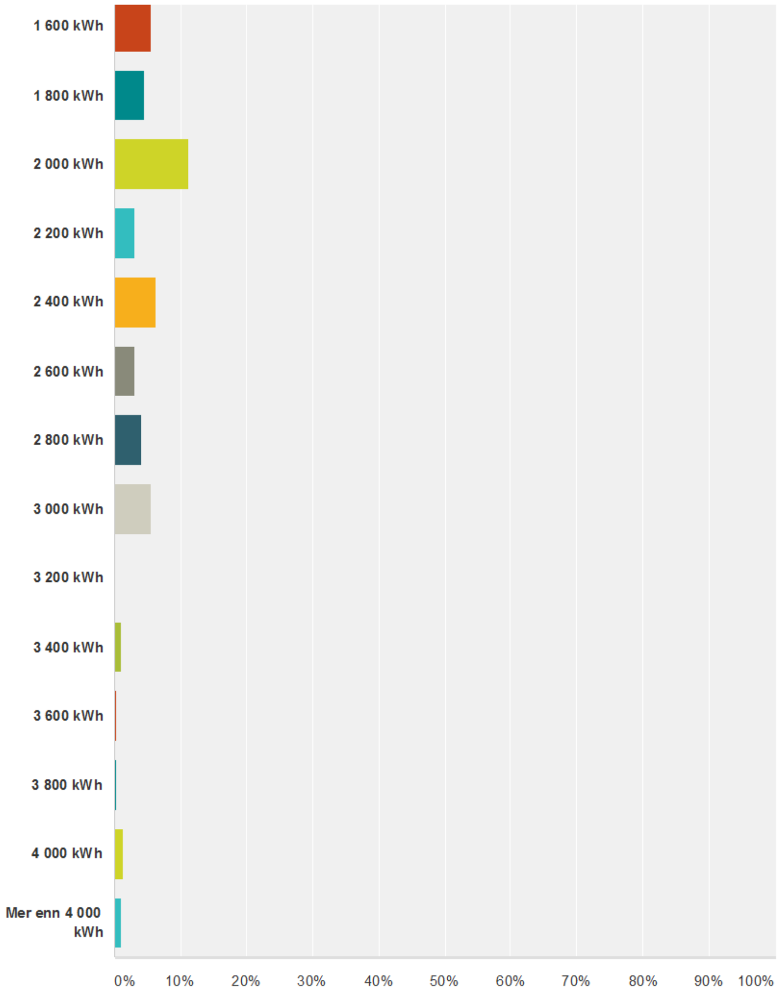
Answer Choices	Responses	
Helt uviktig	2.96%	6
Uviktig	3.45%	7
Nøytral	36.95%	75
Viktig	45.81%	93
Veldig viktig	10.84%	22
Total		**203**

Q9 Vennligst gi ditt beste anslag på din husholdnings gjennomsnittlige månedlige strømforbruk.

Answered: 194 Skipped: 11



FJERNVARME



Answer Choices	Responses	
0 kWh	0.52%	1
200 kWh	2.58%	5
400 kWh	4.64%	9
600 kWh	9.28%	18
800 kWh	8.76%	17
1 000 kWh	10.82%	21
1 200 kWh	6.70%	13
1 400 kWh	8.25%	16
1 600 kWh	5.67%	11
1 800 kWh	4.64%	9
2 000 kWh	11.34%	22

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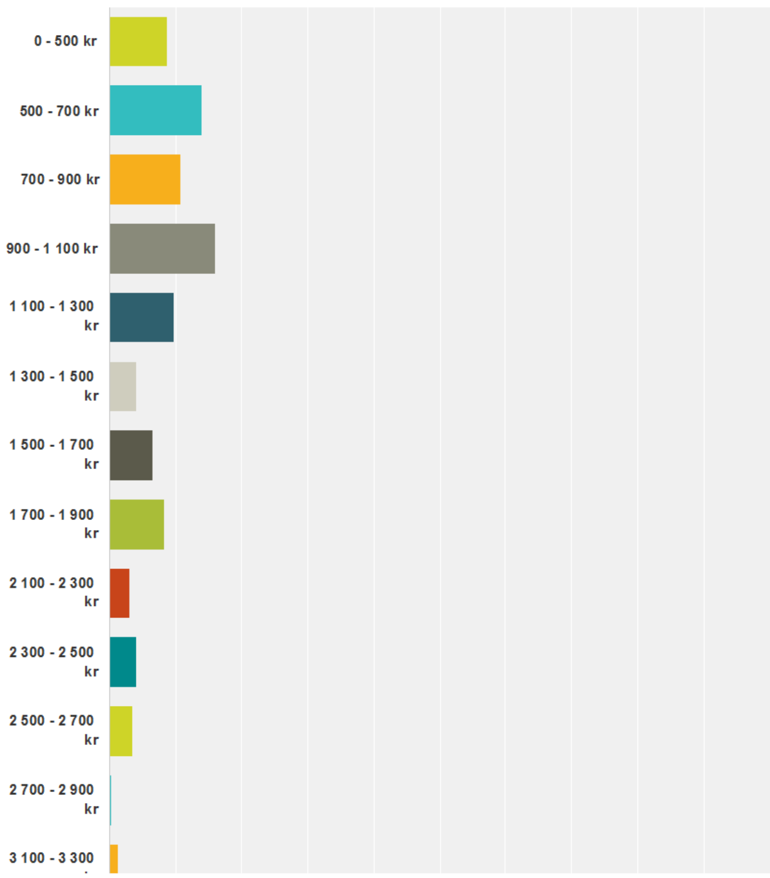
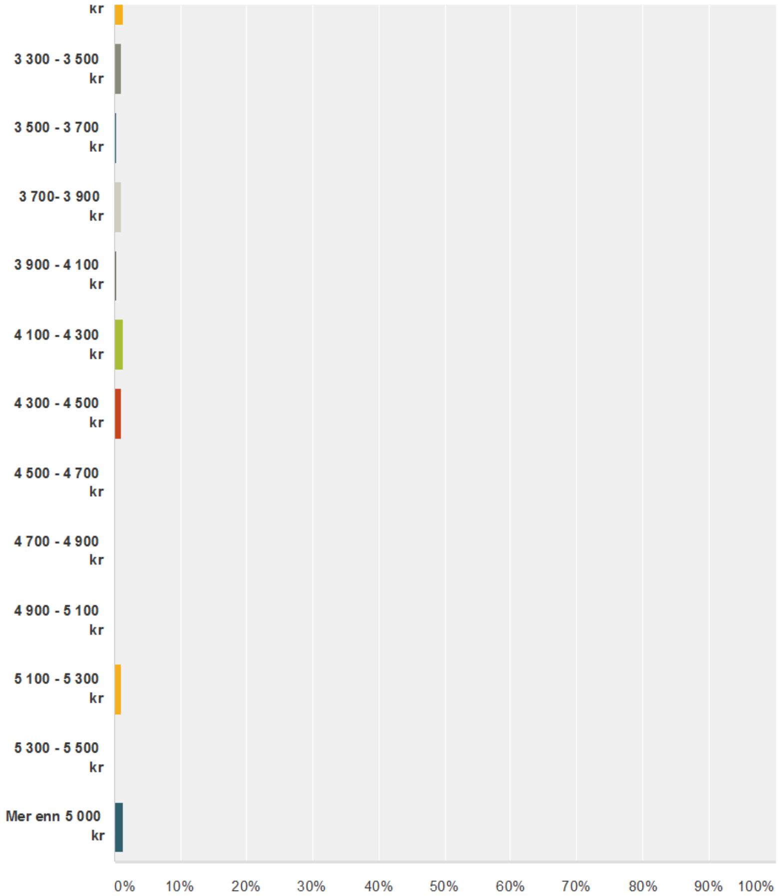
2 200 kWh	3.09%	6
2 400 kWh	6.19%	12
2 600 kWh	3.09%	6
2 800 kWh	4.12%	8
3 000 kWh	5.67%	11
3 200 kWh	0.00%	0
3 400 kWh	1.03%	2
3 600 kWh	0.52%	1
3 800 kWh	0.52%	1
4 000 kWh	1.55%	3
Mer enn 4 000 kWh	1.03%	2
Total		**194**

Q10 Vennligst gi ditt beste anslag på hvor mye din husholdning betaler i gjennomsnitt i strøm per måned.

Answered: 193   Skipped: 12



FJERNVARME

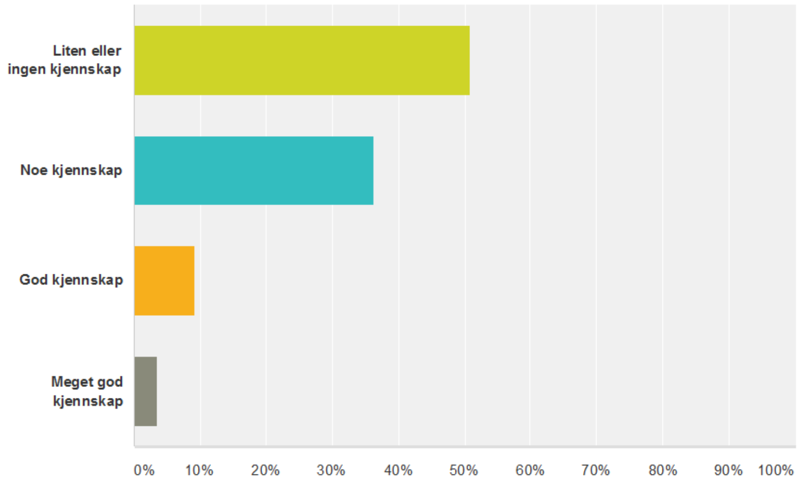


Answer Choices	Responses	
0 - 500 kr	8.81%	17
500 - 700 kr	13.99%	27
700 - 900 kr	10.88%	21
900 - 1 100 kr	16.06%	31
1 100 - 1 300 kr	9.84%	19
1 300 - 1 500 kr	4.15%	8
1 500 - 1 700 kr	6.74%	13
1 700 - 1 900 kr	8.29%	16
2 100 - 2 300 kr	3.11%	6
2 300 - 2 500 kr	4.15%	8
2 500 - 2 700 kr	3.63%	7
2 700 - 2 900 kr	0.52%	1
3 100 - 3 300 kr	1.55%	3

3 300 - 3 500 kr	1.04%	2
3 500 - 3 700 kr	0.52%	1
3 700- 3 900 kr	1.04%	2
3 900 - 4 100 kr	0.52%	1
4 100 - 4 300 kr	1.55%	3
4 300 - 4 500 kr	1.04%	2
4 500 - 4 700 kr	0.00%	0
4 700 - 4 900 kr	0.00%	0
4 900 - 5 100 kr	0.00%	0
5 100 - 5 300 kr	1.04%	2
5 300 - 5 500 kr	0.00%	0
Mer enn 5 000 kr	1.55%	3
Total		**193**

Q11 Hva er din nåværende kjennskap til fjernvarme?

Answered: 196 Skipped: 9



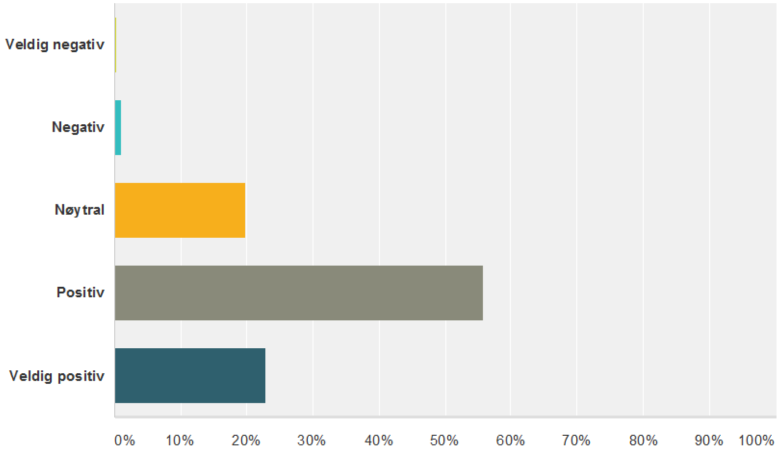
Answer Choices	Responses	
Liten eller ingen kjennskap	51.02%	100
Noe kjennskap	36.22%	71
God kjennskap	9.18%	18
Meget god kjennskap	3.57%	7
Total		**196**

Q12 Basert på overståede informasjon,

FJERNVARME

hvordan stiller du deg til fjernvarme?

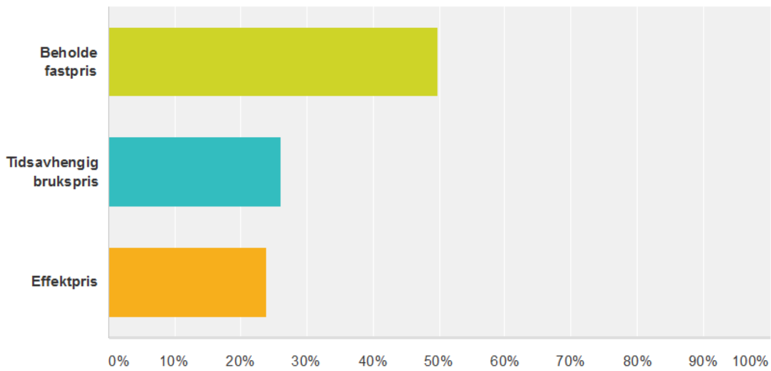
Answered: 192 Skipped: 13



Answer Choices	Responses	
Veldig negativ	0.52%	1
Negativ	1.04%	2
Nøytral	19.79%	38
Positiv	55.73%	107
Veldig positiv	22.92%	44
Total		**192**

Q13 Hvilket prisalternativ foretrekker du?

