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Can Automated Smart-Homes increase Energy Efficiency and Grid Flexibility?

- A Case Study of Stavanger, Norway investigating Barriers and Justice Implications -

Master´s Thesis in Energy, Environment and Society

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Preface

This master´s thesis is written as the final part of the MA in Energy, Environment, and Society at the University of Stavanger.

The process of writing this thesis was challenging and a bit of a rollercoaster, as it was a subject, I knew little to nothing about.

I would like to thank my supervisor, Siddharth Sareen, for helping and guiding me through this process.

An additional thank you goes out to all the students and professors of the MEES program who have made the last two years a fun and educational time, despite the ongoing pandemic.

Abstract

Artificial intelligence (AI) advocates deem it essential for the energy transition. Such a complex and penetrative set of technologies that impact everyday lives must be implemented cautiously. This thesis examines barriers to the diffusion of AI-based, automated smart homes at the household and industry scales. It examines an AI system that acts as an intermediary between households, electricity distribution companies and energy producers for domestic energy efficiency and grid flexibility. The thesis focuses on the ethical and justice implications of AI. It draws on a case study of Stavanger in Norway to investigate how AI can fairly enable energy efficiency and grid flexibility. The methods used include a small questionnaire survey, semi-structured interviews, and secondary research. Grounded theory is used to theorise barriers for households, qualitative content analysis identifies barriers for industry, and findings are also interpreted through an energy justice lens. The findings reveal multi-layered barriers and justice concerns related to the diffusion of automated smart-homes. The main barriers for households include functionality, saturation, and data management. For industry, barriers relate to economic, technical, regulatory, and market aspects. Justice and ethical implications linked with AI in the energy context are identified in terms of distributive, procedural and recognition streams of energy justice. The thesis argues that economic incentives, supportive policies, and an enabling market to involve actors are necessary to enable complex AI systems feasible for smart grids. For consumers, technologies must target a wide range of lifestyles and preferences for sufficient market saturation to make AI systems viable. Moreover, ethical AI requires a combination of regulations anchored in energy policies and the development and operationalisation of internal guidelines. The thesis concludes that while AI can aid transitions to low-carbon societies, failure to account for the humans involved and affected by its roll-out risks doing more harm than good.

Keywords: artificial intelligence, automated smart homes, energy management, electricity grid, energy efficiency, grid flexibility, energy justice, energy transition

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1 Introduction

Our society currently operates on the principles of growth, and energy plays a critical role in enabling this growth. Many of the problems we face today are centred on energy. Climate change, security, income inequality, and food production are among them. “Energy is the golden thread that connects economic growth, social equity, and environmental sustainability. With access to energy, people can study, go to university, get a job, start a business – and reach their full potential” (United Nations in India, n.d.). This quote by Ban Ki-Moon, Secretary-General of the United Nations, paints a vivid picture of energy's influence and significance. The current energy production, on the other hand, is not sustainable and contributes to global warming. When compared to other sectors, the electricity and heating production sector was responsible for the majority of GHG emissions in 2019(Ritchie & Roser, 2020a). As a result, Sustainable Development Goal 7, or SDG 7, calls for affordable and clean energy for all and challenges developing, and particularly developed and industrialized nations, to adopt a cleaner form of energy production and find solutions that can lead the world to a cleaner energy future (United Nations in India, n.d.). The 17 Sustainable Development Goals (SDGs) are, at their core, an urgent call to action for all nations - developed and developing - to collaborate in a global partnership. They recognize that eradicating poverty and other deprivations necessitates a concerted effort that prioritizes health and education, reduces inequality, and stimulates economic growth – all while addressing climate change and protecting our waters and forests (United Nations, n.d.).

It is critical to invest in renewable energy, increase energy efficiency, and find solutions to challenges in renewable energy production to achieve SDG 7. One of these challenges is ensuring a consistent and secure supply of renewable energy across the grid.

As climate change becomes a more pressing issue in the twenty-first century, energy systems are undergoing significant changes. As the demand for renewable energy grows, the grid is evolving to meet the challenges associated with renewable energy supply. These challenges include the intermittent nature of renewables, as well as an increase in the number of energy providers at the grid's distributional level (Muench et al., 2014). The latter has emerged as a result of favourable developments, such as consumer adoption of grid-connected technologies. Among these technologies are electric vehicles, energy management systems, and photovoltaics. Smart grid (SG) technologies have been implemented to ensure the stability and reliability of energy supply and transportation (Kranz et al., 2010).

Despite these developments, current solutions alone will not be sufficient to meet future renewables shares in the grid. The fact that electricity demand is expected to rise by nearly 50% until 2050 (IEA, 2018) that the share of renewables will continue to rise, and that electrification of transportation, industry, and buildings is well underway, demonstrates this abundantly.

There are numerous potential solutions being discussed, tried, and tested. Increased grid energy efficiency is one of these solutions. "Efficiency can enable economic growth, reduce emissions, and improve energy security," says Fatih Birol, Executive Director of the International Energy Agency (IEA). Without the need for new technology, the right efficiency policies could allow the world to achieve more than 40% of the emissions reductions required to meet its climate goals" (IEA, 2018). Furthermore, energy efficiency is a promising solution because of its low cost, low environmental impact, lack of public concern about its implementation, and ability to be implemented in a relatively short timeframe.

Smart meters have been installed in homes to encourage more efficient energy use. However, as research on installed smart meters has shown, people tend to revert to their old, inefficient habits (Bhati et al., 2017; Muench et al., 2014). To address this, fully automated control devices that use artificial intelligence to control electricity use in households could potentially increase energy efficiency in homes while also improving grid flexibility. There are, however, specific challenges associated with complete automation of electricity control.

The purpose of this thesis is to identify barriers and concerns that may impede the possible implementation of artificial intelligence (AI)-based home automation devices, as well as to discuss ethical concerns associated with the spread of such systems. A particular emphasis will be placed on how social inequalities can persist in AI systems and how to avoid this by investigating injustices using energy justice. Furthermore, careful consideration is given to how consumer data is collected and stored, as well as how privacy concerns are addressed in accordance with the General Data Protection Regulation (GDPR). This emphasis is due to concerns about providing suppliers with knowledge of consumer habits, which could be sold to third parties if proper safeguards are not in place (Stephens et al., 2013).

Buildings and cities currently account for up to 20% of global emissions, and the residential sector accounts for 26.1% of total energy consumption (Eurostat, 2020; Greenman, 2019). Furthermore, it is expected that by 2050, approximately 68% of the world's population will be living in cities (United Nations, 2018). Greater cities bring with them a plethora of challenges as well as opportunities. Until 2050, the EU has set a goal of reducing energy consumption in residential and commercial buildings by 55% compared to 1995. (European Comission, 2020).

Nonetheless, global energy demand continues to rise. As a result, sectors such as transportation, manufacturing, and industry have been working to reduce their energy consumption (Reinisch et al., 2015). And still, despite accounting for roughly one-third of global final energy consumption in 2010, advances in energy-efficient technologies and practices in the residential sector continue to fall short of the targets set (Reinisch et al., 2015; Schachinger et al., 2018). Norway has one of the highest per capita annual electricity consumption rates in the world (Ritchie & Roser, 2020b), making it an ideal testing ground for energy-efficient technologies and a case study for this thesis.

Stavanger is an appropriate case because it is Norway's energy capital, has the largest industrial cluster in Norway, and provides the researcher with the benefit of established connections and relationships to investigate automated smart technologies.

Smart technologies and smart homes have emerged as a popular solution for increasing energy efficiency, lowering overall energy consumption in homes, and reducing grid load.

Cook (2012) defines a Smart Home as a "computer software playing the role of an intelligent agent perceives the state of the physical environment and residents using sensors and then takes actions to achieve specified goals, such as maximizing comfort of the residents, minimizing the consumption of resources, and maintaining the health and safety of the home and residents" (p.2).

Current smart technology in smart homes is based on the internet of things (IoT), which connects the technology to the internet and allows the user to remotely control the installed technologies (Schachinger et al., 2018) The internet of things is a network of interconnected computing devices, mechanical and digital machinery, items, and people that have unique identifiers (UIDs) and the ability to send data over a network without the need for human-to-human or human-to-computer contact (Gillis, 2020).

Nonetheless, despite homeowner awareness and motivation to increase energy efficiency within homes, as well as advancements in more sophisticated technology, smart homes are not living up to their full potential (Reinisch et al., 2015). Furthermore, research shows that changing and maintaining user behaviour to make more energy-efficient decisions is difficult.

Specific pilot projects demonstrated that smart meters' information on electricity consumption is only considered for a short period of time. After a brief period, users reverted to their previous behaviour patterns (Muench et al., 2014). Another barrier to smart technology is that it complicates users' lives rather than simplifying them (Muench et al., 2014).

Until now, smart home research has been focused on providing users with control over their home environment and thus their lives to ensure user satisfaction and compliance. However, this implies the need for smart device control and interference, which may result in the occupants' lives becoming more complicated rather than simpler (Davidoff et al., 2006; Fabi et al., 2017).

Parallel to smart technology, artificial intelligence applications are gaining traction as a result of the ever-increasing amount of data available as a direct consequence of the IoT's surge in smart infrastructures (Schachinger et al., 2018).

According to the Encyclopaedia Britannica, artificial intelligence (AI) is defined as “the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings” (Copeland, 2020). AI has emerged as an important tool in the fight against climate change. Nonetheless, it is not without its challenges and quandaries. There are growing concerns about the ethical and fair use of big-data technologies such as AI and machine learning (ML), which refers to computer software that can learn on its own (Hosch, 2021).

Machine learning systems aid in the identification and analysis of patterns in existing data sets to make predictions and, ultimately, decisions. Concerns have been raised about the use of such systems in terms of privacy, transparency, intentional misuse, and data bias, which can lead to discrimination and inequality (Ekin, 2019).

As a result of the described developments, the phenomenon investigated in this thesis are smart homes connected to ML systems that predict user consumption behaviour, centralised and decentralized energy production, weather, and temperature to optimize energy use in homes and reduce grid stress.

Since no such large-scale system exists in Norway to the best of the researcher's knowledge, this thesis seeks to contribute by investigating the barriers and challenges that such a system's implementation might entail.

The advantage of ML systems is that they will allow for better matching of electricity supply and demand within the grid by efficiently communicating "between networks of consumers, transmission lines, substations, transformers, and suppliers" (Greenman, 2019),

increasing energy efficiency in homes as well as grid flexibility.

The section that follows explains why we chose Stavanger, Norway, to investigate automation.

1.1 A smart home case study in Stavanger, Norway

For several reasons, this thesis investigates the automation of smart homes in Stavanger, Norway.

Norway consumes approximately 25 000 kWh per capita per year (Ritchie & Roser, 2020b),

making it the world's third-largest consumer (Ritchie & Roser, 2020c). In 2017, the residential sector accounted for 22% of total energy consumption in Norway, with electricity being the most commonly used energy carrier (Energy Facts Norway, 2019a). Furthermore, the use of electricity for heating is becoming more common (EIA, 2017).

Overall, electricity's share of Norway's energy mix has steadily increased, reaching 83% in 2017 (Energy Facts Norway, 2019a).

Norway has a nearly emission-free electricity sector due to a high share of renewables in the energy production phase. In Norway, hydropower is the primary source of electricity, with other clean energy sources on the rise (Ritchie & Roser, 2020b; The Scientific Committee of the Norwegian Smart Grid Centre, 2015).

As a result, one could argue that Norway, despite its high energy consumption, does not need to worry about reducing national electricity consumption. However, the reality is more complicated. Not only is Norway the leader in the sale of electric vehicles (Regjeringen, 2019), but electrification of the transportation, building, and industrial sectors is well underway (Sweco, 2019).

As stated at the beginning of this section, electricity demand is increasing, and if the aforementioned sectors electrify, there will be an even greater need for electricity in the future.

In Norway, the situation for other renewable energies is still in its early stages. Solar only accounts for 119MWp, and wind energy production accounts for no more than 7.5% of total electricity production (Dale, 2019; Energy Facts Norway, 2021a).

Another critical factor is that Norway imports a significant portion of its electricity from countries such as Germany, the United Kingdom, Denmark, and the Netherlands (Energy Facts Norway, 2017). Energy production in those countries is not always as emission-free as in Norway, resulting in a less clean energy sector in Norway, as previously assumed (IEA, 2021).

To deal with ever-increasing electricity demand and the reality that Norway's energy sector may not be as clean as previously indicated, smart energy system solutions are required to assist Norway in meeting its climate targets and possibly leading other countries to establish more efficient and less energy-intensive systems. These systems will have to combine various energy sources with varying reaction times, a greater proportion of prosumers, local energy storage capacities, and rising electricity demand (The Scientific Committee of the Norwegian Smart Grid Centre, 2015).

The subject of this research thesis is the concept of an interconnected ML system that could increase energy efficiency in homes and grid flexibility by removing humans as decision-makers.

Because the true potential of smart homes has yet to be realized, this thesis investigates the integration of comprehensive, interconnected systems, and how the use of ML to increase energy efficiency in homes contributes to peak shaving on the grid.

The focus of this thesis is on ethical considerations related to user consumption data and artificial intelligence in electricity distribution, as well as the barriers to the diffusion of automated systems that control smart home appliances independently of user behavior and direct interference (Reinisch et al., 2015).

The case study of Stavanger, Norway, employs a constructivist grounded theory methodology to aid in the development of theory for the context of households adopting new technology, as well as a mixed-methods approach to investigate industry barriers, with energy justice as a theory to frame ethical considerations.

1.2 Research Questions

The thesis aims to contribute to the discussion on how AI can safely and fairly enhance energy efficiency in homes and increase grid flexibility. The challenges and concerns addressed in the introduction aided to phrase the following research questions:

i. *What are the most prominent barriers hindering the diffusion of automated systems in the grid and homes, and are they feasible?*

i. *How are possible ethical considerations concerning AI systems acting as intermediaries between households and the energy grid, addressed?*

1.3 Thesis Structure

The remaining chapters of this thesis are as follows. First a review previous research that touches upon the relevant fields for this thesis in presented in chapter two. The Norwegian energy market and the concept of flexibility are explained to set the stage for where the ML systems would come into play and how flexibility currently works in the Norwegian context. The technological section of the literature review gives more detailed insight into the workings of IoT, AI and ML, and Smart Homes. That section is followed by a breakdown of the GDPR and how it addresses AI. The literature review concludes with a section on the social aspects connected and surrounding AI, including an assessment of ethics in AI, social inequality, and social justice.

Chapter three accounts for the logics of inquiries, inductive and abductive, and the epistemological and ontological assumptions for this thesis. Energy justice is introduced as the leading theory for this thesis in Chapter four. Chapter five introduces case studies as the methodology for the thesis and discusses the methods used to conduct the case study.

The empirical findings are presented and analysed in Chapter six, and Chapter seven contains the discussion of the findings in connection to previous research and energy justice as a theory. Chapter eight offers the conclusion of this thesis, the motivation for conducting the study and possible further research needed in the field.

2 Literature Review

Before diving into different contexts that ML systems are embedded into, the Norwegian electricity market and flexibility are explained to set the stage for where automation would be placed.

This section discusses the construction and operation of the Norwegian power system and the electricity market in detail to explain the concept of flexibility in the Norwegian context.

2.1 Norwegian Electricity Market

To comprehend the idea of flexibility and how ML systems could contribute to it, one must first understand the structure and operation of the Norwegian power system and power market. This section discusses the construction and operation of the Norwegian power system and the electricity market in detail.

Norway's electricity grid is organized into three voltage levels: transmission, regional, and distribution. The transmission network is the total system of 132-420 kW voltage levels connecting big producers and consumers in a national system. In Norway, the transmission network is controlled by Statnett, also known as TSO (Transmission System Operator). The regional grid, which connects the transmission and distribution grids, operates at a voltage of 33-132 kW. The distribution network is an extra power distribution network that provides electricity to smaller end customers locally. The distribution network operates at a maximum voltage of 22 kW, and it is divided into high- and low-voltage distribution networks. Low voltage distribution networks contain voltages less than 1 kW, whereas high voltage distribution networks include voltages more than 1 kW and up to 22 kW (Sønju & Walstad, 2019). The multiple grid levels depicted in Figure1 explain how the producer and the end-user are connected.

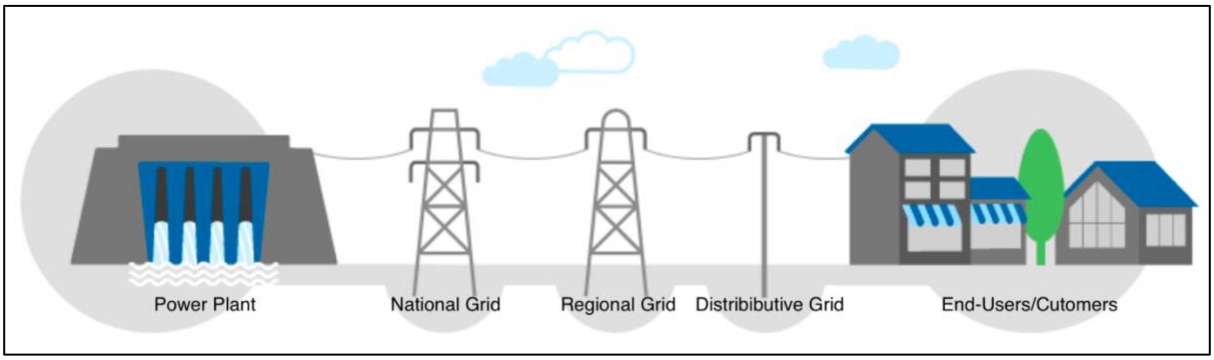

Figure 1:The different grid levels in Norway

Source: Adapted and translated from (Sønju & Walstad, 2019)

While production plants can theoretically be linked to all three grid levels, their size dictates which voltage level they connect to. While large manufacturing plants connect to transmission or regional networks, smaller manufacturing plants connect to regional or distribution networks. The size of a consumer's power outlet also dictates the mains level to which the consumer must connect. Large customers frequently have high-voltage outlets and must thus get electricity directly from the transmission or regional grid, whereas users with low-voltage outlets, such as homes, are linked to the distribution system(Energy Facts Norway, 2019c).

Regulation and the grid system's function

Electrical energy is produced, transmitted, distributed, and sold by a variety of players. Electricity sales and manufacturing are highly competitive industries. An energy producer generates electricity and sells it on the electricity market, whereas a power supplier purchases electricity on the market and resells it to consumers. Additionally, a participant, preferably a small business, can act as both generator and provider.

A marketplace license is necessary to establish or manage a physical delivery transaction in electrical energy. Nord Pool presently holds the only marketplace license in Norway for the wholesale market's market divisions, which comprise the spot market (day-ahead market), Elbas (intraday market), and regulating power market (balanced market).

The system operator not only manages the transmission network but is also responsible for regulating the electricity market.

The diagram depicts the many types of actors, their position in the power structure as a monopoly or competitive activity, the necessary agreements between the actors, the actors with whom an activity intersects, and the existing regulatory requirements that include the activity (Energy Facts Norway, 2019).

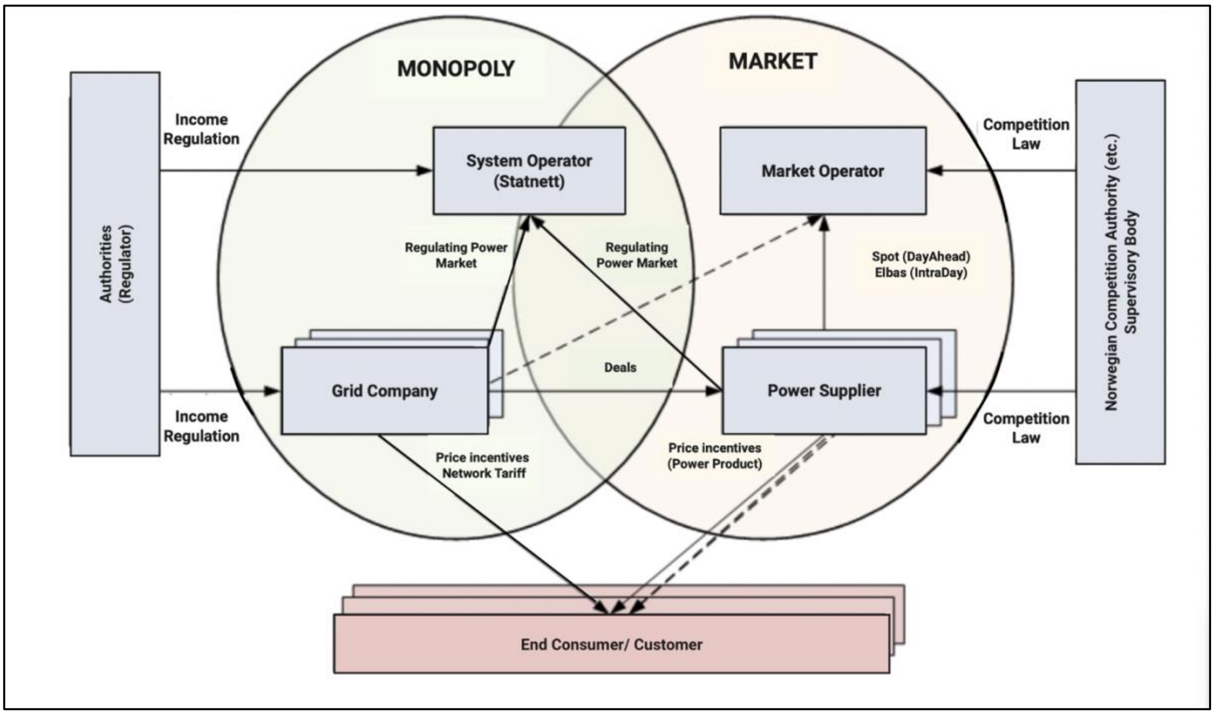

Figure 2: The actors in the Norwegian power system and their interactions

Source: Adapted and translated from (Sæle et al., 2019).

Frequency regulation

The voltage levels and frequency of a power grid are the two most straightforward measures of its stability. Voltage level fluctuations are less severe than frequency variations. Changes in voltage levels frequently occur locally and are not always indicative of system stability, whereas frequency is constant throughout the network and indicates something about the network's production and consumption balance.

Frequency refers to the number of times per second that the alternating current (AC) in the electrical system reverses direction. The frequency is a measure of the power system's instantaneous balance and is uniform throughout the Nordic synchronous area, encompassing Norway, Sweden, Finland, and Denmark. The frequency is 50 Hertz (Hz), with a typical 49.9 to 50.1 Hz range. Deviations in frequency can be instigated by faults, imbalances caused by changes in the flow, foreign connections, or abrupt power generation or consumption changes. When use exceeds output on the grid, the frequency decreases; when output exceeds demand, the frequency increases (Sønju & Walstad, 2019).

The frequency is preserved at 50 Hz by keeping a balance between production (supply) and consumption (demand) (AEMO, 2018).

Statnett is responsible in Norway for maintaining a continuous and instantaneous balance across the whole power system, from the transmission to distribution. Statnett is thus referred to as the system's administrator in Norway. The system manager is responsible for ensuring that the system consumes precisely the same amount of power as it produces, i.e., that the frequency is as near to 50 Hz as feasible. To maintain immediate balance and avoid frequency variations and, in the worst-case scenario, interruptions caused by abrupt changes or defective events, the system administrator must have sufficient reserves to cope with imbalances (Energy Facts Norway, 2019b). If the frequency deviates excessively, it can cause damage to network equipment, and, in the worst-case scenario, the network can collapse.

The energy law governs energy production, sale, transformation, transmission, distribution, and consumption. The law's goal is to ensure that regulated elements of the electricity sector operate in a socially reasonable way that balances public and private interests.

An area license is necessary to construct, own, and operate a facility to distribute electrical energy across voltage levels within a defined region. A player, often a grid business, holding an area license is responsible for delivering electricity to all subscribers within the licensing area and connecting new electrical energy production and extraction units. (Lovdata, 2021).

A trade license is necessary to convert electrical energy. The term "sales license" has varying "connotations" based on the type of player. A trading license is required for an energy producer to produce energy and deliver it to the grid; a trading license is required for a power supplier to buy and sell energy; and a trading license is required for a grid company to transport produced electrical energy in order to meet its supply and connection obligations as an area licensee (Sønju & Walstad, 2019).

The electricity market

Electrical energy is unsuitable for storage and is a "live commodity" consumed immediately upon production. To maintain network balance, the generation of electricity must match the consumption of electricity. In Norway, the transmission network operator, Statnett, is responsible for maintaining this balance. Statnett is therefore referred to as "responsible for billing" and is responsible for ensuring that all feeds and withdrawals of electrical energy are appropriately invoiced in line with the Energy Law to maintain an economic equilibrium in the power market (Statnett, n.d.).

Norway is a member of the Nordic electricity market, which includes Norway, Sweden, Denmark, and Finland. Through links to the Netherlands, Germany, the Baltics, Poland, and Russia, the Nordic power market links into the European power market. Additionally, new links are being established between Norway and Germany and between Norway and the United Kingdom. Nord Pool trades a large portion of the electricity exchanged in the Nordic and Baltic republics. Nord Pool's power contracts are traded implicitly, implying that the day-ahead market calculates both prices and energy flow across regions concurrently. A unified intraday market for Europe is also being established (Energy Facts Norway, 2021b).

The electricity market is divided into two segments: retail and wholesale. The end-user market consists of end-users, such as businesses and individuals, who purchase electricity through a power supplier or broker. The wholesale market brings together power sector professionals, such as power providers and producers, and big electricity customers. Power providers conduct power trades on behalf of small and medium-sized end consumers and small and medium-sized industries (Energy Facts Norway, 2021b).

Each day, the Nord Pool power exchange determines the system price of electricity for the following 24 hours. The system pricing is calculated on the premise that the Nordic transmission network is devoid of bottlenecks. The price is consistent across the Nordic market and acts as a benchmark for pricing the Nordic region's financial power trade (Energy Facts Norway, 2021b).

Statnett is responsible for Norway's systems and hence for the overall balance. Power suppliers are responsible for balancing their portfolios, which means purchasing enough energy to satisfy their customers' demands. Grid companies bear a balance of responsibility for distribution network losses, which means they must purchase the power required to compensate for the losses. Grid companies have a delivery duty, which implies they must also purchase energy to satisfy the demands of consumers in their concession area who do not have a power purchase agreement (NVE, 2021a). The necessary electricity is purchased on the wholesale market by power providers and grid firms.

DSO responsibilities

A DSO (Distribution System Operator) is responsible for the ownership and operation of the distribution network within a specific geographic area. The DSO distributes energy to end-consumers via the transmission network and small producing units. According to EY, the responsibility of a DSO includes "maintaining a safe and reliable grid, connecting new generation and identifying the most cost-effective solutions for energy customers" (Colle et al., 2019, p. 17).