Answered: 96 Skipped: 109



Answer Choices	Responses	
Beholde fastpris	50.00%	48

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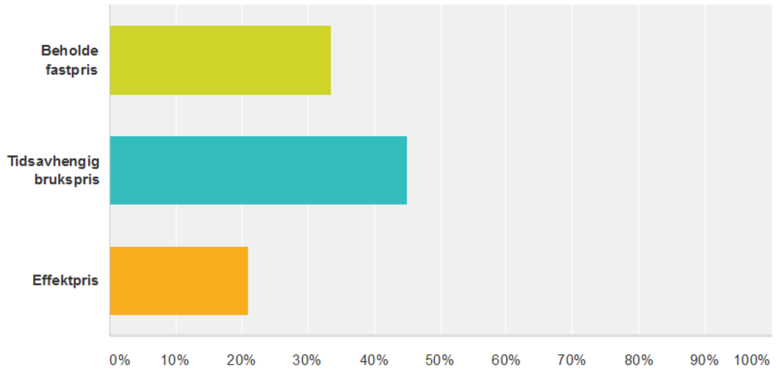
Tidsavhengig brukspris	26.04%	25
Effektpris	23.96%	23
Total		**96**

Q14 Hvilken prisalternativ foretrekker du nå?

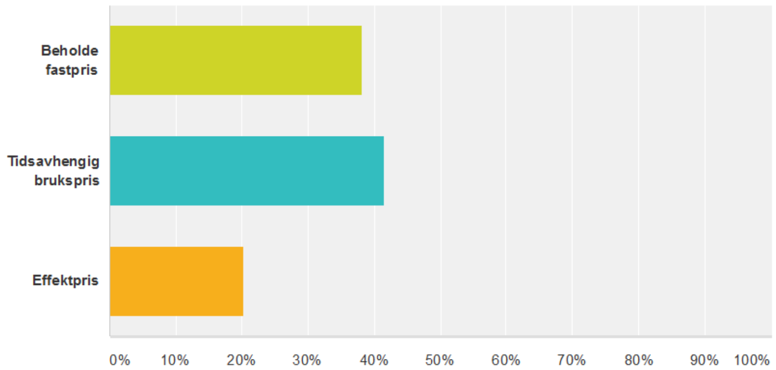
Answered: 104 Skipped: 101



Answer Choices	Responses	
Beholde fastpris	33.65%	35
Tidsavhengig brukspris	45.19%	47
Effektpris	21.15%	22
Total		**104**

Q15 Hvilket prisalternativ foretrekker du?

Answered: 89 Skipped: 116

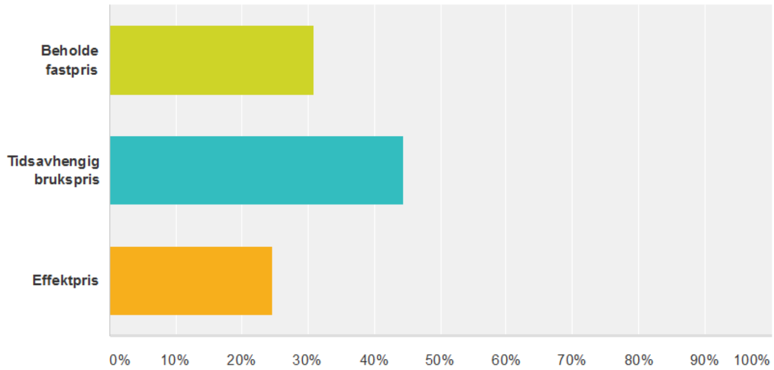


Answer Choices	Responses	
Beholde fastpris	38.20%	34

Tidsavhengig brukspris	41.57%	37
Effektpris	20.22%	18
Total		**89**

Q16 Hvilken prisalternativ foretrekker du nå?

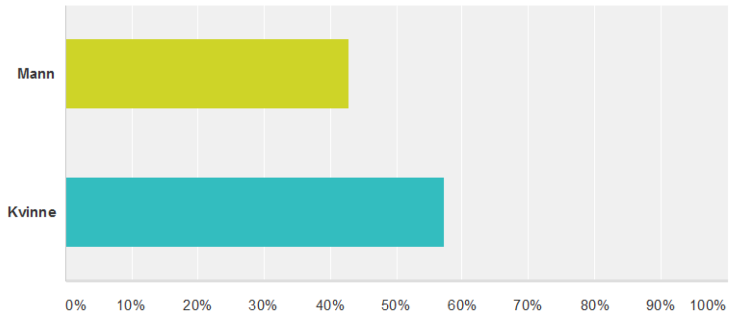
Answered: 81 Skipped: 124



Answer Choices	Responses	
Beholde fastpris	30.86%	25
Tidsavhengig brukspris	44.44%	36
Effektpris	24.69%	20
Total		**81**

Q17 Er du mann eller kvinne?

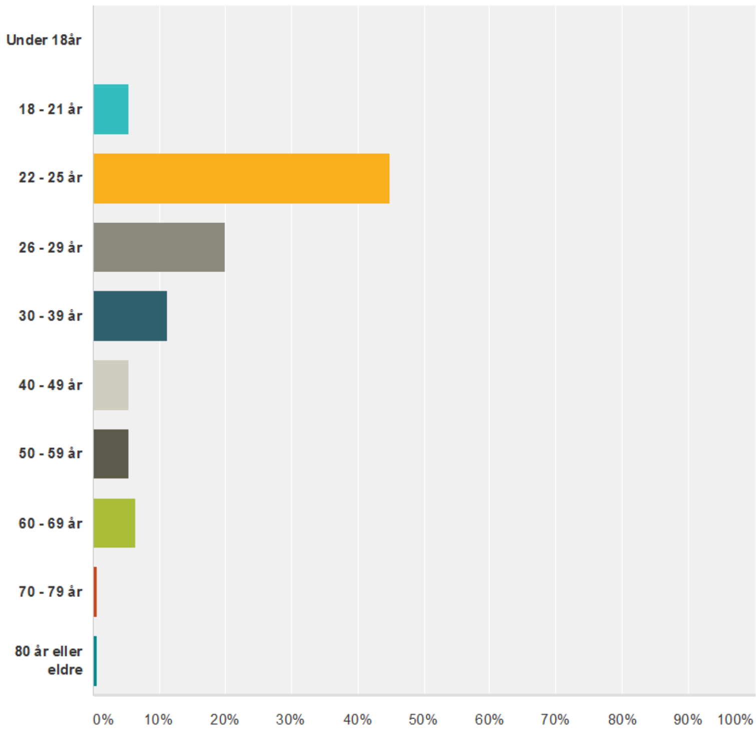
Answered: 185 Skipped: 20



Answer Choices	Responses	
Mann	42.70%	79
Kvinne	57.30%	106
Total		**185**

Q18 Hva er din alder?

Answered: 185 Skipped: 20

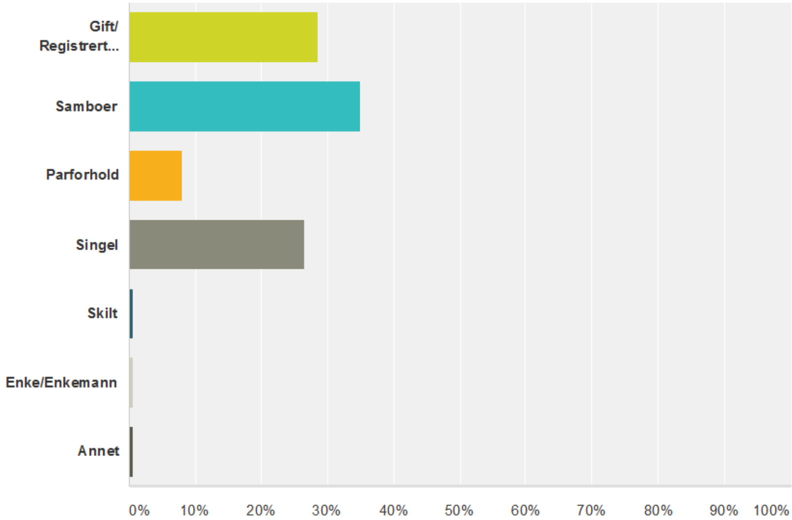


Answer Choices	Responses	
Under 18år	0.00%	0
18 - 21 år	5.41%	10
22 - 25 år	44.86%	83
26 - 29 år	20.00%	37
30 - 39 år	11.35%	21
40 - 49 år	5.41%	10
50 - 59 år	5.41%	10
60 - 69 år	6.49%	12
70 - 79 år	0.54%	1
80 år eller eldre	0.54%	1
Total		185

Q19 Hva er din sivilstatus?

Answered: 185 Skipped: 20

FJERNVARME

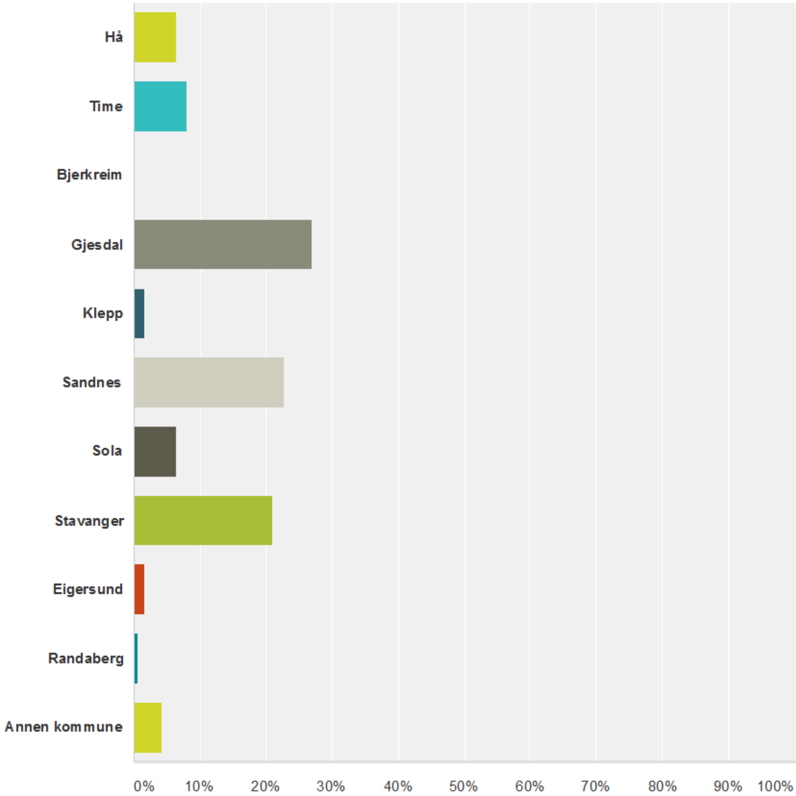


Answer Choices	Responses	
Gift/ Registrert partner	28.65%	53
Samboer	35.14%	65
Parforhold	8.11%	15
Singel	26.49%	49
Skilt	0.54%	1
Enke/Enkemann	0.54%	1
Annet	0.54%	1
Total		185

Q20 I hvilken kommune bor du?

Answered: 185 Skipped: 20

FJERNVARME

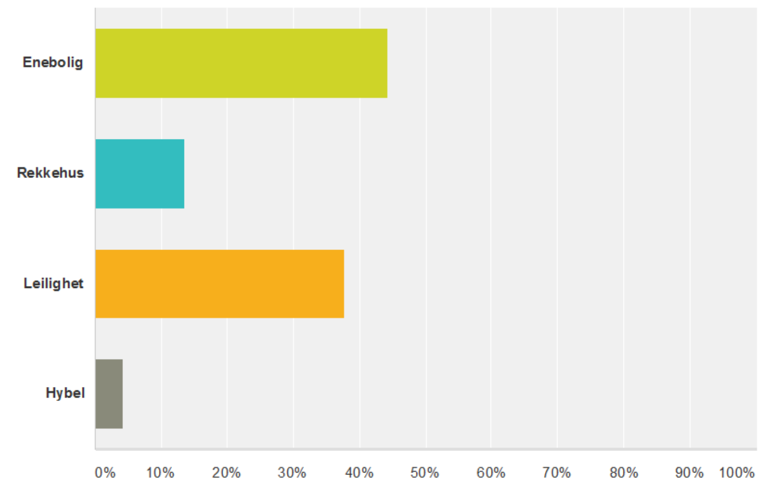


Answer Choices	Responses	
Hå	6.49%	12
Time	8.11%	15
Bjerkreim	0.00%	0
Gjesdal	27.03%	50
Klepp	1.62%	3
Sandnes	22.70%	42
Sola	6.49%	12
Stavanger	21.08%	39
Eigersund	1.62%	3
Randaberg	0.54%	1
Annen kommune	4.32%	8
Total		**185**

Q21 Hva slags bolig bor du i?