The European Commission underlines the critical nature of market neutrality for DSOs, which requires them to act as a neutral market facilitator (ACER & CEER, 2017), implying that a DSO cannot possess electric storage units or infrastructure for charging electric cars (ACER & CEER, 2017). DSOs must abstain from performing functions that may be delegated to the free market. According to CEER and ACER, this is critical because:

- Free markets are frequently more efficient than regulated markets at delivering value-for-money services to customers.
- If a DSO engages in competitive activities, such as electric storage, there is a possibility that the DSO will prioritize its storage services over other, preferably less expensive, services, resulting in increased costs for the customer.
- The DSO may prefer certain sorts of clients. The market's primary feature is the security of DSO's market neutrality.

Statnett is responsible for the whole balance of the Norwegian electricity grid, from the transmission to local end customers at the distribution level and bottleneck management. Today's system responsibility regulations state:

The system operator is responsible for the smooth operation of the regional and transmission networks. The system operator should establish bidding zones to resolve significant and persistent bottlenecks in the regional and transmission networks. In anticipated energy shortages in a restricted geographical region, the system management shall typically establish distinct bid areas (Lovdata, 2002).

The aggregator's role

The aggregator's role is to consolidate flexibility into a manageable portfolio to sell it to stakeholders via a digital marketplace or through contracts/agreements. Aggregation of freight, storage, and manufacturing units with varying restrictions and features of more extensive portfolios with fewer constraints improves the dependability of service delivery (network and market operations) (Bjerkan, 2016). To operate as an aggregator, the aggregator must have a trade license that permits aggregator operations explicitly.

Aggregators require consumers to alter their consumption habits and allow their loads to be managed by a management system. The reward must be adequate to pay the expenses involved with making their loads available to the aggregator to make this plan appealing to customers. If an aggregator sells flexibility to a buyer (a grid company, a transmission system operator, a power provider, or potentially a big corporate client), the aggregator is responsible for supplying reserved flexibility. If the flexibility provider cannot offer the agreed-upon flexibility for activation, the provider may pay the aggregator (Bjerkan, 2016). If the aggregator cannot supply the agreed-upon quantity of flexibility, the area's balance manager may have to activate reserves to ensure that the buyer of flexibility obtains the agreed-upon amount. The way this will be reimbursed is unknown at this point.

Today, direct agreements exist between significant energy users and grid corporations or TSOs. Industries that require a great deal of energy, such as giant smelters, are fed directly from the transmission network. TSO´s often have agreements with these industries for emergency disconnections. Additionally, network providers frequently enter into such disconnection agreements with energy-intensive sectors that rely on the regional network. It is feasible that such direct agreements might be routed through an aggregator, requiring TSOs and network firms to deal with a single party rather than many agreements (Sønju & Walstad, 2019).

Prosumers

NVE defines prosumers as End users with consumption and production located behind the connection point, where the power input at the connection point does not exceed 100 kW at any moment. A prosumer may not operate a facility that needs a license behind its connection point or conduct business that requires a trade license behind the connection point (NVE, 2021b). Prosumers have the option of selling locally generated power to an aggregator. If a prosumer feeds in more than 100 kW, the customer is classified as a power producer and is required to get a sales license and pay a feed-in rate (NVE, 2021b).

NVE is now evaluating revisions to the laws governing how grid companies might design grid rent. The concept behind the work that has begun is that the grid rent should incentivize energy consumers to utilize electricity wisely, preventing the electricity bill from becoming excessively expensive. The authorities intend to implement a new grid rent pricing mechanism known as the demand tariff. Customers should thus benefit from shifting usage from periods of high grid demand to periods of low grid load. Customers that consume a large amount of power in a short period and consequently charge the electricity grid the most pay a higher rate than customers who consume electricity seldom. The overall amount collected from customers by network firms remains the same, but there will be a rebalancing of who pays the most and pays the least. Throughout the day and week (Lyse Elnett, 2020; NVE, 2020).

The concept of flexibility is examined below to clarify how the actors in the energy grid can make use of greater flexibility,

2.1.1 Flexibility

Flexibility can potentially be used to maintain the balance between energy production and consumption. When combined with intelligent operation, flexibility at the distribution level can be utilized to minimize grid losses, boost delivery security, improve voltage quality, and avoid or postpone costly grid improvements. This section discusses different aspects of grid flexibility.

Network flexibility and Consumers

Historically, flexibility has been used in the transmission network to maintain frequency by changing production in response to consumption. Frequency can also be maintained by modifying consumption at the transmission level in response to the production, although this approach is only utilized in emergencies. The rising trend toward decentralized, renewable, and sometimes uncontrolled energy generation complicates efforts to balance output and consumption at the transmission level. As a result, a shift in consumption and perhaps output may be required to preserve equilibrium at the distribution level. Consumer flexibility is defined in this thesis as a consumer's ability to modify its energy consumption and possible production in the short or medium-term by using ML systems (Lovdata, 2021; Sæle et al., 2016).

Flexibility is defined in this thesis as a change in consumption or production across all voltage levels caused by a signal (price or activation signal). In contrast, consumer flexibility is defined as a change in consumption and possible production at the distribution level caused by, for example, price changes or the interference of an ML system (Sønju & Walstad, 2019).

Network operators can leverage consumer flexibility in times of network pressure. Purchasing consumer flexibility from local suppliers in conjunction with better operations can postpone grid improvements and result in lower grid losses.

Actors who generate and store renewable energy, primarily for personal consumption, can input electricity into the distribution network. This sort of consumer flexibility can help decrease transmission losses by transferring electricity to neighbouring customers while also decreasing the strain on the local supply network.

In addition to consumption behaviour changes and locally produced energy, batteries can increase grid flexibility. Battery banks are energy storage devices deployed in strategic locations across the system to provide electricity locally. They can be charged when the area's energy consumption is low, and the electricity price is low, and they may release energy when the area's energy consumption is high, and the electricity price is high (Sønju & Walstad, 2019).

Numerous end consumers can provide relocation, reduction, or disconnection of unprioritized appliances of various sizes and at various periods on the distribution network. These offers can be combined using an aggregator to provide a sufficient flexibility offer to the network companies. Households and commercial and industrial clients with fewer power outlets are examples of consumers who can aggregate their consumer flexibility.

Households consume relatively little energy, but because they are a more homogeneous population, it is easy to implement the same procedures with several consumers (Sæle et al., 2019).

This circumstance indicates that when many homes in the same region make themselves accessible in a flexible market, the overall supply to the market could become sufficient.

Furthermore, network operators and electricity providers may be interested in acquiring network flexibility. The shift to more renewable and dispersed energy sources and introducing new power-intensive loads, such as electric cars, leads to increased power production and consumption variations. Network operators might purchase customer flexibility to balance the load on the distribution network and therefore minimize transmission losses, while electricity suppliers can purchase flexibility to minimize their portfolio imbalance (Bjerkan, 2016).

A precondition for utilizing the network's considerable flexibility is having the appropriate tools and appliances in place. They are required to enable a consumer to adjust their consumption in response to an activation signal automatically. Additionally, technologies are required that enable consumers to submit an amount of available flexibility to an aggregator or network firm, for example, to obtain an overview of available flexibility. Moreover, flexibility providers should categorize offers based on which ones they wish to be redeemed first (Sønju & Walstad, 2019).

One of these tools is a so-called smart meter or AMS meter.

The AMS meter offers real-time data on the customer's consumption and potential production and the ability to issue alerts in the case of mistakes. Customers can provide information about their usage to network firms through AMS meters (Sønju & Walstad, 2019).

The AMS meter is a device that measures the amount of electricity used in households and businesses. The amount of information available to the grid company is determined by the communication solution used between the meters and the grid company. Network providers that interact with meters via mobile networks can obtain data on usage every hour by putting SIM cards in the meters. The network company can also "stream" consumption to the consumer via the connection between the AMS meter and the network company over the mobile network, which means that the network operator has real-time access to the customer's use. Consumption streaming to individual consumers will occur only if the network company has a compelling motive. The consumer may be streamed for various reasons, including voltage issues, frequent earth failures, or the like (Sønju & Walstad, 2019).

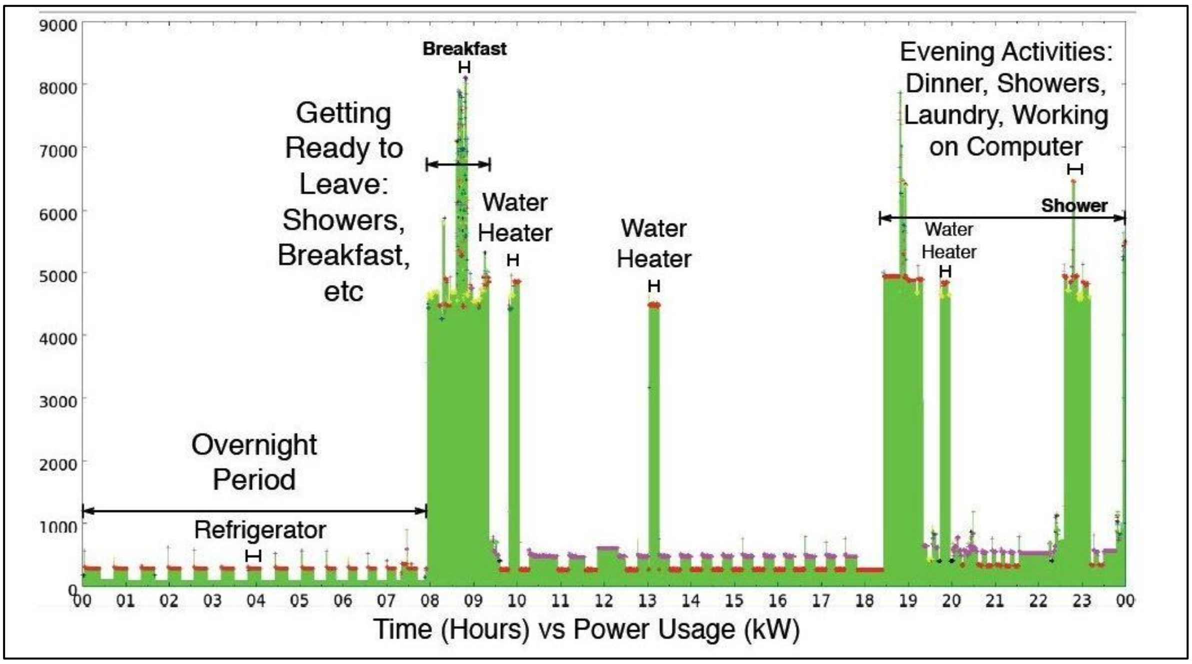

Figure 3: High-frequency smart meter data

Source: (Molina-Markham et al., 2010)

A smart meter has several benefits, including increased meter reading accuracy and energy management optimization, resulting in cost savings, bidirectional energy flows, and two-way communication capabilities that enable a new range of activities. As with any new technology, it will have several advantages and disadvantages. One significant drawback of smart meters is the risk to privacy. To be precise, it is to prevent unauthorized third parties from gaining access to the users' power. People´s lifestyle is inextricably linked to their power usage statistics, as seen in figure 3. The data gathered by smart meters in a local area network are accessible to grid companies (Ibrahim, 2020).

To begin, one must determine the type of data being collected by the smart meter. The collected data can is into two main categories. The "low frequency" data is required for billing and grid management, as well as the "high frequency" data required for consumer energy and management. The primary distinction between the two is the polling rate. The polling rate indicates the amount of time that passes between two successive data packets. Typically, it is sufficient to gather data every 15/30/60 minute for invoicing and grid management needs. On the other hand, it is deemed essential to have data available in near real-time to monitor and enhance the consumer's energy efficiency, which leaves the consumer vulnerable to data misuse and security threats (Ibrahim, 2020).

Incentives for energy conservation

Households and business customers require incentives to conserve or adjust their energy use under grid stress. Price signals are one approach to influence customers' energy use.

A client who consumes energy must pay the price for the electricity used plus grid rent to the local grid business that delivers the electricity (NVE, 2021c). The client may choose the power provider and electricity agreement, whereas the customer's location decides the grid company. Norway's most prevalent forms of energy contracts are spot price, standard variable pricing, and fixed price (Rosvold, 2021).

NVE has proposed including a demand price into the grid fee for individual energy customers (Naper et al., 2016; Verlo et al., 2020). NVE suggests a system in which users would subscribe to energy and incur additional expenses if they exceeded their selected subscription. The implementation of a demand tariff can also be used to price-control consumers' energy use (Naper et al., 2016).

Flexibility benefits the electricity system because it enables innovative, more efficient, and cost-effective solutions for all involved players, which benefits society.

By attaining equal consumption, network firms may employ flexibility and customer flexibility to lower the maximum load on the regional and distribution networks. Decreased demand on main appliances and fewer hours of congestion will enable appliances to last longer and reduce transmission network losses. This occurrence might result in delayed investments in the network, both due to the longer service life of components and because the network's capacity is better used. In this sense, flexibility might serve as a temporary substitute for online investing.

Flexibility can improve supply security by reducing outages caused by overloaded power components such as transformers and high- and low-voltage networks. Additionally, flexibility can aid in maintaining the quality of voltage by distributing consumption more evenly (Sæle et al., 2016).

End customers can save money by balancing their usage with the introduction of electricity tariffs. Additionally, end-users will be able to negotiate a reduced grid rent from the grid company if this results in the grid company deferring or avoiding investments due to network consumers paying for the network company's expenditures through network rent.

Customers who have a spot pricing agreement with their power supplier will save money by shifting their usage away from times of peak grid load. Electricity prices will be higher during periods of high demand than during periods of low demand.

End-users may potentially earn money by selling flexibility if doing so is more advantageous than responding to price signals from the prospective power link in the grid lease (Heiene & Hillesund, 2018).

Certain technologies are needed to achieve the highest amount of flexibility and for homeowner energy efficiency. Section 2.2 of the literature review explains the most relevant technologies and concepts related to the automation of smart homes and the increase of energy efficiency and grid flexibility.

2.2 Smart Homes and AI

Automated smart homes are at the centre of this thesis. Smart homes have been around for a while and have become more advanced and intricate over time. Still, the full potential of smart homes remains untapped, owing to the systems' complexity and variety, poorly built, and configured installations, and the frequent occurrence of inefficient control techniques. In summary, these issues result in two undesired circumstances in the "not-so-smart" home: energy consumption remains greater than necessary, and users are unable to enjoy complete comfort in their automated houses (Reinisch et al., 2015). This thesis explores a complete system model incorporating artificial intelligence that will aid smart homes living up to their full potential in the future.

This section reviews current literature on smart homes and building automation, and the internet of things, which are the basis for a more automated smart home system. It furthermore gives some background on AI and ML, which would serve as the intermediaries between smart homes, the grid, and energy producers.

2.2.1 Smart Homes

The phrase "Smart Home" refers to a collection of electronic gadgets and sensors that may be managed remotely (or locally) via a phone, computer, or other devices. These devices frequently have their dedicated app or interface for controlling other devices within a particular ecosystem. For example, Philips Hue smart lights are Smart Home devices, and the manufacturer maintains its dedicated app for controlling other Philips Hue devices.

The definition of what a smart home entails has advanced and expanded, just as the smart home itself. Very general definitions such as calling it a home with advanced automation systems (Smart Home Energy, 2020) to more detailed definitions such as Cooks idea that a smart home “is that computer software playing the role of an intelligent agent perceives the state of the physical environment and residents using sensors and then takes actions to achieve specified goals, such as maximizing comfort of the residents, minimizing the consumption of resources, and maintaining the health and safety of the home and residents" (Cook, 2012).

Craven (2020) defines a smart home as "a house with highly advanced automatic systems for lighting, temperature control, multimedia, security, and other functions". Meaning that the home will appear "intelligent" because its computer system can monitor so many aspects of daily living (Alonso et al., 2011).

The more sophisticated and complex smart homes become, the more intricate will the definitions be. For this thesis, a more general understanding of the smart home will suffice as the focus lies on the connection of machine learning systems that control and manage the electricity use within a smart home.

According to Schachinger et al. (2017), smart homes are meant to maximize efficiency and save operating costs by connecting the building's different energy and security systems over a single network. However, smart buildings typically have extra tools and controls. Often, they let building managers remotely operate systems through a smartphone or other hand-held device. Additional connections, such as a business's schedule, enable smart buildings to intelligently and automatically choose when to switch on lights or heat meeting rooms. Their software tools make it easier than ever for building managers to monitor energy use and determine the return on investment on their investment (Schachinger et al., 2017)

Additionally, the rising amount of data available due to the growth of smart infrastructures in the context of the Internet of Things (IoT) stimulates artificial intelligence technologies (Schachinger et al., 2018).

Modelling building processes to anticipate their behaviour is a critical undertaking in the energy management of buildings. Rather than relying on sophisticated, costly, and building-specific modelling by domain specialists, learning-based approaches such as neural networks or ML may be used to discover intrinsic process behaviour in the rising quantity of accessible monitoring data (Schachinger et al., 2018).

This thesis proposes to utilize an autonomous ML system to unify the prediction of important time series related to energy consumption and comfort requirements for smart homes.

2.2.2 Internet of Things

IoT has revolutionized our lives and changed how we conduct day to day activities and control the home environment. The largest market for IoT devices is the smart home as they allow users to automate tasks and services, increase comfort, and help realize the vision to connect the world through machine-to-machine communication.

A definition by Tan and Wang (2010) describes IoT as such: “Things have identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environment, and user context” (p.1). The concept of IoT is credited to help realize the vision of a connected world through machine-to-machine communication over the internet.

The network connecting the devices and applications is the essential feature of the smart home, as it is this element distinguishes a smart home system from a home that is simply equipped with individual, advanced technology (Fabi et al., 2017). The network allows the real-time exchange of information between the building and the users as it connects and coordinates all devices and applications installed in the smart home system (Fabi et al., 2017).

The developments of smart sensor systems have led to a new era of universal networks (Suryadevara & Mukhopadhyay, 2015). The increase in users of the internet and advancements in global computing widely enables internet-connected everyday things. IoT has become an integral part of the modern smart home and allows households to increase security and comfort and automate tasks and services (Davis et al., 2020). Indeed, the largest market for IoT devices is the smart home market - globally, 120 new IoT devices connect to the internet per second, and the global smart home market was projected to reach 99.41 bill USD in 2021 (Holst, 2021).

IoT does come, however, with its challenges that can be related to physical, network, software, and encryption risks. These risks stem from a multitude of factors. For one, vendors and manufacturers are under constant pressure to win the market and therefore neglect security issues favouring market domination. Especially lesser-known companies get away with not following privacy and security standards, as more prominent companies may have more robust security stances. Additionally, security studies usually target mostly more prominent companies

Furthermore, there are little to no security standards for IoT devices; this leads to security weaknesses uncovered during usage when it is often too late to fully reverse these risks within the installed technology (Davis et al., 2020).

Lastly, a large-scale empirical analysis by Kumar et al. (2019) has shown that Weak and easily hackable passwords often fail to protect IoT devices, leaving homeowners vulnerable to privacy and security risks. The technology used in smart homes is already vulnerable to privacy and safety concerns; ML systems could amplify these issues due to the need for extensive and often personal data. Before looking into regulations concerning these issues, a basic outline of AI and ML are given in the next section.

2.2.3 AI and ML

When the World Wide Web was created in the 1990s, it changed our way of communicating, living, and doing business. This development resulted in a five-year dot com boom followed by a dramatic bust in 2000. Shortly after, the era of "big data" was hauled in by the emergence of tech giants such as Google, Amazon, and Facebook. "Big data" has since been accompanied by the promise of solving complex world problems, albeit it comes with its potential to wreak havoc and cause duplicity and misfeasance (White, 2020).

The rise of the Internet has made way for ever more advanced and intricate technologies, making our world better, more comfortable, more efficient, and to an increasing extent, interconnected.

One of these emerging technologies is Artificial intelligence (AI) and, more specifically, machine learning (ML) systems. They have the potential to increase the well-being and security of countless people. However, no one thing with significant impacts such as these technologies come without its dangers and challenges (White, 2020). The following section gives an account of the technological background of AI and ML.

AI, as a concept, is nothing novel. Indeed, the idea of automated machines has been around since antiquity (Steele, 2019). Some even claim that the fundamental logic principles of AI are rooted in Aristoteles work (384-322 BC). He was the first that attempted to apply a binary system, which was based on Pythagoras dualistic approach in geometry, to everyday objects and beings (Steele, 2019). A general definition of AI describes it as attempting to make machines "'perform functions that require intelligence when performed by people"(Sartor, 2020).

A more detailed definition of AI provided by the High-Level Expert Group on AI, launched by the European Commission, explains AI as:

> *"Artificial Intelligent (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions"* (AI HLEG, 2019, p. 6).

However, modern AI systems can only perform a small percentage of the actions mentioned in the definition and seldomly combine more than one specific activity - such as picture recognition or language processing - they have been trained for (AI HLEG, 2019).

Artificial intelligence and large data

In the last decade, artificial intelligence has advanced at a breakneck pace. It has developed a solid scientific foundation and resulted in several successful applications. It enables economic, social, and cultural growth; energy sustainability; improved health care; and information dissemination. These opportunities come with significant hazards, including unemployment, inequality, discrimination, social isolation, monitoring, and manipulation. Since AI began to focus on the application of machine learning to large amounts of data, it has made significant strides (Sartor, 2020)

Machine learning algorithms identify connections in data and construct matching models that connect probable inputs to accurate outputs (predictions). In machine learning applications, artificial intelligence (AI) systems learn to make predictions after being trained on massive amounts of data. Thus, AI has developed a voracious appetite for data, which has fuelled data collecting in a self-reinforcing spiral: the development of AI systems based on machine learning assumes and encourages the generation of massive data sets, dubbed big data. Integration of AI with big data can yield numerous benefits for economic, scientific, and societal advancement. However, it also adds to hazards for people and society, such as widespread surveillance and influence over citizens' behaviour and polarisation and division in the public realm (Sartor, 2020).

Artificial intelligence and personal data

Numerous uses of artificial intelligence analyse personal data. On the one hand, personal data may be utilized to augment data sets used to train machine learning systems, specifically to construct their algorithmic models. On the other hand, similar models may be used to personal data to conclude specific persons (Sartor, 2020)

According to Sartor (2020), AI enables the analysis, forecasting, and influencing of human behaviour, transforming such data and the consequences of its processing into valuable commodities. AI enables automated decision-making in fields where complicated decisions must be made based on various circumstances and non-predefined criteria. Automated predictions and choices are frequently less expensive and more exact and unbiased than human ones because AI systems can avoid common errors of human psychology and may be subjected to rigorous controls. However, computer choices might be incorrect or biased, repeating and adding human biases. Even when automated assessments of persons are fair and accurate, they are not without risk: they may have a detrimental effect on the individuals under surveillance, chronic evaluation, persistent influence, and possible manipulation.

The AI-based processing of massive amounts of data on individuals and their activities has significant social implications: it creates the potential for social knowledge and improved governance, but it also risks devolving into the ‘surveillance capitalism' and ‘surveillance state' extremes (Sartor, 2020)

Still, despite the processes by which AI models are built are relatively well understood, how these systems attain the final result or decision is much less apparent, which has led to describing said systems as “black-box” systems (Simonite, 2017 Sartor et al., 2020).

Machine Learning

As I.J. Good once phrased it, “the first ultra-intelligent machine is the last invention that man need ever make” (Heaven, 2020). Machine learning (ML) has the potential to solve complex problems such as public health crisis, climate change, and failing democracies by being able to think and make decisions like us or even better, for more extended periods, and at a faster rate than any human can (Heaven, 2020).

Machine learning is a subset of artificial intelligence. Although all machine learning is considered AI, not all AI is considered machine learning. For instance, symbolic logic - rules engines, expert systems, and knowledge graphs – can all be classified as artificial intelligence, but none of them is machine learning (Nicholson, 2020).

One feature that distinguishes machine learning from knowledge graphs and expert systems is its capacity to adapt to new data; in other words, machine learning is dynamic and does not require human involvement to make specific adjustments. As a result, it becomes less fragile and less dependent on human expertise.

Arthur Samuel, a pioneer of machine learning, defined machine learning as a "discipline of research that enables computers to learn without being explicitly programmed" in 1959. In a way, machine-learning systems adapt to the data they are exposed to (Nicholson, 2020).

The "learning" component of machine learning implies that machine learning algorithms seek to optimize along a specific dimension; that is, they often seek to decrease error or maximize the chance of their predictions being correct. This is referred to as an error function, a loss function, or an objective function, depending on the aim of the algorithm.

But how are mistakes minimized? One approach is to develop a framework that multiplies inputs to make educated estimates about their nature. The algorithm produces various outputs/guesses because of the inputs. Typically, the initial estimates are often incorrect, and if fortunate enough to have ground-truth labels for the input, one can determine how incorrect the assumptions are by comparing them to the truth and then modifying the algorithm accordingly. That is the function of neural networks. They continue monitoring errors and changing their settings until they cannot obtain any further reduction in error.

In a nutshell, they are an optimization method. If the algorithms are tuned properly, they will decrease their mistake by guessing and guessing and guessing some more (Nicholson, 2020).

For the context of this thesis, the term of machine learning is used to cover all types of smart systems, whether these would be neural networks or deep learning in a real-life context, as the concern is related to the justice implications of AI and ML rather than the exact workings of such systems. The following section reviews how current policies are addressing the topic of AI.

2.3 The Policy Perspective

As of late, energy policies have mainly been focused on promoting the use and adaption of more energy-efficient appliances. However, the topic of automation in the energy context has been somewhat neglected, even though automation controls play an integral part in increasing energy efficiency and aid grid flexibility (Fabi et al., 2017). However, the general data protection regulation (GDPR) is an exemption and is currently considered one of the strictest data laws. How it addresses AI is the topic of the next section.

The General Data Protection Regulation (GDPR) is hitherto the strictest privacy and security law globally (Wolford, 2018). The regulation is based on seven principles *lawfulness, fairness and transparency, purpose limitation, data minimisation, accuracy, storage limitation*, *integrity, confidentiality,* and finally, accountability. Article 5-11 of the GDPR can be consulted for a more detailed version (Intersoft Consulting, 2016).

The GDPR is based on the 1950 European Convention of Human Rights, which states that “Everyone has the right to respect for his private and family life, his home and his correspondence” (Wolford, 2018). Not long after the internet was invented in 1983, the European Data Protection Directive was passed in 1995, instituting basic privacy and security guidelines and standards. However, as the development of the internet progressed, a more “comprehensive approach to personal data protection” was needed (Wolford, 2018), which resulted in the current GDPR.

Bypassing the GDPR in 2018, Europe has established a firm stance on privacy and security issues to protect people in the age of the internet and cloud-based services. Despite being drafted and passed in the EU, any organisation that targets or collects data linked to individuals in the EU must comply with the GDPR (Wolford, 2018).

The general definition of personal data is whether an individual is identifiable by the provided information. Nonetheless, according to the GDPR, all data connected to a person is considered personal data, even if identifiers have been removed (White, 2020).