Answered: 185 Skipped: 20

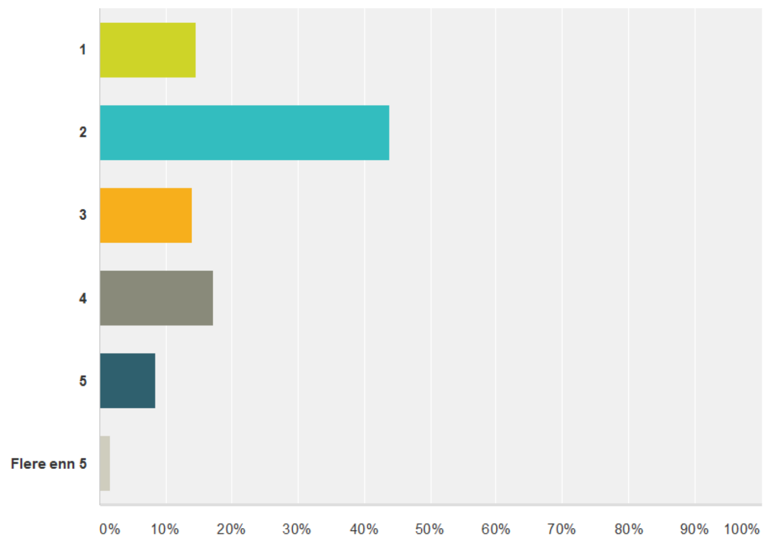
FJERNVARME



Answer Choices	Responses	
Enebolig	**44.32%**	82
Rekkehus	**13.51%**	25
Leilighet	**37.84%**	70
Hybel	**4.32%**	8
Total		**185**

Q22 Inkludert deg selv, hvor mange mennesker (barn og voksne) er det i din husstand?

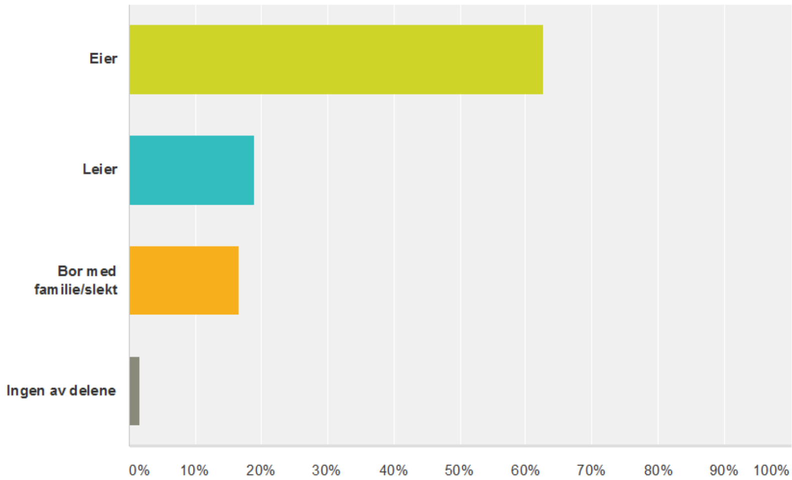
Answered: 185 Skipped: 20



Answer Choices	Responses	
1	14.59%	27
2	43.78%	81
3	14.05%	26
4	17.30%	32
5	8.65%	16
Flere enn 5	1.62%	3
Total		185

Q23 Eier du ditt eget hjem eller leier du?

Answered: 185 Skipped: 20

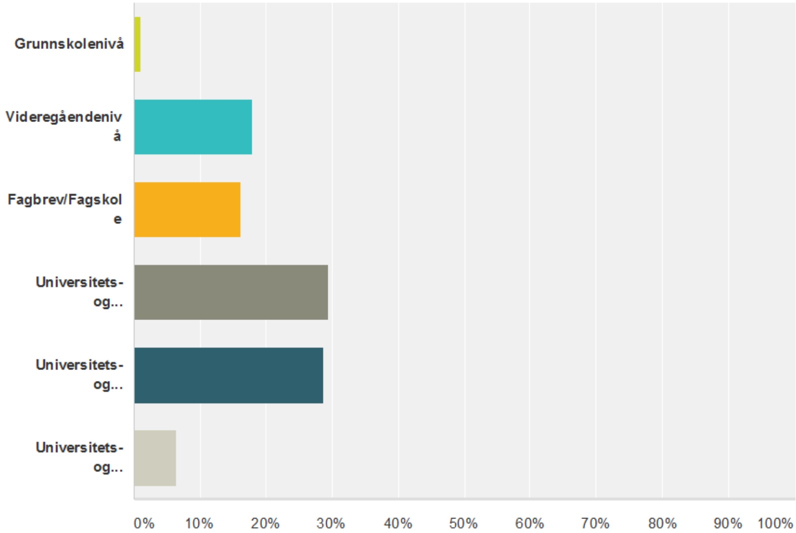


Answer Choices	Responses	
Eier	62.70%	116
Leier	18.92%	35
Bor med familie/slekt	16.76%	31
Ingen av delene	1.62%	3
Total		185

Q24 Hva er ditt høyeste fullførte utdanningsnivå?

Answered: 184 Skipped: 21

FJERNVARME

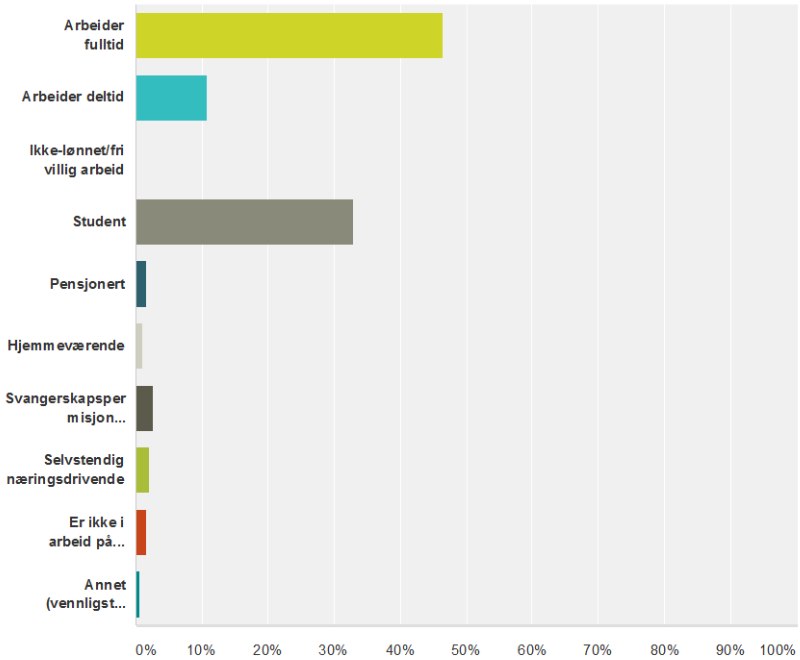


Answer Choices	Responses	
Grunnskolenivå	1.09%	2
Videregåendenivå	17.93%	33
Fagbrev/Fagskole	16.30%	30
Universitets- og høyskolenivå, 1 - 3 år	29.35%	54
Universitets- og høyskolenivå, 3 - 5 år	28.80%	53
Universitets- og høyskolenivå, mer enn 5 år	6.52%	12
Total		184

Q25 Hvilke alternativ beskriver best din nåværende arbeidssituasjon?

Answered: 185 Skipped: 20

FJERNVARME

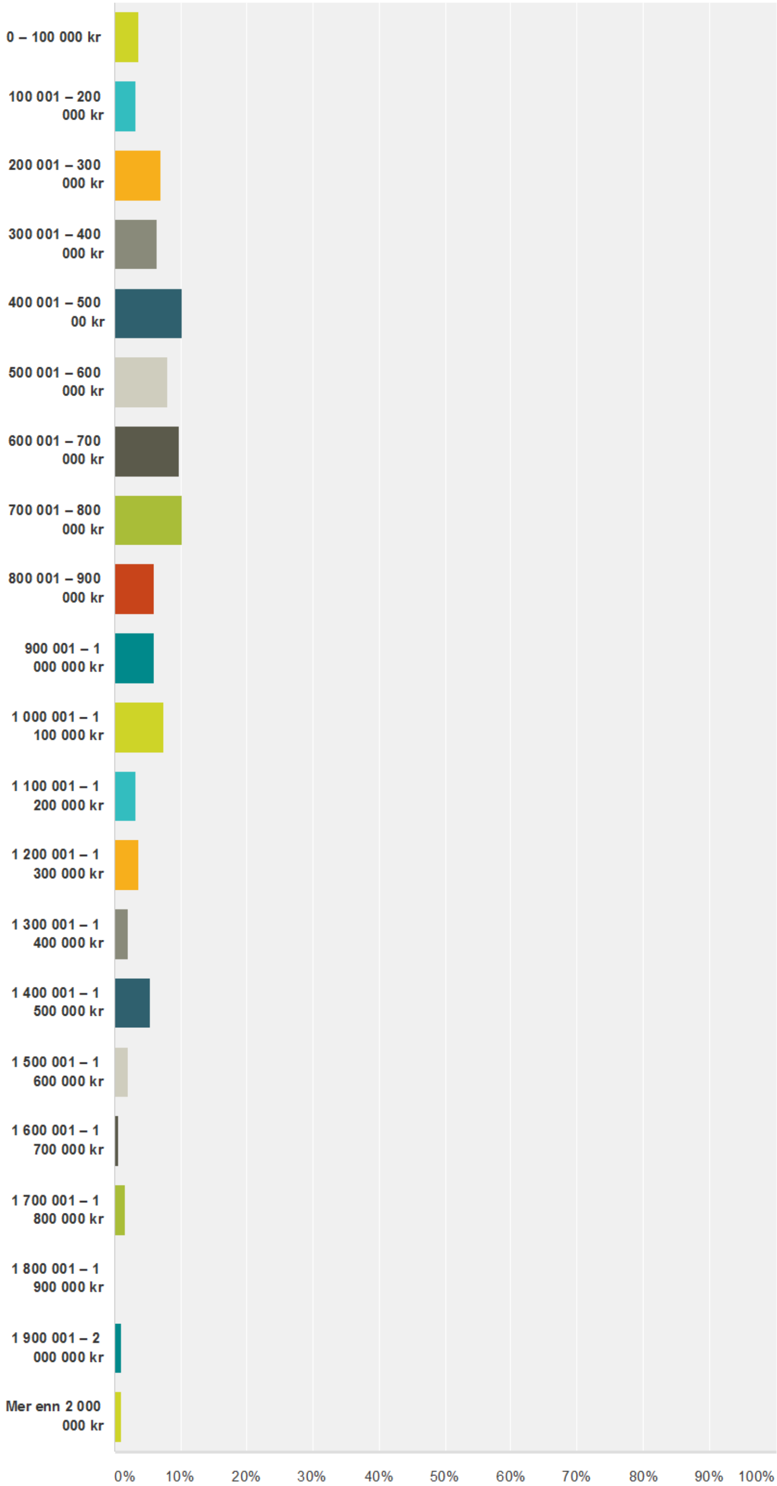


Answer Choices	Responses	
Arbeider fulltid	46.49%	86
Arbeider deltid	10.81%	20
Ikke-lønnet/frivillig arbeid	0.00%	0
Student	32.97%	61
Pensjonert	1.62%	3
Hjemmeværende	1.08%	2
Svangerskapspermisjon (midlertidig permisjon)	2.70%	5
Selvstendig næringsdrivende	2.16%	4
Er ikke i arbeid på nåværende tidspunkt	1.62%	3
Annet (vennligst spesifiser):	0.54%	1
Total		**185**

Q26 Vennligst oppgi omtrentlig årlig brutto inntekt i din husstand. Det vil si all samlet inntekt i husstanden før skatt er trukket fra.

Answered: 184 Skipped: 21

FJERNVARME



0 – 100 000 kr
100 001 – 200 000 kr
200 001 – 300 000 kr
300 001 – 400 000 kr
400 001 – 500 00 kr
500 001 – 600 000 kr
600 001 – 700 000 kr
700 001 – 800 000 kr
800 001 – 900 000 kr
900 001 – 1 000 000 kr
1 000 001 – 1 100 000 kr
1 100 001 – 1 200 000 kr
1 200 001 – 1 300 000 kr
1 300 001 – 1 400 000 kr
1 400 001 – 1 500 000 kr
1 500 001 – 1 600 000 kr
1 600 001 – 1 700 000 kr
1 700 001 – 1 800 000 kr
1 800 001 – 1 900 000 kr
1 900 001 – 2 000 000 kr
Mer enn 2 000 000 kr
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Answer Choices	Responses	
0 – 100 000 kr	3.80%	7
100 001 – 200 000 kr	3.26%	6
200 001 – 300 000 kr	7.07%	13
300 001 – 400 000 kr	6.52%	12
400 001 – 500 00 kr	10.33%	19
500 001 – 600 000 kr	8.15%	15
600 001 – 700 000 kr	9.78%	18
700 001 – 800 000 kr	10.33%	19
800 001 – 900 000 kr	5.98%	11
900 001 – 1 000 000 kr	5.98%	11
1 000 001 – 1 100 000 kr	7.61%	14
1 100 001 – 1 200 000 kr	3.26%	6
1 200 001 – 1 300 000 kr	3.80%	7
1 300 001 – 1 400 000 kr	2.17%	4
1 400 001 – 1 500 000 kr	5.43%	10
1 500 001 – 1 600 000 kr	2.17%	4
1 600 001 – 1 700 000 kr	0.54%	1
1 700 001 – 1 800 000 kr	1.63%	3
1 800 001 – 1 900 000 kr	0.00%	0
1 900 001 – 2 000 000 kr	1.09%	2
Mer enn 2 000 000 kr	1.09%	2
Total		184

Q27 Har du andre kommentarer til denne undersøkelsen som du ønsker å dele med oss?