The GDPR applies to both data controllers and processors. A data processer is responsible for collecting the data, whereas a data controller is in charge of deciding the objective and use of the collected data (White, 2020). Contrary to prior regulations, the GDPR includes more direct responsibility for the data controllers and processors. Case in point, both individuals and authorities can hold the controllers and processors accountable in the case that data or data methods are not in compliance with the GDPR (White, 2020)

As part of the European economic area (EEA), Norway is bound to comply with the newly released GPDR (easyGDPR, 2017)

A weakness with the GDPR that can be pointed out is that consumers and business leaders are still struggling to understand the law. The lack of understanding and awareness among consumers can lead to less GDPR compliance, especially in SME´s (Wolford, 2019). A more detailed look into how the GDPR addresses AI is given in section 2.3.1.

2.3.1 The GDPR and AI

One cannot think of the GDPR or AI without the other due to the GDPR being the most impactful law on creating a more regulated data market globally (Spyridaki, 2020).

The convergence of AI and the GDPR has raised conversations around critical issues related to policies in the EU. But how much does the GDPR restrict or enable AI?

Although the GDPR somewhat restricts or complicates the use of personal data within an AI context, the regulations might help build the trust needed for full AI acceptance among consumers and governments alike by establishing an insincere feeling of safety and security among users (Spyridaki, 2020).

Even though AI is not explicitly addressed in the GDPR, various terms in the regulation apply to AI and are even challenged by how personal data is processed in AI applications (Intersoft Consulting, 2016; Sartor, 2020). AI challenges certain aspects of the GDPR, such as “purpose limitation, data minimisation, the special treatment of' sensitive data', [and] the limitation on automated decisions” (Sartor, 2020, p. 6).

AI thrives on big data, which means that large quantities of data related to individuals, habits, and relations are collected and processed, often without a clear purpose for using the collected data (Sartor, 2020). Still, the GDPR can guide AI-based processes by ensuring that data subjects are informed of the purpose, and limits of each AI process their data is involved in. Furthermore, purpose limitation is consistent with AI and big data by applying the concept of compatibility, which allows the reprocessing of personal data when the purpose is compatible with the objective the data was collected for initially. The principle of data minimization can be met by encoding personal data and removing distinct details that could make individuals easily recognizable (Sartor, 2020).

Additionally, according to Spyridaki (2020), specific requirements within Article 22 of the GDPR impinge on AI-based decisions concerning individuals. This goes especially for automated decision making and profiling. However, the complexity of the matter, and the far-reaching negotiations and compromises made during the legislative process, can limit the comprehensibility of the provisions concerning AI in the GDPR. Accurate reading of the letter of the law, while keeping the intentions of the legislator in mind, is necessary to understand these provisions correctly and to be able to apply them (Spyridaki, 2020).

The GDPR may not need an extensive overhaul to address and include AI applications. Still, the regulation does not give a clear answer to numerous AI-related data protection issues, leading to uncertainty and increased costs that can slow down the development of AI systems. Especially data controllers and subjects should receive better guidance on applying AI, which will lower uncertainty and costs alike (Sartor, 2020).

To sum up, the GDPR does not hinder the advancement of AI systems if these systems are designed and implemented appropriately. However, the GDPR does not provide clear guidelines on how to achieve AI systems that balance data protection and the social or economic interests they are built for (Sartor, 2020). Instead, it provides imprecise clauses and open standards, which increase the uncertainty around this novel, complex technology even more (Sartor, 2020).

The European Commission, being aware of the shortcomings of the GDPRinn providing clear policies and guidelines for the ethical use of AI, has welcomed supplementary initiatives to build trust in AI. These initiatives include the *Ethics Guidelines for Trustworthy Artificial Intelligence*, a *Report on liability for Artificial Intelligence and other Emerging Technologies*, and the *Declaration of Cooperation on Artificial Intelligence* (European Commission, 2021a). Whether or not these additional initiatives incorporate clear guidelines and regulations that encompass the complex nature of AI systems and fill the gaps within the GDPR will have to be seen. Either way, interdisciplinary discussions on the fair and ethical employment of AI and ML are crucial to continuing the road towards a better understanding of the systems and the policies needed to ensure that no one gets left behind.

It is critical to guarantee that the development and deployment of AI tools take place within a socio-technical framework – including technologies, human capabilities, organizational structures, and norms – that protects and enhances individual interests and the common good. To offer regulatory support for the development of such a framework, ethical and legal principles, as well as sectoral laws, are required (Sartor, 2020).

The ethical principles enshrined in the EU charter, EU treaties, and national constitutions are autonomy, harm prevention, fairness, and explicability; the legal principles enshrined in the EU charter, EU treaties, and national constitutions are the rights and social values. Sectoral rules include, but are not limited to, data protection, consumer protection, competition law, and other areas of law such as labour law, administrative law, and civil liability protected by them. The widespread effect of artificial intelligence on European society is reflected in the breadth of legal concerns it poses (Sartor, 2020).

Apart from legislation and public enforcement, sufficient protection of citizens against the hazards associated with AI misuse requires the countervailing power of civil society to uncover abuses, alert the public, and activate enforcement. Citizens-empowering technologies driven by artificial intelligence can play a critical role in this effort by enabling citizens to not only protect themselves from unwanted surveillance and 'nudging,' but also to detect unlawful practices, identify instances of unfair treatment, and distinguish between fake and untrustworthy information (Sartor, 2020; Spyridaki, 2020).

In conclusion, the GDPR alone will not guarantee the fair implementation and diffusion of AI and ML. It will take more to ensure ethical and just development. And the application of AI systems. But what is ethical? And what is just?

Section 2.4 discusses ethics in general and in connection to AI to give some insights into where inequalities come from, who should be responsible for reducing them, and how social justice can help focus on different types of justices.

2.4 Ethics, Inequality, and Justice

The energy transition has introduced and reimagined technologies that have helped to decrease emissions globally. Still, by focusing on technologies, their impact on humans is often neglected, and inequalities on a local, regional, and global scale can be amplified. Ethics and justice theories are applied to technological changes to counteract such a development and introducing a socio-technological perspective.

A socio-technological perspective emphasizes the interdependence and inextricable linkages between people (sociological systems) and information and communication technologies (ICTs) and emphasizes the co-evolution of these systems. It also stresses that both systems must be optimized in concert to produce positive practical outcomes in practice (Sawyer & Jarrahi, 2015). This perspective allows focusing on the processes and systems around technology just as much as the technology itself. This means that social and technological constitutions are jointly significant, which is the basis for the term "sociotechnical." According to the mutual constitution, academics should examine a phenomenon without making a priori judgement about the relative relevance or significance of social or technological components (Sawyer & Jarrahi, 2015).

A rudimentary outline of the concepts, the basics of ethics, as well as the origin and foundation of inequality, and different social justice streams are presented in the ensuing section to understand how social justice and ethics can be used to build fair AI and ML systems,

2.4.1 Ethics in AI

AI has an immense potential to impact society positively. Still, ethical concerns are prevailing and need to be considered during all AI development and deployment stages. These concerns are related to both the humans involved in designing, developing, and using the technology and the machines themselves, which can also be referred to as Artificial Moral Agents (AMAs) to account for their role in decision-making and discrimination against specific groups of individuals (Steele, 2019)

The research on ethics is based on the aspiration to increase the well-being and happiness of human lives (Kraut, 2018). Aristoteles describes this as eudaimonia, which is, according to him, the highest good and exists as an end in itself (Kraut, 2018). The modern smart home is designed to contribute to human well-being by increasing comfort and security.

A second important element in Aristoteles ethical theory is that its methodology must be in accordance with the context of good action (Kraut, 2018).

Synthesizing on Plato´s teaching, which considers training in philosophy, sciences, and mathematics crucial to develop an understanding of virtuousness, Aristoteles believed that in order to apply ethics, humans have to develop the emotional and social skills required to increase human wellbeing through practice (Kraut, 2018)

Aristoteles considered the amalgamation of good education and habits to be of the essence to comprehend which alternative in each circumstance would be best supported by reason. In other words, practical wisdom may not be acquired exclusively by learning general rules (Kraut, 2018).

By operating on Aristoteles understanding of ethics, fair and ethical AI should not solely be based on policies and regulations but on continued reflections of best practices during the development and deployment lifecycle of each technology. It puts the human back in focus.

Current guidelines for ethical AI are based on the ideas of fairness, responsibility and safety, privacy and security, inclusiveness, transparency, and accountability (Intersoft Consulting, 2016). Nevertheless, despite the implementation of strict regulations, AI technology tends to discriminate against certain groups of a population unconsciously.

Steele´s (2019) concerns on the matter are voiced in questions such as "Which moral principles should we follow? How do we avoid perpetuating biases when developing algorithms? What, if any, rights should be granted to robots?". Whichever way we look at the issue, there is no simple answer, and a continuous debate on the matter will be necessary to ensure the best possible solutions for the myriad of applications for AI.

This issue was demonstrated by Jobin et al. (2019) that identified that despite a large number of documents addressing ethics and AI, significant divergences across ethical principles could be seen on four fundamental factors:

1. how ethical principles are interpreted
2. why they are believed to be essential
3. the topic, domain, or people to whom they apply, and
4. how they should be applied

These conceptual and procedural divergences demonstrate ambiguity about which ethical principles should be emphasized, how ethical principle conflicts should be handled, and how they may jeopardize efforts to create a worldwide agenda for ethical AI. For instance, the demand for ever-larger, more diverse datasets to 'unbias' AI may clash with the desire to offer individuals more choice over their data and usage to respect their privacy and autonomy. Similar differences exist between the attitude of avoiding harm at all costs and that of allowing some degree of harm as long as risks and rewards are balanced. Furthermore, risk-benefit analyses are likely to produce inconsistent outcomes depending on who is well-being is being optimized and by whom. These divergences and conflicts highlight a chasm between articulating principles and their application in practice (Jobin et al., 2019).

Current ethics guidelines for AI published by the European commission try to establish practices that help make AI more ethical and just.

According to these guidelines, trustworthy AI should be the following:

1. legal - that is, it should adhere to all applicable laws and regulations
2. ethical - adhering to ethical standards and ideals
3. robust - both technically and socially.

The Guidelines provide a set of seven critical conditions for AI systems to satisfy in order to be considered trustworthy. A detailed assessment list is intended to aid in the verification of the implementation of each of the critical requirements:

- Human agency and oversight: Artificial intelligence systems should empower humans by enabling them to make informed choices and promoting their fundamental rights. Simultaneously, adequate supervision mechanisms must be established, which may be accomplished by human-in-the-loop, human-on-the-loop, or human-in-command techniques.
- Technical Robustness and Security: Artificial intelligence systems must be resilient and secure. They must be safe, with a contingency plan in place in the event of an error, as well as accurate, dependable, and repeatable. That is the only method to ensure that deliberate and inadvertent harm is reduced and averted.
- Privacy and data governance: in addition to guaranteeing complete respect for privacy and data protection, sufficient data governance procedures must be in place to assure the data's quality and integrity and enable legitimate access to data.
- Transparency: data, systems, and business models based on artificial intelligence should be transparent. Traceability techniques can aid in this endeavour. Additionally, AI systems and their choices should be communicated in a manner that is appropriate for the stakeholder. Humans must be aware that they are interacting with an AI system and be educated about the system's capabilities and limitations. • Diversity, non-discrimination, and fairness: Unfair bias must be avoided, as it can have a number of negative consequences, ranging from the marginalization of vulnerable groups to the exacerbation of prejudice and discrimination. AI systems should be accessible to everyone, regardless of handicap, and engage all key stakeholders throughout their life cycle to promote diversity.

- Economic and environmental well-being: Artificial intelligence systems should benefit all humans, including future generations. As a result, they must be sustainable and ecologically beneficial. Additionally, they should include the environment, including other living things, as well as their social and societal implications.
- Accountability: Mechanisms for ensuring responsibility and accountability for AI systems and their consequences should be established. Auditability, which permits the evaluation of algorithms, data, and design processes, is essential in this regard, particularly for mission-critical systems. Additionally, sufficient and accessible remedies should be guaranteed (European Comission, 2021).

The guidelines are a holistic approach to the better implementation of AI. How effectively these guidelines are implemented in real-life contexts is a question that was investigated during the fieldwork phase of this thesis.

Before moving on to reviewing social inequalities and justices in the next section, a different approach to AI ethics given by Kate Crawford in her new book, Atlas of AI, is shortly outlined to account for more extensive, distributive injustice within AI.

The book explores artificial intelligence's hidden costs, from natural resources and labour to privacy, equality, and freedom, framing the technology as a collection of empires, decisions, and acts that rapidly eradicate the possibility of global sustainability. Crawford, a senior principal researcher at Microsoft's FATE (Fairness, Accountability, Transparency, and Ethics in AI) division, view AI as a symbiotic term for imperial design. Artificial intelligence, machine learning, and other ideas are seen as attempts, practices, and embodied material manipulations of global power levers (Spezio, 2021).

The book maps solutions to how AI is produced and how its production imprisons humans by taking power and materiality seriously and putting aside issues about intelligence. The concept is that AI is not about comprehending or seeking intelligence, but rather a "register of power," a metaphor that encompasses social, political, and economic power, as well as the insatiable demands AI makes on electric power infrastructures and nonhuman nature[1] (Crawford, 2021). This perspective touches upon distributive justice by looking at AI from the cradle to the grave and procedural justice by focusing on the decision-makers, people wielding power over the processes of AI.

For this thesis, the focus on injustices is related to the development (programming) of AI systems and energy distribution.

The topic of social inequalities and the relevance of social justice aiding technologies achieving a fair energy transition is the subject of section 2.4.1.

2.4.2 Social Inequality

According to Rousseau et al. (2002), there exist two main types of inequality. The first one is understood as a natural, physical inequality grounded on characteristics such as health, age, height, strength, and qualities of mind and soul. The second type of inequality is that of moral or political origin. This type depends on “convention and is established, or at least authorized by the common consent of humankind” (Rousseau et al., 2002, p. 87). The latter inequality is expressed through the enjoyment of certain privileges to the prejudice of others. These privileges can take the shape of excess in wealth, power, respect, or control (Rousseau et al., 2002).

The creation of property and the division of work mark the start of moral inequality. Property enables the affluent to dominate and exploit the impoverished. However, at first, interactions between affluent and poor are perilous and unstable, eventually escalating into a state of war.

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[1] Reviewing the topic of power in AI and the distribution of benefits over the lifecycle of AI, goes beyond the scope of this thesis but are important factors in relation to the larger context of distributive and procedural justice and are therefore integrated in the literature review and discussion.

To evade this war, the affluent dupe the poor into forming a political organization. The poor assume that this construction would ensure their liberty and safety, but it fixes the pre-existing ties of control by enacting laws establishing inequality. The disparity has become more disconnected from man's fundamental nature; physical inequality has been supplanted by moral inequality (Rousseau et al., 2002).

Rousseau's account of society's operation is stage oriented. Beginning with the rich's deception, he saw society growing increasingly unequal, culminating in tyranny or the unfair control of one man overall. This development is not a foregone conclusion, but it is plausible. Conflict and dictatorship become conceivable when wealth becomes the measure by which persons are judged. According to Rousseau et al. (2002), the worst type of contemporary society is one in which money serves as the sole unit of value.

Rousseau's conclusion to *the Discourse* is unambiguous: inequality exists solely in relation to physical distinctions between persons. However, inequality in modern societies results from a process of human development that has perverted man's nature and exposed him to rules and property, both of which encourage a new, unjustified kind of inequality dubbed moral inequality (Rousseau et al., 2002).

For this thesis, merely the moral, political inequality, as discoursed by Rousseau, is relevant to discussing the fair and just diffusion of AI systems for energy management.

Applying Rousseau’s understanding of inequality to this research, politics are considered a source of inequality, and it is essential that politicians and policymakers set the stage to decrease and eventually obliterate inequalities connected to fair energy distribution.

Additionally, processes and procedures surrounding AI can amplify or dimmish the fairness of these systems, which is why social justice is employed to help zoom in on injustices encompassing AI.

Section 2.4.2 gives insight into the concept of social justice and how it relates to AI and energy management.

2.4.3 Social Justice

Justice is a central concept in both ethics and legal and political philosophy. We apply it to individual behaviours, laws, and governmental policies and believe that if they are unfair, this is a compelling, if not decisive, reason to reject them in each case. Justice was traditionally considered one of the four cardinal virtues (and occasionally the most essential of the four); in contemporary times, John Rawls famously characterized it as the "first virtue of social institutions" (Miller, 2017; Rawls, 1999, p. 3).

The foundations of Western civilization's traditional concept of justice may be traced back to the Judeo-Christian biblical (religious) tradition, which emphasizes God's bestowal of merited good or evil throughout one's lifetime. Given this concept's prominence in social life, it is unsurprising that it has been explored extensively throughout scholarly history. In classical Greek philosophy, significant academic publications include Aristotle's (1926) Nicomachean Ethics and Plato's (2004) Republic. These writings served as a foundation for subsequent social sciences and philosophy, motivating researchers such as Karl Marx, Thomas Hobbes, and John Stuart Mill to create concepts about the social arrangements necessary to establish a just society.

Social justice theory emerged in the early nineteenth century during the Industrial Revolution and following European civil wars, which sought to establish a more equitable society and end capitalist exploitation of human labour. Due to the glaring divisions between the affluent and the poor during this era, early social justice campaigners concentrated their efforts on capital, property, and wealth distribution.

By the mid-twentieth century, social justice had grown beyond economics to encompass other domains of social life, such as the environment, race, gender, and other sources and expressions of injustice. Simultaneously, the concept of social justice grew beyond the nation-state (or government) to encompass a universal human component. For instance, governments currently calculate income disparity by comparing individuals within the same country. However, social justice may also be applied on a larger scale to humankind. As the United Nations puts it, "slaves, exploited labourers, and repressed women are first and foremost victimized human beings whose location is irrelevant in comparison to their conditions" (Pachamama Alliance, n.d.).

In modern culture, the normative-philosophical study of justice continues to thrive. In this regard, one may point to some of the most prominent, though disputed, scholars of the 1970s, such as Barry (1989), Miller (1976), Rawls (1971), and Walzer (1983). Complementary, but not necessarily parallel to this, the empirical study of justice began to flourish in the late 1950s across social scientific fields, including psychology, sociology, economics, and political science. Thus, historically, justice study has grown within a multidisciplinary framework. (Sabbagh & Schmitt, 2016).

Using a justice-centred approach to the subject of sociotechnical change compels us to think of technology and systems as more than just machines and hardware. It calls for a reframing of what technologies are. From a social-justice view, technologies can be all from "mechanisms of resource extraction that transfer wealth from developing countries to developed ones" to "systems of segregation that separate negative harms from the positive attributes across different classes of consumers" (Sovacool and Hess, 2016, p. 19). Consequently, technologies have the power to aid human rights misuses, increase existing inequalities, influence national discourses, and endorse specific methodologies of social and economic developments.

Dividing social justice into multiple streams can be traced back to Nancy Fraser. She introduced the stream of distributive justice, which is concerned with the equitable distribution of resources, recognition justice – recognition of the different groups within a society-, and representative justice, arguing for proper representation of affected groups (Fraser, 1998).

The modern social justice theory is an amalgamation of religious and naturalist notions of justice. It can be divided into four main streams. These are 'distributive justice', 'procedural justice', 'cosmopolitan justice', and lastly 'recognition justice' (Sovacool and Hess, 2016).

For this thesis, energy justice, which is rooted in social justice and sustainable development (Guruswamy, 2010), is used to investigate the justice implications of AI energy management systems. Social justice and energy justice are reviewed further in the theory chapter.

3 Logics of Inquiry

Both inductive and abductive logic of inquiry is used to answer the research questions of this thesis. The inductive research method will answer the first research question, whereas an abductive research method is utilized to answer the second research question concerning ethical and justice implications. The two logics of inquiry will be explained in the following sections.

3.1 Inductive

The purpose of inductive logic is to develop restricted generalizations regarding the distribution of seen or measured qualities of persons and social events and patterns of relationship among them. While simple descriptions of people or events are feasible, researchers sometimes require more broad descriptions to address their inquiries, descriptions of the features of categories, groups, or collectivities of people. To address the study question, this logic of inquiry needs the researcher to select a set of traits, gather data on them, and then make generalizations based on the findings. According to this logic of inquiry, social reality can only be seen or quantified through the use of researcher-defined terms.

Inductive logic aims to generate limited generalizations from observed or measured physiognomies of individuals and social phenomena (Blaikie and Priest, 2019). Part of this research consists of inductive content, which required to make observations and measurements that exposed patterns and regularities that helped explain certain phenomena and eventually lead to a theory that could, in turn, be tested through a series of hypotheses. While identifying patterns in the data is critical, establishing patterns alone is unsatisfying. Such pattern explanations are only the beginning. Inductive logic is a critical tool for addressing 'what' questions, albeit it is not the only one.

It is critical to emphasize that the descriptions generated by inductive logic can not be viewed as universal rules, as its initial proponents asserted. (Blaikie & Priest, 2019, pp. 59–70).

The inductive logic of inquiry does not disregard previous research and theories when phrasing the research questions but instead tries to generate meaning from the knowledge and data collected. It is based on learning from the patterns discovered, and the experiences gained to formulate a conclusion. Inductive research starts with the case, makes observations, and can then generalize and establish regularities (Dey, 2004).

Furthermore, inductive research leaves the possibility to adjust the research direction and objectives during the research process. The logic of induction is used in this thesis to help make predictions of future behaviour and developments within an observed phenomenon. For this thesis, it gave insights into the possibly encountered obstacles on different levels of future implementations of home automation into the grid.

3.2 Abductive

According to Giddens, the essential subject matter of the social sciences is the shared knowledge that social actors employ to negotiate their interactions with others and make sense of social activity. A social scientist can not explain any social action without first determining what social actors know, either explicitly or implicitly, while engaged in social activity. The tools accessible to a researcher for learning a way of life are the same as those available to anybody wishing to join any social group. Understanding what other people say and do is a talent that competent social actors possess, not the domain of the professional social investigator. As a result, social scientists must employ the same 'mutual knowledge' that social actors make sense of their behaviour. Social research must deal with a social environment that its participants have already defined as significant. To understand this reality, one must first learn what social actors already know and what they need to know to carry out their everyday tasks (Giddens, 1976, 1979). Thus, the concept of abduction is used to describe the process of transitioning from ordinary accounts of social life to technical descriptions of that social activity.

Abductive logic integrates what Inductive and Deductive logic leave out — the meanings and interpretations, the motives and intents that individuals employ in their daily lives and that guide their behaviour — and elevates them to a critical position in social theory and research. As a result, the social world is viewed and experienced from the 'inside' by its members. The goal of the social scientist is to identify and characterize this 'insider' perspective, not to impose an 'outsider' perspective on it.

The use of abductive logic entails constructing descriptions and producing theories anchored in social actors' everyday behaviours, language, and meanings. It consists of two stages:

1. defining these actions and their associated meanings; and
2. generating categories and notions that might serve as a foundation for comprehending the situation at hand (Blaikie & Priest, 2019).

Blaikie and Priest (2019) define the aim of abductive research as making a distinction of the construction of reality according to different actors and how these actors conceptualize, understand, and give meaning to their social world. Furthermore, according to Danermark et al. (2002), abductive research enables the concept of recontextualization. This concept entails observing, describing, interpreting, and explaining a phenomenon, pattern and so forth within the frame of a new context. A known phenomenon can be seen through a new lens through recontextualising and result in original meaning and interpretation of the phenomenon. The aim is not to test the accuracy or truth of a theory but to use theory and observation hand in hand to arrive at novel interpretations of specific phenomena, events, and concepts. Abductive logic does not aim to produce generalizable results but rather concerns itself with certain phenomena and events (Dey, 2004). Abductive research enables the interpretive process, which ascribes meanings to events in a broader context. It lacks, however, a fixed criterion which makes it difficult to assess the validity of a conclusion derived from abductive research.

Abductive logic is most frequently employed in conjunction with idealist ontological assumptions and constructionist epistemology.

The abductive logic of inquiry will be used to recontextualize ethical and justice considerations of automated smart homes in the context of energy justice and how they can be addressed (Danermark et al., 2002; Dey, 2004).

3.3 Ontological and Epistemological Assumptions

Ontological assumptions concern themselves with claims of what kind of social phenomena can and do exist. The conditions of existence and how these phenomena are related falls additionally under the jurisdiction of ontological assumptions. On the other hand, Epistemological assumptions examine the types of knowledge that are possible and the criteria that are suited to decide when knowledge is adequate and legitimate (Blaikie & Priest, 2019).

For this thesis, a constructivist view is deemed appropriate. This method suggests that the physical world is the result of the social scientist bringing order to it. The world is not available for an empirical study to uncover; instead, knowledge is filtered via the researcher's chosen theory.

According to social constructivists, the reality is created via human activity. Members of a civilization collaborate to create the world's properties (Kukla, 2000).

Knowledge is likewise a human product, according to social constructivists, and is socially and culturally created (Ernest, 1999; Gredler, 1997). Individuals generate meaning due to their interactions with one another and the world in which they live.

Reality is subjective, and subjectivity is a necessary component of comprehension. The emphasis is on a holistic approach to phenomena with intricately connected aspects. Understanding phenomena necessitates examining several contexts, including chronological, geographical, economic, historical, political, social, and personal.

Constructivism viewpoint on the ontological state of objects; is that certain items do not exist independently of minds but are instead produced or invented by the mind. As Hacking (1999) argues, “social constructionists tend to believe that categories are not determined by the way the world is but are only handy ways to describe it” (p. 33)

The epistemological assumption is that access to social worlds is only achievable through the language of the actors correspondingly. Theories are not accurate descriptions to be judged on their connection to any discoverable reality, but incomplete accounts of the universe should be compared for their explanatory ability (Kratochwil, 2008). Furthermore, knowledge is produced through mediating between social language and scientific language. Finally, according to this assumption, there are no lasting criteria to establish the truth and validity of knowledge (Blaikie & Priest, 2019). By combining ontological and epistemological assumptions, a holistic view of understanding knowledge is achieved, known as a research paradigm.

As this thesis is mainly concerned with barriers according to peoples understanding and experiences and ethical and justice implications within AI, a constructivist view is used. The ambition is not to create a generalisable theory but make sense of how AI among households and industry experts is perceived and understood.

Additionally, how ethics and justice are grasped in AI development and operation in the energy grid depends on individual experiences and cannot be approached as objective truth.

Chapter four introduces social justice and the development of energy justice.

4 Theory: Social justice and Energy Justice

The path towards a low carbon society is pierced with challenges. Research has demonstrated that transitions can add to existing socio-economic inequalities rather than diminishing them (Nordholm & Sareen, 2021). Often, the most vulnerable groups get unproportionally disadvantaged during an energy transition. Increased energy prices can cause this due to feed-in tariffs enabling a more significant share of renewables in the grid (Nordholm & Sareen, 2021), or in this case, energy-saving technologies that decrease the energy cost of a household are reserved for the wealthier groups that can afford additional appliances.

As Nordholm & Sareen (2021) state in their paper, “a democratic energy transition must help transform spatial patterns of socio-economic activity to bring about a more just energy system”, this notion of bringing about a more just and fair energy system applies to all aspects of the energy transition. This thesis uses the theory of energy justice to analyse how AI and ML can reduce social inequalities rather than translating or even amplifying them.