Answered: 12 Skipped: 193

Q28 Ønsker du å delta i trekningen av et VISA gavekort pålydende 1 000 kroner?

Answered: 148 Skipped: 57

Answer Choices	Responses	
Mobiltelefon	98.65%	146
E-post	91.89%	136

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APPENDIX C: FIRM SURVEY

FJERNVARME BEDRIFT

Om denne undersøkelsen

Din mening er viktig!

Takk for at du hjelper med denne undersøkelsen som er en del av ressursøkonomisk forskning ved Universitetet i Stavanger. Svarene du gir vil hjelpe oss med å få bedre innsikt i bedrifters preferanser og betalingsvillighet for energieffektive oppvarmingsløsninger. Fokuset er spesielt på bruk av fjernvarme.

Det tar ca. 10-15 minutter å fylle ut hele skjemaet. Du som deltar i denne undersøkelsen vil være helt anonym. Vi er bare interessert i sammenfatninger av svarene over alle deltakerne. Vi gir ikke individuell informasjon til tredjeparter til noe som helst formål.

Skulle du ha problemer med å fylle ut skjemaet eller ha spørsmål angående undersøkelsen kan du kontakte oss på e-post eller telefon.

Gorm Kipperberg
Førsteamanuensis og prosjektleder
Handelshøgskolen ved UiS
Universitetet i Stavanger
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Mobiltelefon: (+47) 97 04 30 91

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FJERNVARME BEDRIFT

Introduksjonsspørsmål

1. Hva er din stilling i bedriften?

- ◯ Medarbeider
- ◯ Leder
- ◯ Øverste leder i bedriften

FJERNVARME BEDRIFT

Introduksjonsspørsmål

2. Hvilken del av bedriften jobber du i?

- ◯ Salg/Markedsføring
- ◯ Ledelse
- ◯ Stab (Økonomi/IT/Infrastruktur)
- ◯ Produksjon
- ◯ Innkjøp
- ◯ Annet

FJERNVARME BEDRIFT

Introduksjonsspørsmål

3. Hvilken bransje opererer bedriften i?

- ◯ Industri/Produksjon
- ◯ Kraft- og vannforsyning
- ◯ Bygge- og anleggsvirksomhet
- ◯ Hotell- og restaurantvirksomhet
- ◯ Transport/Logistikk/Lager
- ◯ Finansiell tjenesteyting og forsikring
- ◯ Olje/Gass/On- og offshore/Maritim
- ◯ Utdanning/Forskning/Utvikling
- ◯ Næringsmiddelindustri/Matproduksjon
- ◯ Annet (vennligst spesifiser):

4

FJERNVARME BEDRIFT

Introduksjonsspørsmål

4. Hvor mye omsetter bedriften for per år, sånn omtrent?

- Under 1 million NOK
- 1 - 5 millioner NOK
- 6 - 20 millioner NOK
- 21 - 50 millioner NOK
- 51 - 100 millioner NOK
- 101 - 200 millioner NOK
- 201 - 1000 millioner NOK
- Mer enn 1000 millioner NOK

FJERNVARME BEDRIFT

Introduksjonsspørsmål

5. Hvor mange ansatte har bedriften?
(Antall ansatte, uavhengig av stillingsprosent)

- 1- 10
- 11 - 30
- 31 - 50
- 51 - 100
- 101 eller flere

FJERNVARME BEDRIFT

Introduksjonsspørsmål

6. I hvilken kommune er bedriften lokalisert?

- ◯ Hå
- ◯ Time
- ◯ Bjerkreim
- ◯ Gjesdal
- ◯ Klepp
- ◯ Sandnes
- ◯ Sola
- ◯ Stavanger
- ◯ Eigersund
- ◯ Randaberg
- ◯ Annen kommune

FJERNVARME BEDRIFT

Energibruk

7. Hvilke oppvarmingskilder bruker din bedrift?
(Kryss av de alternativene som er relevant for din bedrift)

- ☐ Ved
- ☐ Elektrisitet
- ☐ Varmepumpe
- ☐ Vannbåren varme
- ☐ Olje
- ☐ Solcelle
- ☐ Fjernvarme
- ☐ Annet

8

FJERNVARME BEDRIFT

Energibruk

8. Hva er den VIKTIGSTE oppvarmingskilden i din bedrift?

- ◯ Ved
- ◯ Elektrisitet
- ◯ Varmepumpe
- ◯ Vannbåren varme
- ◯ Olje
- ◯ Solcelle
- ◯ Fjernvarme
- ◯ Annet

FJERNVARME BEDRIFT

Energibruk

9. Sånn omtrent, hvilket av de følgende alternativene ligger nærmest din bedrifts gjennomsnittelige månedlige strømforbruk?

- 0 kWh
- 500 kWh
- 1 000 kWh
- 1 500 kWh
- 2 000 kWh
- 2 500 kWh
- 3 000 kWh
- 3 500 kWh
- 4 000 kWh
- 4 500 kWh
- 5 000 kWh
- 5 500 kWh
- 6 000 kWh
- 6 500 kWh
- 7 000 kWh
- 7 500 kWh
- 8 000 kWh
- 8 500 kWh
- 9 000 kWh
- 9 500 kWh
- 10 000 kWh
- Mer enn 10 000 kWh
- Vet ikke

FJERNVARME BEDRIFT

Energibruk

10. Sånn omtrent, hvor mye betaler din bedrift i strøm per måned?

- ◯ 0 - 1 000 kr
- ◯ 1 000 - 2 000 kr
- ◯ 2 000 - 3 000 kr
- ◯ 3 000 - 4 000 kr
- ◯ 4 000 - 5 000 kr
- ◯ 5 000 - 6 000 kr
- ◯ 6 000 - 7 000 kr
- ◯ 7 000 - 8 000 kr
- ◯ 8 000 - 9 000 kr
- ◯ 9 000 - 10 000 kr
- ◯ 10 000 - 11 000 kr
- ◯ 11 000 - 12 000 kr
- ◯ 12 000 - 13 000 kr
- ◯ 13 000 - 14 000 kr
- ◯ 14 000 - 15 000 kr
- ◯ 15 000 - 16 000 kr
- ◯ 16 000 - 17 000 kr
- ◯ 17 000 - 18 000 kr
- ◯ 18 000 - 19 000 kr
- ◯ 19 000 - 20 000 kr
- ◯ Mer enn 20 000 kr
- ◯ Vet ikke

FJERNVARME BEDRIFT

Klima og miljø

11. Har din bedrift vedtatt en plan eller stategi for reduksjon i utslipp av klimagasser?

- ◯ Ja
- ◯ Nei, men er under utarbeidelse
- ◯ Nei
- ◯ Vet ikke

FJERNVARME BEDRIFT

Klima og miljø

12. Inneholder planen/strategien noen av følgende tiltak?
(Kryss av de alternativene som er relevante for din bedrift)

- ☐ Energieffektivisering
- ☐ Kjøpe klimakvoter
- ☐ Konvertering til miljøvennlig brensel
- ☐ Velge transportmåter med lave utslipp
- ☐ Konvertering til miljøvennlig oppvarming
- ☐ Andre tiltak
- ☐ Vet ikke

FJERNVARME BEDRIFT

Klima og miljø

13. Hvor viktig er klimautfordringen når din bedrift drøfter foretningsstrategi for de kommende årene?

- ◯ Ikke viktig
- ◯ Litt viktig
- ◯ Nokså viktig
- ◯ Veldig viktig
- ◯ Vet ikke

FJERNVARME BEDRIFT

Klima og miljø

14. Hvor viktig er følgende drivkrefter for hvorvidt din bedrift vil investere i miljøvennlige tiltak?

	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig
Offentlige krav	◯	◯	◯	◯	◯
Bedret økonomisk lønnsomhet	◯	◯	◯	◯	◯
Godt omdømme hos kundene	◯	◯	◯	◯	◯
Godt omdømme blant ansatte og arbeidssøkere	◯	◯	◯	◯	◯
Godt omdømme i lokalsamfunnet der bedriften er lokalisert	◯	◯	◯	◯	◯
God bedømming blant investorer	◯	◯	◯	◯	◯
Konkurransefortrinn ved å ha en miljøvennlig bedriftsprofil	◯	◯	◯	◯	◯

FJERNVARME BEDRIFT

Energieffektivitet

15. Hvor viktig er energieffektivisering når din bedrift drøfter foretningsstrategi for de kommende årene?

- Ikke viktig
- Litt viktig
- Nokså viktig
- Veldig viktig
- Vet ikke

FJERNVARME BEDRIFT

Energieffektivitet

16. Har din bedrift vedtatt en plan eller stategi for energieffektivitet?

- ◯ Ja
- ◯ Nei, men er under utarbeidelse
- ◯ Nei
- ◯ Vet ikke

FJERNVARME BEDRIFT

Energieffektivitet

17. Hvor viktig er følgende drivkrefter for hvorvidt din bedrift vil forbedre energieffektivitet?

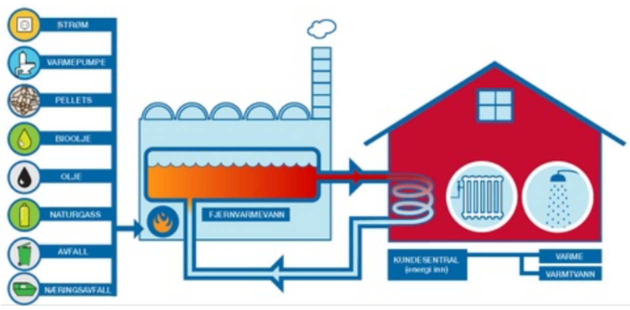
	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig
Reduserte energikostnader	○	○	○	○	○
Miljøhensyn	○	○	○	○	○
Forsyningssikkerhet	○	○	○	○	○
Bidra til å redusere samfunnets energiknapphet	○	○	○	○	○

FJERNVARME BEDRIFT

Fjernvarme informasjon

VENNLIGST LES FØLGENDE INFORMASJON

Et fjernvarmeanlegg er et sentralt anlegg som brukes til å varme opp vann til varmt tappevann og oppvarming av bygninger. Fra fjernvarmeanlegget distribueres vannet til næringsbygg, offentlige bygg og boliger gjennom nedgravde isolerte rør. Hos kunden er det installert en kundesentral med varmevekslere hvor energien overføres fra fjernvarmevannet til kundens varme- og tappevannsanlegg. Herfra transporteres det varme vannet videre i bygningen. Slik som for elektrisk oppvarming styrer kunden varmen med termostater og forbruket registreres med energimålere. Bildet nedenfor illustrerer denne prosessen.



Fjernvarmeanlegg benytter ulike energikilder som gjenvunnet varme, bioenergi, olje, gass og elektrisitet. I Rogaland benyttes hovedsakelig gjenvunnet varme fra industriproduksjon, avfallsforbrenning og annen restvarme som ellers ville gått til spille. Å ta vare på og gjenvinne denne varmen, som ellers ville bli sluppet ut i omgivelsene, er fjernvarmens hovedtanke. Å gjenvinne varme på denne måten er samtidig klimavennlig og energieffektivt.

18. Basert på overstående informasjon, hvordan stiller du deg til fjernvarme?

- ◯ Veldig negativ
- ◯ Negativ
- ◯ Nøytral
- ◯ Positiv
- ◯ Veldig positiv

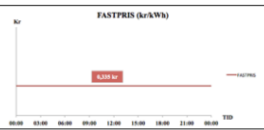
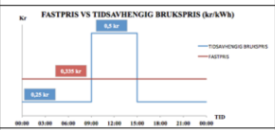
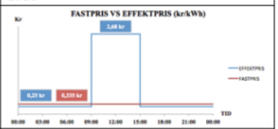
FJERNVARME BEDRIFT

Informasjon om prisalternativ

Nedenfor er det presentert tre prisalternativ for varme: *Fastpris, Tidsavhengig Brukspris* og *Effektpris*.

Ved *fastpris* betales en fastsatt pris per kWh varme brukt per måned. Ved *tidsavhengig brukspris* betales det en høyere pris for noen timer av dagen og lavere pris resten av dagen. *Effektpris* går ut på at det betales en høyere pris noen timer av dagen kun noen utvalgte dager i året. Resten av timene og dagene betales det en lavere pris.