The following section introduces the social justice theory as the foundation for energy justice, to then review and connect the theory of energy justice to the research purpose of this thesis.

For this thesis, energy justice is used to investigate the distribution, processes and recognition justice for increased energy efficiency in households and increased flexibility in the grid by implementing ML systems.

4.1 Social justice

As social justice was introduced in the literature review, this section will give a more detailed account for the four streams - distributive, procedural, cosmopolitan, and recognition - of social justice and reviews a few other social justice perspectives in the technology context.

When talking about ‘distributive justice’ today, three different features of distribution must be considered, the “what”, “who”, and “how”. The first is concerned about the nature of the goods that are to be distributed. This can be anything from wealth, food, and clothing to more intangible things such as respect and power. The “who” is related to the entities the goods are to be distributed amongst, whether this is the current population, future generations, members of a particular demographic, or all of humankind. Lastly, the “how” is about the way the goods are dispersed. It asks whether it should be based on merit, utility, needs, property rights, entitlement, or other features (Sovacool and Hess, 2016).

'Procedural justice', on the other hand, is focused on the process and "the fairness and transparency of decisions, the adequacy of legal protections, and the legitimacy and inclusivity of institutions involved in decision-making" (Sovacool and Hess, 2016, p. 19).

The third stream of social justice theory, 'cosmopolitan justice', claims that the principles of justice must apply universally to all humankind, independent of one's identity.

Lastly, 'recognition justice' scholars challenge the discourse of the two first streams, distributive and procedural justice, and instead propose a jargon of distributive and post-distributive justice, which increases the emphasis on tolerance and respect for marginalised and vulnerable groups (Sovacool and Hess, 2016).

As a theory, social justice helps to inform on the empirical problem of analysing structural inequality.

However, the different streams of social justice theory do not always align with one another. For once, the cosmopolitan stream concerned with human rights issues calls for a lexical approach to group needs for the most vulnerable and marginalized groups to be prioritised and satisfied before considering other possible injustices or inequalities. On the other hand, distributive justice models are focused on the utilitarian investigation of cost and benefits, and procedural are solely concerned with processes.

Another stream of justice theory, the deontological or absolute, ignores cultural relativism and assumes all humans to be equal, treating every culture as the same without paying attention to local differences.

Lastly, most justice theories focus on the necessities of humans above any other nonhuman genus (Sovacool and Hess, 2016).

Justice and technology have become a widely debated and investigated subject, with several influential and significant works published in the field.

Significant other contributions to the study of justice and ethics in AI have been made by scholars such as Anderson and Anderson, Jill Walker Rettberg, Louise Amoore, and Linda Dencik.

Anderson and Anderson contributed significantly to the development of machine and AI ethics by illustrating the benefits of a principle-based approach for machine ethics, vis-à-vis a case-based approach (Anderson, 2007; Anderson et al., 2006, 2017; Anderson & Anderson, 2010, 2011, 2015, 2018).

Jill Walker Rettberg, who does studies on the impact of technology on humans, and Louise Amoore, who focuses on cloud ethics, are additional contributors to the field (

Cloud ethics examines the ethical and political implications of machine learning and deep neural network algorithms and their role as arbitrators in controlling key domains and places of human engagement. According to Amoore, algorithms have become more important in decision-making processes across a broad range of human activities. If carried out incorrectly, these are necessary procedures that can inflict irreversible harm, if not death. As a result, Amoore believes that ethics plays a critical role in designing algorithms and how algorithms influence us. However, the focus on algorithms is too narrow for this thesis, as AI's influence is not confined to its computing capacity but also the processes and decision-making surrounding its lifecycle (Guha, 2020).

Another, more relevant approach for this thesis is Lina Dencik's concept of 'data justice.' The framework of data justice broadens the scope of the debate by accounting for a slew of issues that are exacerbated in the datafied society, as evidenced by recent scholarship on democratic procedures, the entrenchment and introduction of inequalities, discrimination, and exclusion of certain groups, deteriorating working conditions, or the dehumanisation of decision-making and. These debates highlight the importance of clearly connecting data to issues of power, politics, inclusion, and interests, as well as to established concepts of ethics, autonomy, trust, responsibility, governance, and citizenship (Dencik et al., 2019)

The thesis takes a broader approach to justice in terms of technological development, situating the four streams of energy justice within the context of data justice.

The mentioned scholars and research are by far not including all relevant contributors to the subject of social justice within a technology framework but were used to paint how differently justice and ethics can be used to make sense of how technology can impact social injustices.

For this thesis, energy justice, rooted in the four streams of social justice discussed in this section, is applied to investigate justice and ethical implications related to the diffusion of AI in the energy grid of Stavanger, Norway. This approach is used, as the focus is mainly on energy as a commodity and a human right. The concept of energy justice is presented in section 4.1.1.

4.1.1 Energy Justice

As forementioned, the principles of energy justice originate from social justice based on Fraser's work distinguishing between distributive, recognition, and representative justice streams (Fraser, 1998; Wood, 2018).

At its very beginning, energy justice was mainly concerned with the thought of individuals having the right to enough energy to warm their homes. Since then, it has developed into an ever more complex framework that tries to capture the intricacy of the global energy system.

Energy justice enables us to investigate where possible injustices might occur and how these can be avoided. It further contributes by helping new sections of societies being recognised and bridging the gap between "existing and future research on energy production and consumption when whole energy systems approaches are integrated into research designs" (Jenkins et al., 2016).

Energy justice is a conceptual and analytical tool for philosophers and researchers respectively to apply justice principles to "energy policy, energy production and systems, energy consumption, energy activism, energy security and climate change" (Jenkins et al., 2016; Sovacool & Dworkin, 2015) and helps create a better understanding of how values are built into energy systems (Sovacool et al., 2017). Additionally, energy justice provides a decision-making tool for energy planners and consumers in order for them to make more informed and better energy choices (Sovacool et al., 2017).

Just as the social justice theory, energy justice can be divided into distributional, procedural, cosmopolitan, and recognition pathways of justice (Jenkins et al., 2016; Sovacool et al., 2017).

Just as environmental justice is concerned with a fairer distribution of environmental effects, for instance, climate change and different types of pollution (Nordholm & Sareen, 2021), energy justice´s principles relate to inequalities within the energy life-cycle. In contrast to environmental justice, energy justice has developed a system that supports decision-making within policy and is overall more competent to make a real-world impact (Nordholm & Sareen, 2021).

The different stages of energy, from the cradle to the grave, have fairness and justice implications. The cost of climate change is worse for the poor and developing nations, whereas rich countries receive the potential benefits.

Some of these environmental and social burdens come from having too much energy, such as waste, over-consumption, pollution. On the other hand, they can result from too little energy or lack of access to modern energy services, leading to under-consumption and energy poverty.

Despite these facts, policymakers and planners tend to frame the risks associated with the climate and environment in a space void of morals (Sovacool et al., 2017).

Some researchers argue that the complexity and vastness of the energy and climate issues make it impossible for us to grasp our moral system. Furthermore, due to the dooming developments and pessimistic forecasts of climate change scenarios, people tend to try and avoid confrontation with the subject and to take responsibility and action (Stoknes, 2015). It can go even further, to avoid the negative feelings and a sense of responsibility when it comes to the climate crisis, many people will resort to optimistic biases and offer counter negative information with cheerful outlooks for the future (Stoknes, 2014).

This is where energy justice comes into play. The concept of energy justice gives way for a fair diffusion of both the energy costs and the benefits and underwrites "representative and impartial energy decision-making" (Sovacool et al., 2017, p. 1).

In other words, energy justice applies the notions from social justice theory to the global energy system.

As Sovacool (2017) encapsulates it:

> "*The conceptual framework of energy justice, therefore, involves burdens, or how the hazards, costs and externalities of the energy system are disseminated throughout society; benefits, or how access to modern energy systems and services is distributed throughout society; procedures or ensuring that energy decision-making respects due process and representation; and recognition, that the marginalized or vulnerable have special consideration*" (p. 1).

Based on Sovacool and Dworkin (2015), this energy justice framework connects energy policy and technology with the philosophical concepts shown in the table below and reframes them as justice themes.

Energy justice analytical applications to energy problems.

Topic	Concept(s)	Major philosophical influence(s)	Applications to energy	Injustices	Solutions
Energy efficiency	Virtue	Plato and Aristotle	Energy efficiency: high penetration of efficient service	Inefficiencies involved in energy supply, conversion, distribution, and end-use	Fuel economy standards, energy efficiency labeling, industrial retrofits, utility-scale demand-side management, ascending block rate pricing, advanced metering and smart grids, training and capacity building, consumer education and awareness
Energy externalities	Utility	Jeremy Bentham, John Stuart Mill, Henry Sidgwick	Wellbeing: less suffering, pain, externalities, and disasters associated with energy production and use	The imposition of negative social and environmental costs on society such as traffic congestion, the extractive industries affiliated with energy production, the resource curse, nuclear waste, air pollution, greenhouse gas emissions, and water consumption	Passage of a carbon tax, accurate price signals and tax shifting, and environmental bonds
Human rights and social conflict	Human rights	Immanuel Kant	Universal human rights: an obligation to protect human rights in the production and use of energy	The violation of civil liberties—in some extreme cases death and civil war—undertaken in pursuit of energy fuels and technology, as well as the contribution of energy production to military conflict	Extractive industries transparency initiatives, energy truth commissions and inspection panels, improved social/ environmental impact assessments for energy projects, availability of legal aid to vulnerable groups
Energy and due process	Procedural justice	Edward Coke, Thomas Jefferson, Jürgen Habermas	Due process: free prior informed consent for the siting of energy projects; fair representation in energy decision-making	Approaches to energy siting that ignore or contravene free, fair, and informed consent, and/or do not conduct adequate social and environmental impact assessments	Better information disclosure, broader community involvement and participation
Energy poverty	Welfare and happiness	John Rawls, Amartya Sen, Martha Nussbaum	Accessibility and subsistence: an energy system that gives people an equal shot of getting the energy they need, energy systems that generate income and enrich lives	Lack of access to electricity and technology, dependence on traditional solid fuels for cooking, and time-intensive fuelwood and water collection and processing of food in emerging economies, borne mostly by women and children	Social pricing and assistance programs as well as pro-poor public private partnerships for microhydro units, solar home systems, improved cookstoves, biogas digesters, and small-scale wind turbines, mechanical energy for pumping, irrigation, and agricultural processing
Energy subsidies	Freedom	Robert Nozick, Milton Friedman	Libertarianism: energy decisions not unduly restricted by government intervention	Gross subsidies that involve an involuntary wealth transfer to recipients, essentially raiding the pocket books of the unwilling	Elimination of inappropriate subsidies, subsidy impact assessments, sunset clauses, and adjustment packages for those dependent on subsidies
Energy resources	Posterity	Ronald Dworkin, Brian Barry, Edith Brown Weiss	Resource egalitarianism: an obligation to minimize resource consumption and ensure adequate reserves for future generations	Exhaustion of depletable energy reserves and fuels	Improved energy efficiency, establishment of national resource funds, commercial-scale deployment of renewable electricity and biofuels
Climate change	Fairness, responsibility, and capacity	Peter Singer, Henry Shue, Paul Baer, Stephen M. Gardiner, Dale Jamieson, Simon Caney	Intergenerational equity: an obligation to protect future generations from energy-related harms	A daunting suite of negative impacts from climate change including ocean acidification, food insecurity, climate refugees, and the increased frequency and severity of natural and humanitarian disasters	Greenhouse Development Rights, community-based adaptation, mitigation through stabilization wedges

Source: modified from [53].

Figure 4: Energy justice analytical applications to energy problems

Source: (Sovacool & Dworkin, 2015, p. 4)

By applying certain principles of Kantian ethics, which states that every person needs to be taken as an end in itself and moving away from discussing the energy system solely from an economical or technological point of view, the problems of topics such as energy efficiency and energy poverty become essential based on virtue, and welfare and happiness, respectively.

Historical data on energy usage has revealed an oxymoron within energy justices for people of different demographics. The consensus on energy use is generally on decreasing overall consumption. However, energy poorer nations and groups rely on an increase in their energy consumption to improve their wellbeing.

Distributed renewable energies can enable underrepresented groups to participate in the energy production system and increase their recognition and thereby levelling the playing field (Nordholm & Sareen, 2021). Keeping this in mind, the energy justice framework must account for the different needs within energy transitions. By utilising the four streams adapted from social justice theory - distributive, procedural, cosmopolitan, and recognition justice – combined with connecting the philosophical principles to energy policy and technology, as suggested by Sovacool and Dworkin (2015), a more holistic approach, which accounts for all, and everyone involved and impacted by the energy transition, is employed.

Justice Pathways	Ethical Concept	Explanation
Procedural	Procedural Justice Freedom	Due process surrounding AI diffusion: data safety, transparency etc. Democratic and fair decision-making in energy context (diffusion of AI)
Distributive	Welfare and Happiness Virtue	Equal access to energy and efficiency and distribution of its benefits/harm Distribution of energy efficient technologies/appliances
Cosmopolitan	Fairness, responsibility, and capacity	Intragenerational equity on a global scale
Recognition	Welfare and Happiness	Equitable access to energy that people need, vulnerable groups should be satisfied first

Figure 5*:Alignment of energy justice pathways with ethical concepts from Sovacool and Dworkin (2015)*

Figure five shows a subjective understanding of how the ethical concepts discussed by Sovacool and Hess (2017) align with the energy justice pathways applied in this thesis. This alignment was done to show how ethical principles and justice concepts are interlinked but should not be considered factual as no research has been done to investigate the grouping shown in table five.