Anta at din bedrift nå bruker det første alternativet *Fastpris*. De andre to alternativene tilbyr bedriften å spare på varmekostnadene ved å redusere varmebruk i perioder med høy varmepris. Vennligst les gjennom informasjonen nøye og svar på vegne av din bedrift på hvilket alternativ som er fortrukket.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (09:00 - 15:00) i løpet av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastpris.	*Prisen er 8 ganger høyere enn fastpris 10 dager i året i 6 timer (fra 09:00 til 15:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i løpet av året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (09:00-15:00):** *Justere ned termostat 1°C på vinteren *Reduser bruk av varmtvann	**Endringer ved høypristider på dagen (09:00-15:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Reduser bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	15%	2%

19. Hvilket prisalternativ foretrekkes?

◯ Beholde fastprisalternativet

◯ Tidsavhengig brukspris

◯ Effektpris

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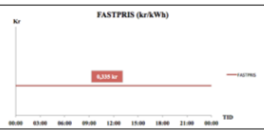
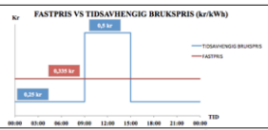
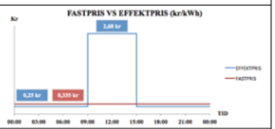
FJERNVARME BEDRIFT

Informasjon om prisalternativ

Nedenfor er den samme tabellen som på forrige side, med unntak av nederste rad *potensiell sparing ved gjennomføring av nødvendig endring*.

Sparing ved tidsavhengig brukspris er nå økt fra 15% til 20% og fra 2% til 10% ved effektpris.

Vennligst ta stilling til endringen og velg hvilket prisalternativ som foretrekkes

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (09:00 - 15:00) i løpet av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastpris.	*Prisen er 8 ganger høyere enn fastpris 10 dager i året i 6 timer (fra 09:00 til 15:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i løpet av året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (09:00-15:00):** *Justere ned termostat 1°C på vinteren *Reduser bruk av varmtvann	**Endringer ved høypristider på dagen (09:00-15:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Reduser bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	20%	10%

20. Hvilket prisalternativ foretrekkes nå?

- ◯ Beholde fastprisalternativet
- ◯ Tidsavhengig brukspris
- ◯ Effektpris

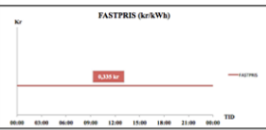
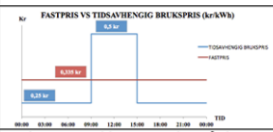
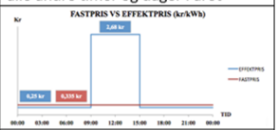
FJERNVARME BEDRIFT

Informasjon om prisalternativ

Nedenfor er det presentert tre prisalternativ for varme: *Fastpris*, *Tidsavhengig Brukspris* og *Effektpris*.

Ved *fastpris* betales en fastsatt pris per kWh varme brukt per måned. Ved *tidsavhengig brukspris* betales det en høyere pris for noen timer av dagen og lavere pris resten av dagen. *Effektpris* går ut på at det betales en høyere pris noen timer av dagen kun noen utvalgte dager i året. Resten av timene og dagene betales det en lavere pris.

Anta at din bedrift nå bruker det første alternativet *Fastpris*. De andre to alternativene tilbyr bedriften å spare på varmekostnadene ved å redusere varmebruk i perioder med høy varmepris. Vennligst les gjennom informasjonen nøye og svar på vegne av din bedrift på hvilket alternativ som er fortrukket.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (09:00 - 15:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastpris.	*Prisen er 8 ganger høyere enn fastpris 10 dager i året i 6 timer (fra 09:00 til 15:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (09:00-15:00):** *Justere ned termostat 1°C på vinteren *Redusere bruk av varmtvann	**Endringer ved høypristider på dagen (09:00-15:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Redusere bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	10%	5%
Miljø- og systemfordeler	*Ingen	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris

21. Hvilket alternativ foretrekkes?

- ◯ Beholde fastprisalternativet
- ◯ Tidsavhengig brukspris
- ◯ Effektpris

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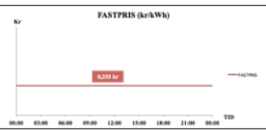
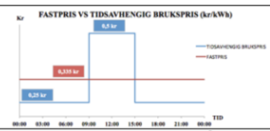
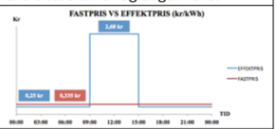
FJERNVARME BEDRIFT

Informasjon om prisalternativ

Nedenfor er den samme tabellen som på forrige side, med unntak av raden *potensiell sparing ved gjennomføring av nødvendig endring.*

Sparing ved tidsavhengig brukspris er nå økt fra 15% til 20% og 2% til 10% ved effektpris.

Vennligst ta stilling til endringen og velg hvilket prisalternativ som er foretrukket.

Prisalternativ:	**Fastpris**	**Tidsavhengig Brukspris**	**Effektpris**
Beskrivelse	*Fast pris per kWh brukt i løp av en måned. Prisen forblir den samme hele dagen og alle dager i året.	*Prisen er 50% høyere enn fastpris for 6 timer (09:00 - 15:00) av dagen på ukedager. *Den resterende tiden vil prisen være 25% lavere enn fastpris.	*Prisen er 8 ganger høyere enn fastpris 10 dager i året i 6 timer (fra 09:00 til 15:00). Det vil bli varslet hvilke dager dette gjelder. *Prisen er 25% lavere enn fastpris alle andre timer og dager i året
Grafisk			
Nødvendig endring	*Ingen	**Endringer ved høypristider på dagen (09:00-15:00):** *Justere ned termostat 1°C på vinteren *Redusere bruk av varmtvann	**Endringer ved høypristider på dagen (09:00-15:00) kun 10 dager i året:** *Justere ned termostat 2,5°C på vinteren *Redusere bruk av varmtvann
Potensiell økning i pris uten gjennomføring av nødvendig endring	0%	0% til 5%	0% til 5%
Potensiell sparing ved gjennomføring av nødvendig endring	0%	20%	10%
Miljø- og systemfordeler	*Ingen	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris	*Lavere vann- og luftforurensing *Bidrar til økt bruk av fornybare ressurser *Økt energieffektivitet *Økt funksjonssikkerhet *Redusert økning i strømpris

22. Hvilket prisalternativ foretrekkes nå?

- ◯ Beholde fastprisalternativet
- ◯ Tidsavhengig brukspris
- ◯ Effektpris

FJERNVARME BEDRIFT

Takk for at du deltok i denne undersøkelsen!

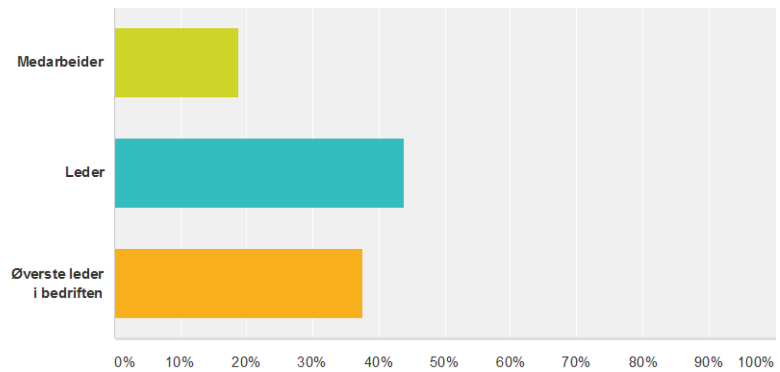
23. Har du andre kommentarer til denne undersøkelsen som du ønsker å dele med oss?

APPENDIX D: FIRM SURVEY RESULTS

FJERNVARME BEDRIFT

Q1 Hva er din stilling i bedriften?

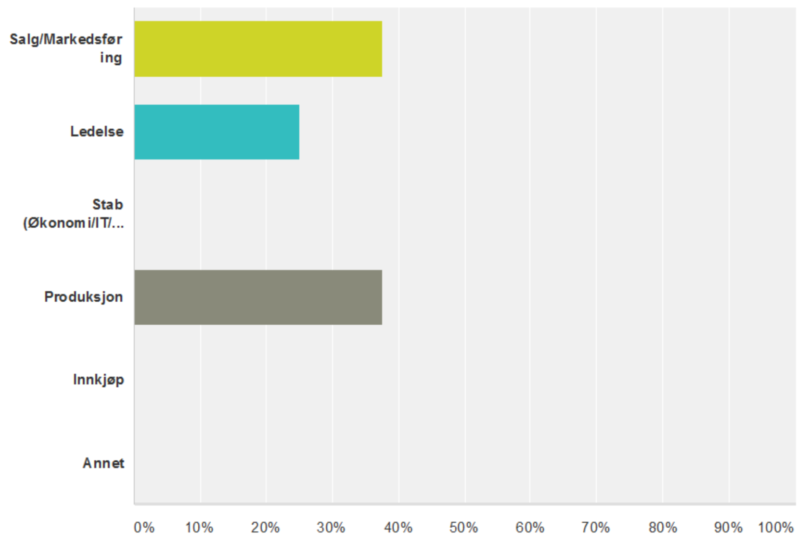
Answered: 16 Skipped: 0



Answer Choices	Responses	
Medarbeider	18.75%	3
Leder	43.75%	7
Øverste leder i bedriften	37.50%	6
Total		16

Q2 Hvilken del av bedriften jobber du i?

Answered: 16 Skipped: 0



Answer Choices	Responses	
Salg/Markedsføring	37.50%	6

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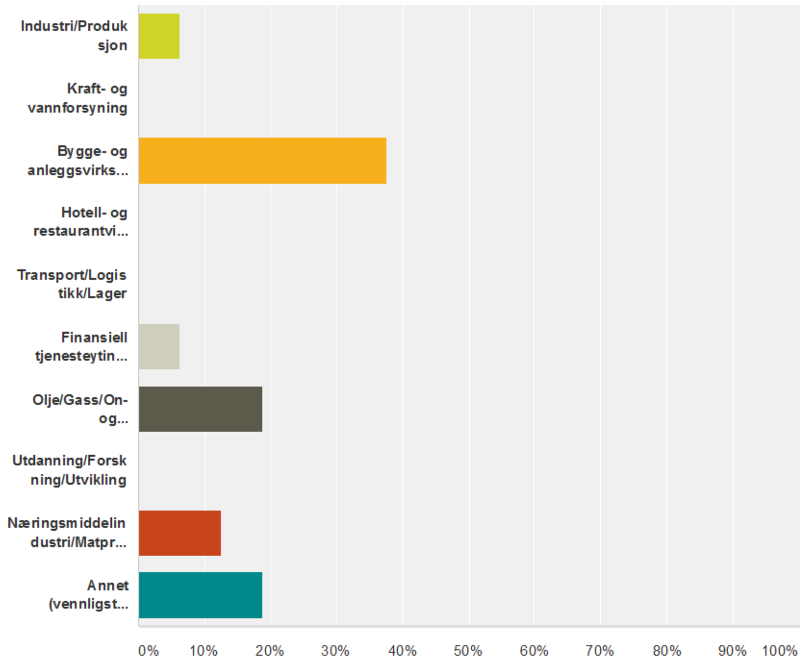
Ledelse	25.00%	4
Stab (Økonomi/IT/Infrastruktur)	0.00%	0
Produksjon	37.50%	6
Innkjøp	0.00%	0
Annet	0.00%	0
Total		**16**

Q3 Hvilken bransje opererer bedriften i?

Answered: 16 Skipped: 0

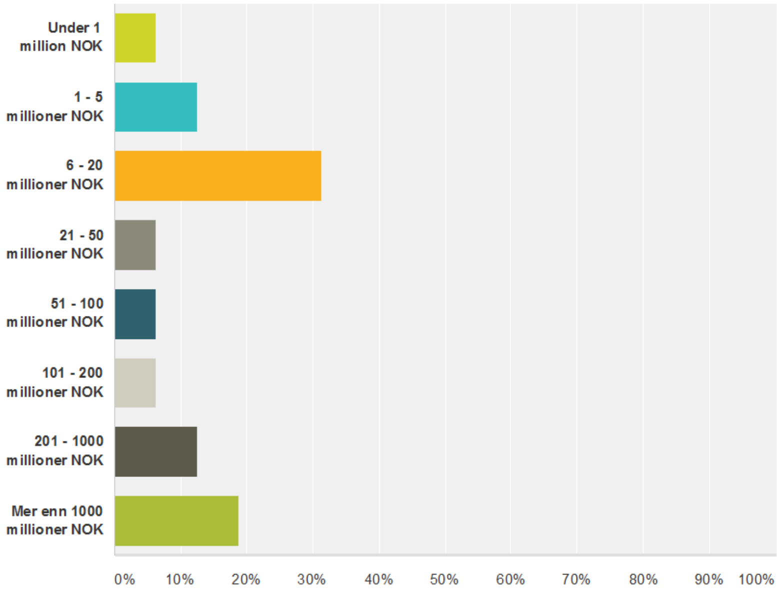


Answer Choices	Responses	
Industri/Produksjon	6.25%	1
Kraft- og vannforsyning	0.00%	0
Bygge- og anleggsvirksomhet	37.50%	6
Hotell- og restaurantvirksomhet	0.00%	0
Transport/Logistikk/Lager	0.00%	0
Finansiell tjenesteyting og forsikring	6.25%	1
Olje/Gass/On- og offshore/Maritim	18.75%	3
Utdanning/Forskning/Utvikling	0.00%	0
Næringsmiddelindustri/Matproduksjon	12.50%	2
Annet (vennligst spesifiser):	18.75%	3

Total	16

Q4 Hvor mye omsetter bedriften for per år, sånn omtrent?

Answered: 16 Skipped: 0

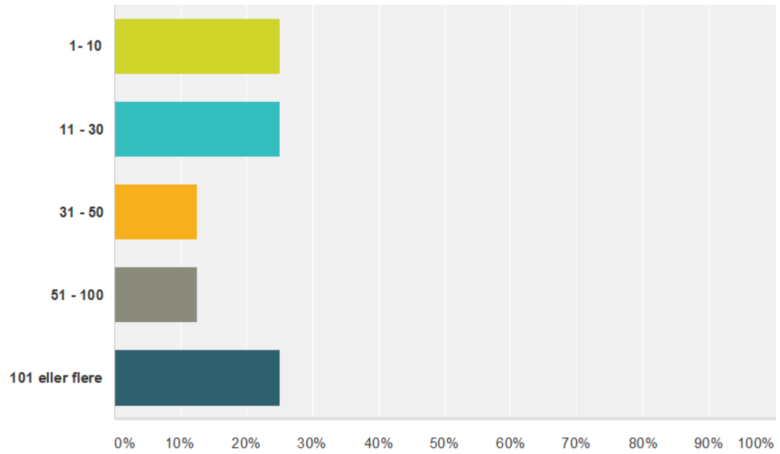


Answer Choices	Responses	
Under 1 million NOK	6.25%	1
1 - 5 millioner NOK	12.50%	2
6 - 20 millioner NOK	31.25%	5
21 - 50 millioner NOK	6.25%	1
51 - 100 millioner NOK	6.25%	1
101 - 200 millioner NOK	6.25%	1
201 - 1000 millioner NOK	12.50%	2
Mer enn 1000 millioner NOK	18.75%	3
Total		16

Q5 Hvor mange ansatte har bedriften? (Antall ansatte, uavhengig av stillingsprosent)

Answered: 16 Skipped: 0

FJERNVARME BEDRIFT

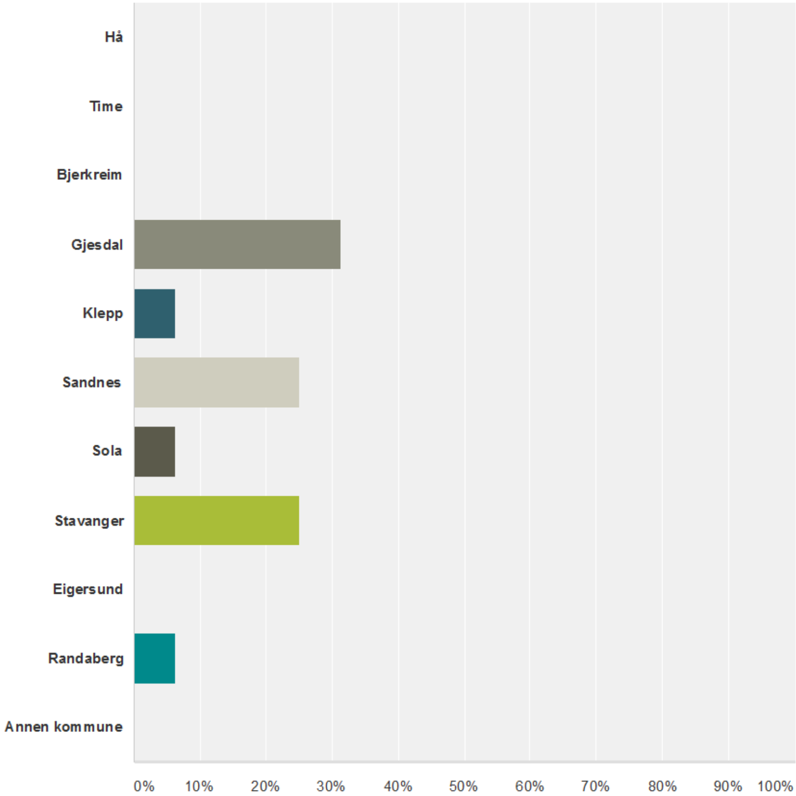


Answer Choices	Responses	
1 - 10	25.00%	4
11 - 30	25.00%	4
31 - 50	12.50%	2
51 - 100	12.50%	2
101 eller flere	25.00%	4
Total		16

Q6 I hvilken kommune er bedriften lokalisert?

Answered: 16 Skipped: 0

FJERNVARME BEDRIFT

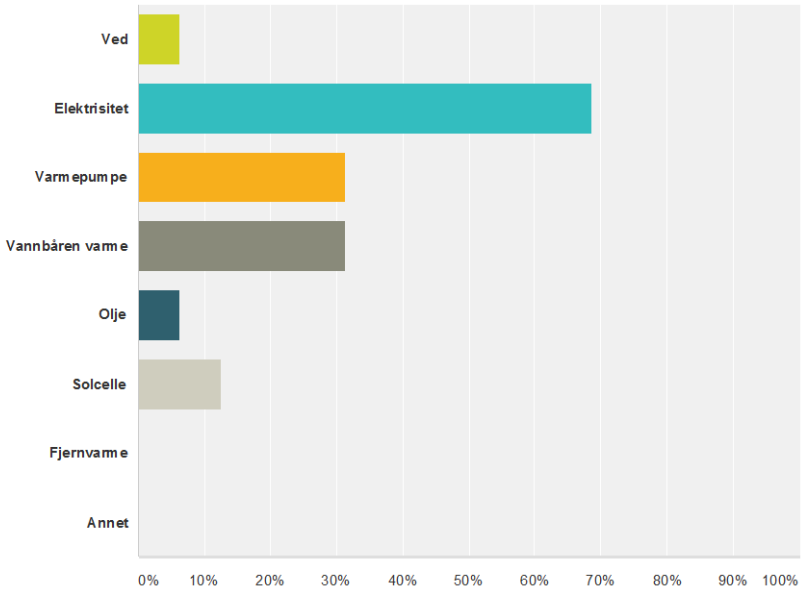


Answer Choices	Responses	
Hå	0.00%	0
Time	0.00%	0
Bjerkreim	0.00%	0
Gjesdal	31.25%	5
Klepp	6.25%	1
Sandnes	25.00%	4
Sola	6.25%	1
Stavanger	25.00%	4
Eigersund	0.00%	0
Randaberg	6.25%	1
Annen kommune	0.00%	0
Total		16

Q7 Hvilke oppvarmingskilder bruker din bedrift?(Kryss av de alternativene som er relevant for din bedrift)

Answered: 16 Skipped: 0

FJERNVARME BEDRIFT

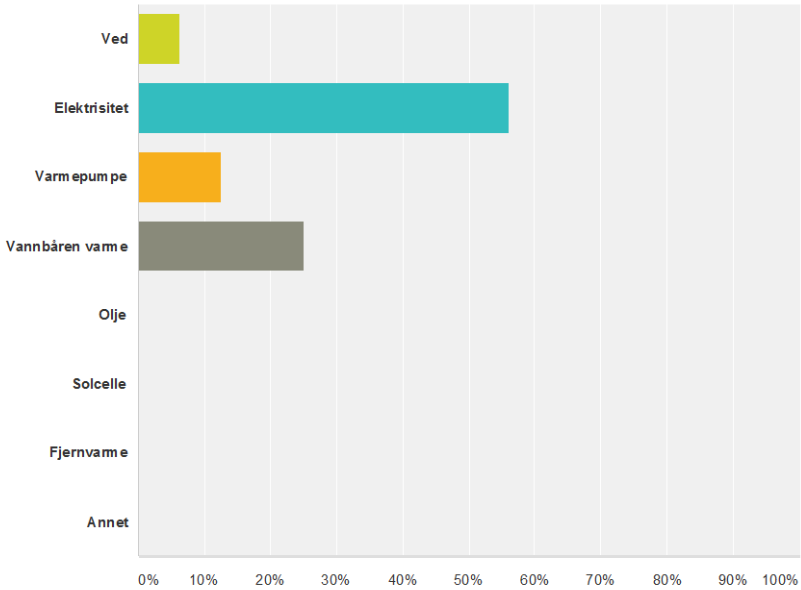


Answer Choices	Responses	
Ved	6.25%	1
Elektrisitet	68.75%	11
Varmepumpe	31.25%	5
Vannbåren varme	31.25%	5
Olje	6.25%	1
Solcelle	12.50%	2
Fjernvarme	0.00%	0
Annet	0.00%	0
Total Respondents: 16		

Q8 Hva er den VIKTIGSTE oppvarmingskilden i din bedrift?

Answered: 16 Skipped: 0

FJERNVARME BEDRIFT

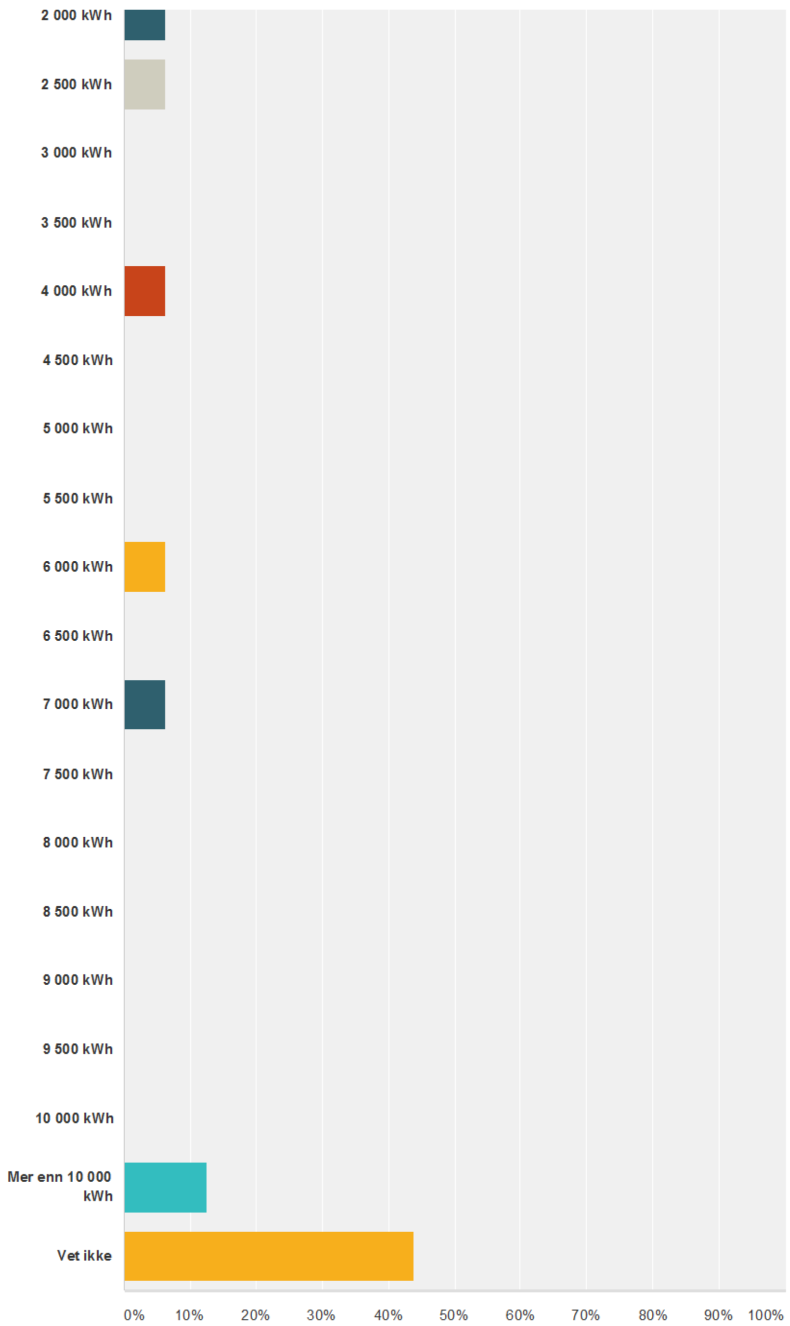


Answer Choices	Responses	
Ved	6.25%	1
Elektrisitet	56.25%	9
Varmepumpe	12.50%	2
Vannbåren varme	25.00%	4
Olje	0.00%	0
Solcelle	0.00%	0
Fjernvarme	0.00%	0
Annet	0.00%	0
Total		16

Q9 Sånn omtrent, hvilket av de følgende alternativene ligger nærmest din bedrifts gjennomsnittelige månedlige strømforbruk?

Answered: 16 Skipped: 0

FJERNVARME BEDRIFT

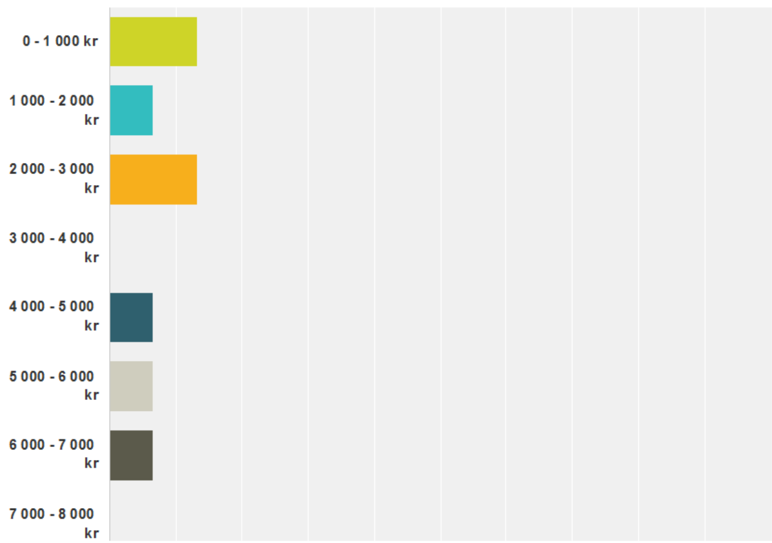


Answer Choices	Responses	
0 kWh	0.00%	0
500 kWh	12.50%	2
1 000 kWh	0.00%	0

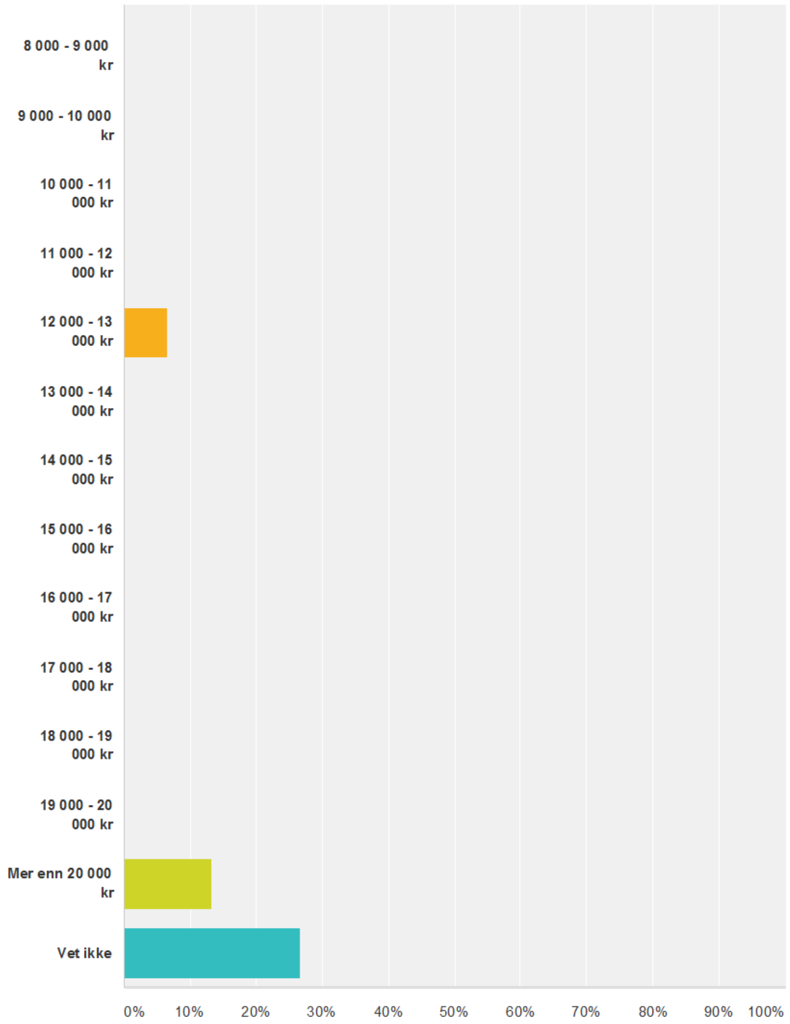
1 500 kWh	0.00%	0
2 000 kWh	6.25%	1
2 500 kWh	6.25%	1
3 000 kWh	0.00%	0
3 500 kWh	0.00%	0
4 000 kWh	6.25%	1
4 500 kWh	0.00%	0
5 000 kWh	0.00%	0
5 500 kWh	0.00%	0
6 000 kWh	6.25%	1
6 500 kWh	0.00%	0
7 000 kWh	6.25%	1
7 500 kWh	0.00%	0
8 000 kWh	0.00%	0
8 500 kWh	0.00%	0
9 000 kWh	0.00%	0
9 500 kWh	0.00%	0
10 000 kWh	0.00%	0
Mer enn 10 000 kWh	12.50%	2
Vet ikke	43.75%	7
Total		**16**

Q10 Sånn omtrent, hvor mye betaler din bedrift i strøm per måned?

Answered: 15 Skipped: 1



FJERNVARME BEDRIFT

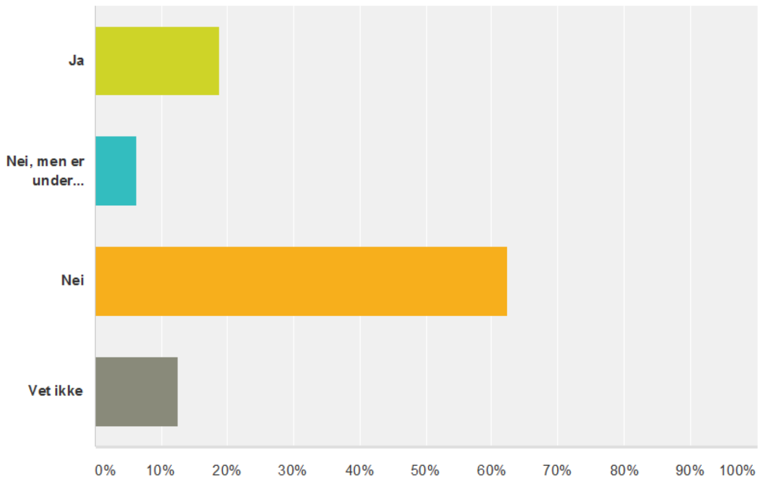


Answer Choices	Responses	
0 - 1 000 kr	13.33%	2
1 000 - 2 000 kr	6.67%	1
2 000 - 3 000 kr	13.33%	2
3 000 - 4 000 kr	0.00%	0
4 000 - 5 000 kr	6.67%	1
5 000 - 6 000 kr	6.67%	1
6 000 - 7 000 kr	6.67%	1
7 000 - 8 000 kr	0.00%	0
8 000 - 9 000 kr	0.00%	0
9 000 - 10 000 kr	0.00%	0

10 000 - 11 000 kr	0.00%	0
11 000 - 12 000 kr	0.00%	0
12 000 - 13 000 kr	6.67%	1
13 000 - 14 000 kr	0.00%	0
14 000 - 15 000 kr	0.00%	0
15 000 - 16 000 kr	0.00%	0
16 000 - 17 000 kr	0.00%	0
17 000 - 18 000 kr	0.00%	0
18 000 - 19 000 kr	0.00%	0
19 000 - 20 000 kr	0.00%	0
Mer enn 20 000 kr	13.33%	2
Vet ikke	26.67%	4
Total		**15**

Q11 Har din bedrift vedtatt en plan eller stategi for reduksjon i utslipp av klimagasser?

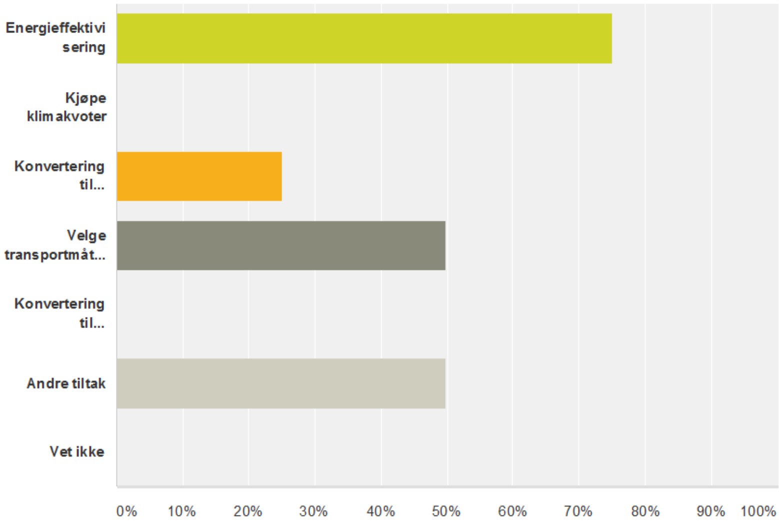
Answered: 16 Skipped: 0



Answer Choices	Responses	
Ja	18.75%	3
Nei, men er under utarbeidelse	6.25%	1
Nei	62.50%	10
Vet ikke	12.50%	2
Total		**16**

Q12 Inneholder planen/strategien noen av følgende tiltak?(Kryss av de alternativene som er relevante for din bedrift)

Answered: 4   Skipped: 12

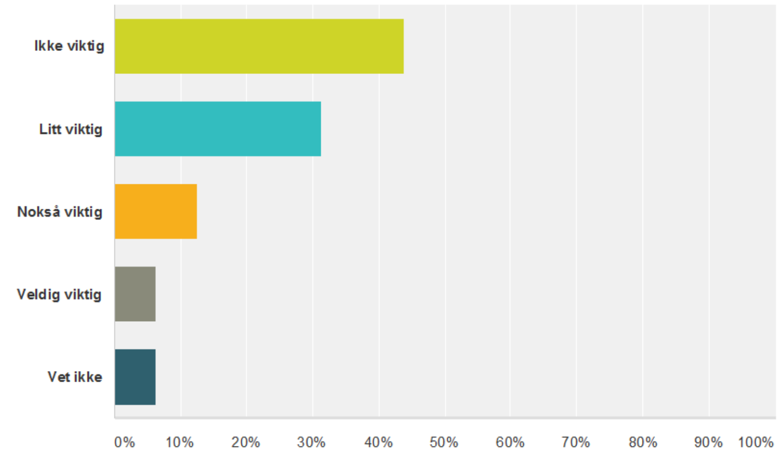


Answer Choices	Responses	
Energieffektivisering	75.00%	3
Kjøpe klimakvoter	0.00%	0
Konvertering til miljøvennlig brensel	25.00%	1
Velge transportmåter med lave utslipp	50.00%	2
Konvertering til miljøvennlig oppvarming	0.00%	0
Andre tiltak	50.00%	2
Vet ikke	0.00%	0
Total Respondents: 4		

Q13 Hvor viktig er klimautfordringen når din bedrift drøfter foretningsstrategi for de kommende årene?

Answered: 16   Skipped: 0

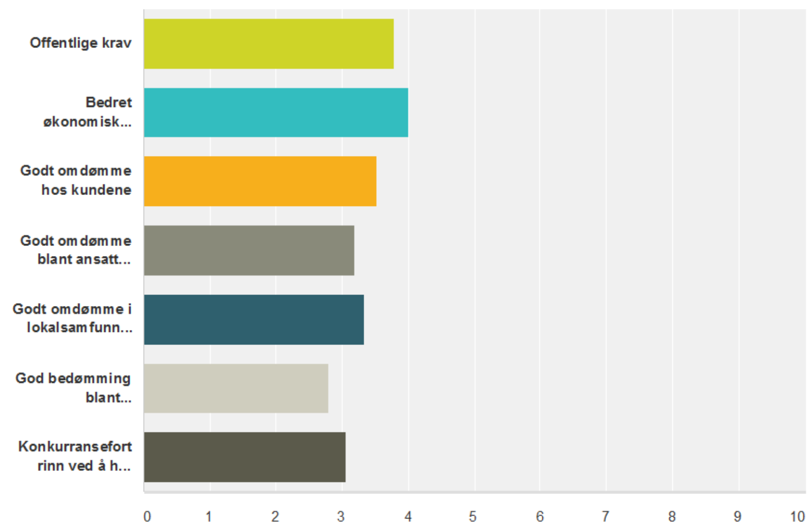
FJERNVARME BEDRIFT



Answer Choices	Responses	
Ikke viktig	43.75%	7
Litt viktig	31.25%	5
Nokså viktig	12.50%	2
Veldig viktig	6.25%	1
Vet ikke	6.25%	1
Total		**16**

Q14 Hvor viktig er følgende drivkrefter for hvorvidt din bedrift vil investere i miljøvennlige tiltak?

Answered: 15 Skipped: 1



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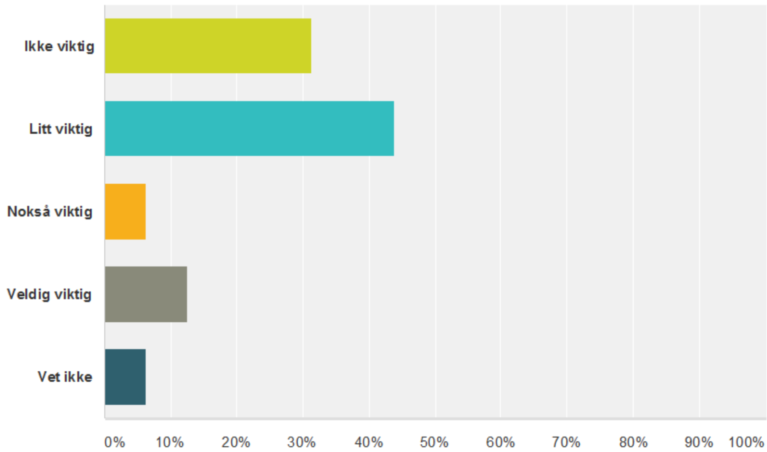
	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig	Total	Weighted Average
Offentlige krav	6.67% 1	13.33% 2	6.67% 1	40.00% 6	33.33% 5	15	3.80
Bedret økonomisk lønnsomhet	6.67% 1	0.00% 0	13.33% 2	46.67% 7	33.33% 5	15	4.00
Godt omdømme hos kundene	6.67% 1	13.33% 2	20.00% 3	40.00% 6	20.00% 3	15	3.53
Godt omdømme blant ansatte og arbeidssøkere	6.67% 1	20.00% 3	26.67% 4	40.00% 6	6.67% 1	15	3.20
Godt omdømme i lokalsamfunnet der bedriften er lokalisert	13.33% 2	6.67% 1	20.00% 3	53.33% 8	6.67% 1	15	3.33
God bedømming blant investorer	6.67% 1	40.00% 6	26.67% 4	20.00% 3	6.67% 1	15	2.80
Konkurransefortrinn ved å ha en miljøvennlig bedriftsprofil	6.67% 1	20.00% 3	40.00% 6	26.67% 4	6.67% 1	15	3.07

Q15 Hvor viktig er energieffektivisering når din bedrift drøfter foretningsstrategi for de kommende årene?

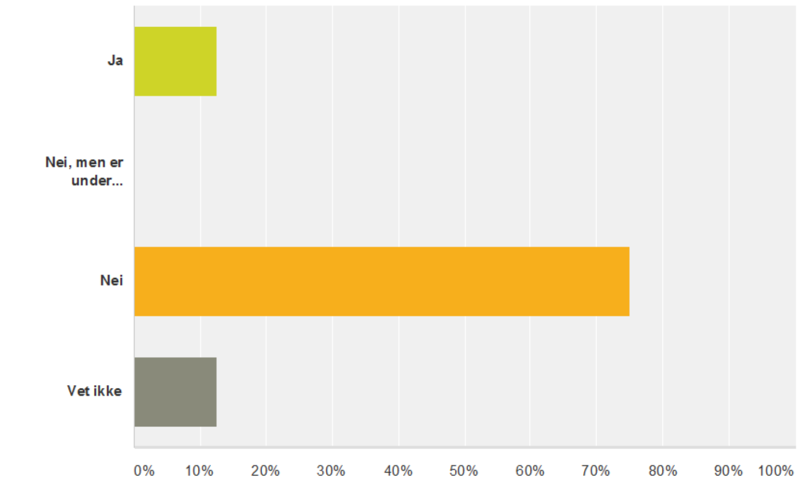
Answered: 16   Skipped: 0



Answer Choices	Responses	
Ikke viktig	31.25%	5
Litt viktig	43.75%	7
Nokså viktig	6.25%	1
Veldig viktig	12.50%	2
Vet ikke	6.25%	1
Total		16

Q16 Har din bedrift vedtatt en plan eller stategi for energieffektivitet?

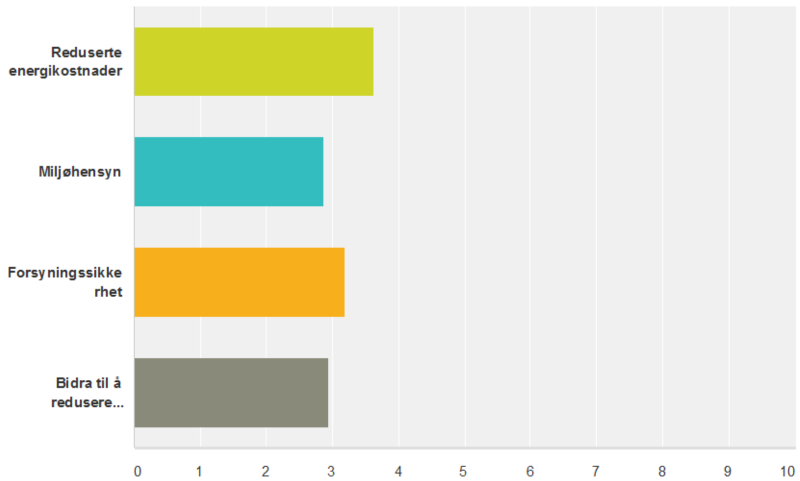
Answered: 16 Skipped: 0



Answer Choices	Responses	
Ja	12.50%	2
Nei, men er under utarbeidelse	0.00%	0
Nei	75.00%	12
Vet ikke	12.50%	2
Total		16

Q17 Hvor viktig er følgende drivkrefter for hvorvidt din bedrift vil forbedre energieffektivitet?

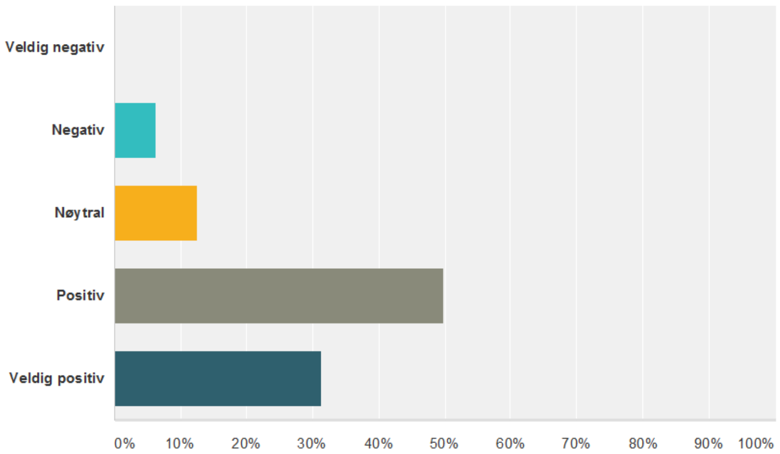
Answered: 16 Skipped: 0



	Helt uviktig	Uviktig	Nøytral	Viktig	Veldig viktig	Total	Weighted Average
Reduserte energikostnader	6.25% 1	0.00% 0	31.25% 5	50.00% 8	12.50% 2	16	3.63
Miljøhensyn	12.50% 2	18.75% 3	37.50% 6	31.25% 5	0.00% 0	16	2.88
Forsyningssikkerhet	6.25% 1	6.25% 1	50.00% 8	37.50% 6	0.00% 0	16	3.19
Bidra til å redusere samfunnets energiknapphet	6.25% 1	12.50% 2	62.50% 10	18.75% 3	0.00% 0	16	2.94

Q18 Basert på overstående informasjon, hvordan stiller du deg til fjernvarme?

Answered: 16 Skipped: 0

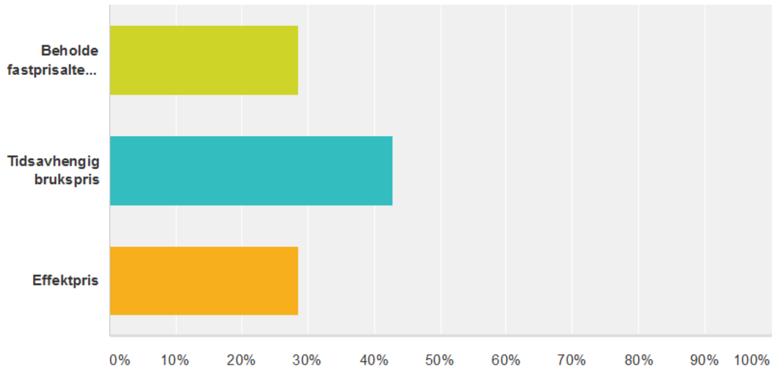


Answer Choices	Responses	
Veldig negativ	0.00%	0
Negativ	6.25%	1
Nøytral	12.50%	2
Positiv	50.00%	8
Veldig positiv	31.25%	5
Total		16

Q19 Hvilket prisalternativ foretrekkes?

Answered: 7 Skipped: 9

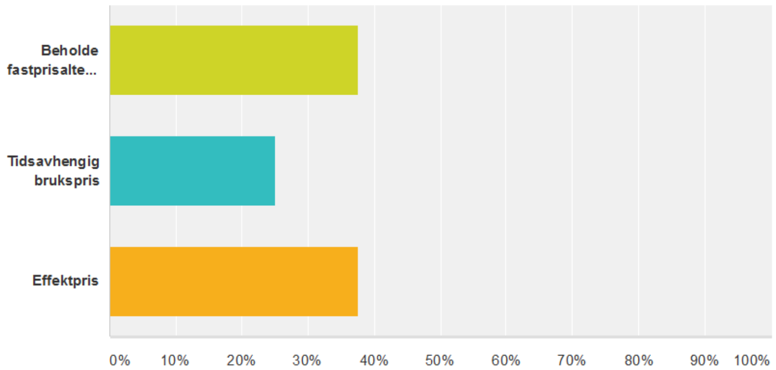
FJERNVARME BEDRIFT



Answer Choices	Responses	
Beholde fastprisalternativet	28.57%	2
Tidsavhengig brukspris	42.86%	3
Effektpris	28.57%	2
Total		7

Q20 Hvilket prisalternativ foretrekkes nå?

Answered: 8 Skipped: 8

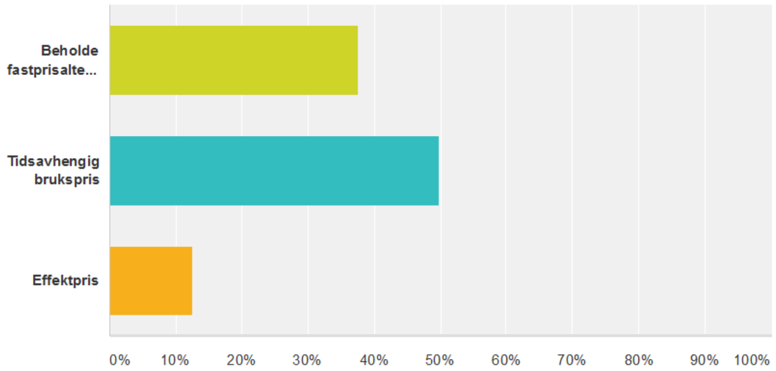


Answer Choices	Responses	
Beholde fastprisalternativet	37.50%	3
Tidsavhengig brukspris	25.00%	2
Effektpris	37.50%	3
Total		8

Q21 Hvilket alternativ foretrekkes?

Answered: 8 Skipped: 8

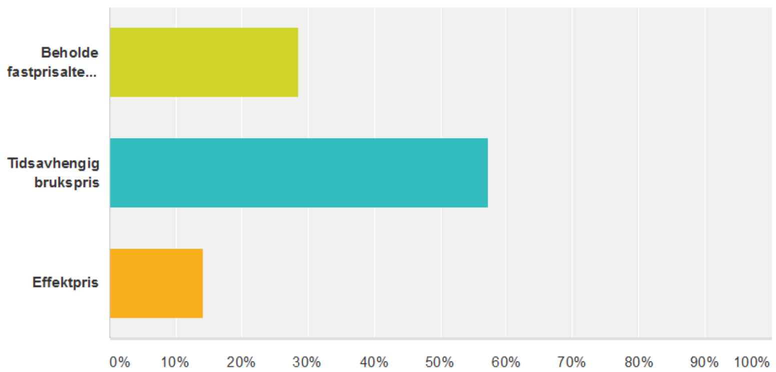
FJERNVARME BEDRIFT



Answer Choices	Responses	
Beholde fastprisalternativet	37.50%	3
Tidsavhengig brukspris	50.00%	4
Effektpris	12.50%	1
Total		**8**

Q22 Hvilket prisalternativ foretrekkes nå?

Answered: 7 Skipped: 9



Answer Choices	Responses	
Beholde fastprisalternativet (1)	28.57%	2
Tidsavhengig brukspris (2)	57.14%	4
Effektpris (3)	14.29%	1
Total		**7**

Basic Statistics

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	3.00	2.00	1.86	0.64

Q23 Har du andre kommentarer til denne

undersøkelsen som du ønsker å dele med oss?

Answered: 0 Skipped: 16

APPENDIX E: INVITATION FLYERS

ENERGIBRUK OG VARME I HJEMMET DITT: HVA SYNES DU?

Gå inn på linken under og svar på undersøkelsen:

www.surveymonkey.com/r/varme

Formålet med undersøkelsen er å kartlegge husholdningers preferanser og meninger når det gjelder effektiv og miljøvennlig energibruk i boliger.

Undersøkelsen er en del av ressursøkonomisk forskning ved Universitetet i Stavanger.

Alle som svarer på undersøkelsen har anledning til å være med i trekningen av et VISA gavekort pålydende 1 000 kroner.

ENERGIBRUK OG VARME I HJEMMET DITT: HVA SYNES DU?

Gå inn på linken under og svar på undersøkelsen:

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Formålet med undersøkelsen er å kartlegge husholdningers preferanser og meninger når det gjelder effektiv og miljøvennlig energibruk i boliger.

Undersøkelsen er en del av ressursøkonomisk forskning ved Universitetet i Stavanger.

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