The next segment briefly links the four streams from social justice theory to the context of energy justice.

In the energy justice framework, distributive justice contends with justly allocating benefits and detriments of energy transitions. Furthermore, according to Nordholm and Sareen (2021), distributive justice should address the geographical inequalities in energy vulnerabilities and assess the processes of recreating and intensifying energy injustices on various dimensions, such as “landscapes of material deprivation, geographic underpinnings of energy affordability, vicious cycles of vulnerability, and spaces of misrecognition” (Nordholm & Sareen, 2021, p. 4).

The third aspect, vicious cycles of vulnerability, is relevant for this research as it reveals how previously vulnerable groups are at risk to be all the more disadvantaged through the energy transition. In the case of this thesis, people with lower income often do not have money to invest in energy-saving technology and lack knowledge of energy-saving strategies.

As Nordholm and Sareen (2021) state, the local environmental characteristics such as energy usage patterns influence family susceptibility to energy poverty; hence, the scale at which energy justice is measured and the locations in which it occurs have an effect on the inequalities exposed.

The procedural justice stream within energy justice peruses whether the energy transitions are instigated fairly and democratically.

In the context of this research, it assesses the processes around AI and ML and how different actor groups are included or omitted from participating in democratic decision-making. As Sovacool et al. (2019, p. 2) state, “all major socio-technical transitions require open and democratic participation by a wide range of actors (including firms and consumers, as well as civil society groups, media advocates, community groups, city authorities, political parties, advisory bodies, and government ministries) to minimize unwanted impacts.”

The third stream, cosmopolitan justice, applies the two first concepts to a global scale by acknowledging the equal worth of every individual, which has to be respected and protected independently of their national affiliations (Nordholm & Sareen, 2021; Sovacool & Dworkin, 2015). Cosmopolitan justice is an anthropogenic stream as it “acknowledges that all ethnic groups belong to a single community based on a collective morality” (Sovacool et al., 2016, p. 1) and is solely concerned with human beings and persons, rather than communities or nation-states (Sovacool et al., 2016). This stream is relevant as it analyses how and if increased energy efficiency through AI systems can benefit groups across all scales and nations.

The fourth and last stream, justice as recognition, pinpoints marginalised and disadvantaged groups that are at risk or are worse off due to the energy transition. It focuses on the equality of outcome rather than treating all groups alike. This means that disadvantaged groups might require favourable treatment and action in order to lift them to the level of more privileged groups (Nordholm & Sareen, 2021)

All four logics of social justice theory are relevant to this thesis and can be found within energy justice. Herein, distributive justice is used to analyse the fair distribution of benefits and ailments connected to introducing AI as an energy management system. Procedural justice assists in understanding how decisions and processes around the AI and ML systems are used to ensure ethical and just systems and affect households. Cosmopolitan justice gives insights on whether and how the lessons learned from this case study could apply to all humankind, critically reviewing the lack of consideration of local cultures, morals, and preferences. Furthermore, recognition justice serves as a guide to investigate how and whether the most vulnerable are being considered and satisfied first before enhancing the well-being of the rest.

5 Methodology and Methods

This section`s purpose is to present the methodology used for this thesis´ exploratory case study using a mixed-method approach consisting of a qualitative research component, inter alia using grounded theory, and a quantitative research component. Grounded theory was used for the first research question to produce a theory on technology adoption in households. The second research question was answered using the triangulation method and data analysis according to qualitative content analysis. While both grounded theory and qualitative content analysis employ coding procedures, content analysis is not concerned with establishing links between categories or developing theories; instead, it is concerned with extracting categories from data. Qualitative content analysis elucidates fundamental meanings (Cho & Lee, 2014).

The qualitative component of the case study enabled a deeper understanding of barriers towards automated smart-homes in Stavanger and the ethical and justice implications of such a development. It allowed theory building for technology adoption using the data collected through interviews, surveys, and document analysis. The quantitative component generated insights into whether such systems are feasible in the Norwegian energy grid context and enabled the comparison of variables determining technology adoption by including collecting numerical data in the survey and interview questions.

The relevance of a mixed methods methodology, grounded theory, and using a constructivist approach for this research is discussed thoroughly in this section. Additionally, the research process, which consists of the methodology, procedures, the study participants, methods used for analysing, and ethical considerations, are vital components of this section.

Methods Employed

The data for this research has been collected by using a case study combining qualitative and quantitative data collection methods. Qualitative data is non-numerical and focuses more on concepts, processes, patterns, and definitions than the quantitative counterpart that relies on objective measurements and focuses on numerical data. Data can be collected through polls, questionnaires, and surveys. Furthermore, data can be gathered by using pre-existing statistical data.

For this thesis, interviews, surveys, existing statistics, and data sets were used to gather information on the willingness of households to install fully automated smart devices and to estimate the gained efficiency of households switching to those automated electricity control systems. Qualitative data collection methods consist of document analysis, interviews, focus group discussions, and observational methods. For this thesis, both document analysis and interviews were used to answer the research questions stated in this thesis. Social science, in general, relies more on qualitative data methods, as social phenomena are difficult to translate into numbers. Additionally, qualitative data gives more detailed insights into specific processes and phenomena needed to gain the relevant data for this thesis. Moreover, qualitative research collects findings from a natural context, allowing the researcher to measure values and constructed social realities rather than objective, numeral facts (Neuman, 2014).

A qualitative approach is most suitable when the aim is to explain a phenomenon by relying on the perception of individuals and their experiences with a particular situation. On the other hand, quantitative approaches are used to understand relations between variables.

As mentioned at the beginning of this chapter, a mixed-methods approach was used to investigate the research questions.

There is a myriad of mixed method approaches available. For this thesis´ purpose, the most known and common approach, the triangulation design, was most fitting (Doyle et al., 2016). The triangulation design aims to attain different, yet complementary, data for the same subject to understand and answer the research question as accurate and reliable as possible. By using this method, the strengths of both qualitative and quantitative approaches can be combined. Qualitative methods are small numbers and in-depth understanding, whereas quantitative methods complement by offering large sample sizes, generalisations, and trends. The triangulation design has been extensively discussed in the scientific literature (e.g., Brewer & Hunter, 1989; Greene et al., 1989; Jick, 1979; MORSE, 1991) and is used when a study is meant to either compare or contrast quantitative with qualitative results or validate and expand qualitative data with quantitative results, and vice versa (Doyle et al., 2016).

There are numerous advantages to conducting a mixed-methods study, which is that it analyzes and contrasts quantitative and qualitative data, reflects the perspective of the participant, encourages intellectual communication, allows for methodological versatility, and collects extensive and detailed data (Wisdom et al., 2012)

However, a mixed-methods approach comes with challenges of its own. They complicate assessments and are time-consuming. Given that each technique has its own set of rigorous requirements, achieving each component of a mixed-methods study can be challenging. Lastly, increased resources are required. (Wisdom et al., 2012).

The data for this thesis was of both secondary and primary nature. The secondary data collected from document analysis and the primary data gained through interviews and surveys were used to answer the research questions.

Secondary data has the great advantage of saving researchers' immense amounts of time by relying on previously conducted researcher by other scientists. It, however, leaves the researcher vulnerable to unknown errors and biases, which might have distorted the data (Blaikie & Priest, 2019). It is, therefore, of the essence to conduct a thoughtful and reflected document analysis to avoid or at least be aware of specific errors and biases.

Having given an account of the grounded theory research methodology and the embedded case study, the chapter now moves on to the data collection methods and finally give a short review of the data reduction and analysis. The section ends by taking up the subject of reliability and validity.

5.1 Case Study

An exploratory case study was used to investigate the current state and possible future deployment of AI control devices for smart homes for increased energy and grid flexibility in Stavanger. According to Yin (2018). a case study is the in-depth empirical analysis of a contemporary occurrence within its real-life setting. Through this analysis, new insights and understanding of phenomena can be gained. Furthermore, it enables the researcher to understand a specific topic thoroughly (Yin, 2018).

An exploratory case study investigates different phenomena that are not well defined. For this type of study, the researcher begins with a broad concept and utilizes it to discover topics that might be the subject of future investigation. (Mills et al., 2010). This type of case study was deemed fitting for this thesis due to the missing information in context to AI and energy management in the grid and households and the ethical implications related to it.

According to Yin (2018), the technical definition of a case study is divided into two sections: the first section specifies the scope of the research, while the second section discusses the technical features of the study, including data collecting and analysis techniques. This is because in real-world settings, the phenomena and their context are not always apparent. Thus, a case study is an empirical investigation that delves deeply into a current phenomenon and situates it within its real-world context, mainly when the distinction between phenomenon and context is not readily apparent. The case study inquiry addresses the technically unique situation in which there will be many more variables of interest than data points and thus relies on multiple sources of evidence, with the data required to converge in a triangulating fashion. It also benefits from the prior development of theoretical propositions to guide the data collection and analysis (Fouché & Schurink, 2011).

According to Yin (2018), case studies are essential when the study topic demands clarification of the conditions. For example, "how" or "why" a specific social event is influential. It is also effective for documenting a current condition or phenomena when a detailed description is necessary, but the researcher does not need to alter events

A case study should collect evidence from a variety of sources, including surveys, archival documents, interviews, direct observations, physical artefacts, and any type of media (Yin, 2018). The data for this study were gathered from these sources using semi-structured questionnaires (surveys), semi-structured in-depth interviews, and document analysis. These sources of evidence were gathered over seven months and are analysed and discussed in detail in chapters six and seven.

The case for this thesis is the diffusion of AI-controlled energy management systems in the electricity grid of Stavanger. Both households and industry experts were interviewed and surveyed to understand the multi-levelled barriers to this implementation. Industry experts were also the source for ethical and justice considerations of AI in the energy context. The data collected through fieldwork were supplemented with information gathered through document analysis. The scope of the case study included a group of eight household respondents and fourteen industry experts working in relevant fields.

Due to the low number of respondents and the fact that a single case study was employed, the concern of not being able to generalize from a single example, and therefore the case study cannot contribute to scientific advancement, need to be addressed.

In the study of human affairs, predictive theories and universals are absent. Thus, concrete, context-specific information is more critical than the fruitless pursuit of predictive theories and universals (Flyvbjerg, 2006). Meaning, even though the case study investigating barrier and ethical implications might not produce a generalisable theory, trends and patterns that emerged can still be helpful to research, companies, and policymakers alike.

5.1.1 Constructivist Grounded Theory

The case study investigating household barriers was conducted by using a grounded theory methodology. As Stark (2010) stated, “when the main aim is to build theories, a respected qualitative way to move from individual knowledge to collective knowledge is ‘grounded theory’” (p. 17).

This research method is called “grounded” because “researchers seek to avoid wedding themselves to a particular theory before they begin their investigation, instead "grounding" their analysis inductively in the data itself” (Sovacool et al., 2018, p. 30).

Grounded theory is generally an unstructured analytical approach with systematic guidelines for collecting and analysing data to generate a middle-range theory. Grounded theory strives to continuously incorporate the formulation of theory with the analysis of data (Sovacool et al., 2018). This practice involves continuous reviewing of the data collected to identify repeating ideas, notions, and patterns, which are coded and sorted into different concepts, and finally, categories when the research has progressed, and a more substantial amount of data has been collected and re-reviewed (Charmaz & Belgrave, 2015; Corbin & Strauss, 1998). These categories can become the foundation of a new theory. In this sense, grounded theory differentiates from other research approaches, which traditionally consists of a researcher choosing a theoretical framework to collect data and eventually reveal how the chosen theory applies to the phenomenon being studied (Charmaz & Belgrave, 2015).

Glaser and Strauss (1967) developed this methodology which allows theory to emerge through systematically coding interviews into terms that abstractly summarise phrases, lines, and words.

According to Charmaz (2006), grounded theory has both constructivist and positivist predispositions, with the first one being described by Birks & Mills (2011) and Charmaz (2006) as a view that rejects the notion of objective knowledge existing in an external reality which can be retrieved mechanically. Instead, the knowledge collected is subjective to the researchers' values and interactions with the participants and the phenomenon and manipulated by society, culture, and other influences.

A constructivist grounded theory approach was used to investigate barriers to AI-based home automation by using Stavanger, Norway, as the core for the case study.

The constructivist grounded theory seeks to "conceptualize the studied phenomenon to understand it in abstract terms, articulate theoretical claims, acknowledge subjectivity in theorizing, and offer an imaginative interpretation" (Charmaz, 2006, p. 127). In the setting of this study, the constructivist grounded theory approach was applied to understand the data collected from each interviewee in abstract terms and build a theory based on interpreting the shared and contrasting experiences of the participants, complemented with data from documents and statistics.

Using a constructive grounded theory approach, emphasis was on a reflective research process that allowed and guided changes in interview and survey questions to discover further details of the emerging theory. To identify differences and similarities in the data, the researcher had to examine subtleties and nuances zealously. By interpreting the data, a theory emerged, which is in line with the constructivist grounded theory approach (Charmaz, 2006), and presented in the discussion part of the thesis.

5.1.2 Data Collection

Three different principles should be considered to ensure reliable and valid data within a qualitative case study. Firstly, the principle of triangulation, which emphasizes the importance of using different sources and methods to collect data and evidence in a case study. This was done by collecting data from multiple sources during the document analysis and conducting interviews with experts and non-experts from different sectors and demographics. This measure helped increase the construct validity of measures (Yin, 2018). The second principle is based on creating a database for the cases which contains all information concerning the cases, such as notes, transcripts, documents, and memos. Excel, word, and colour coding was used to ensure a structured database. Lastly, the principle of maintaining a chain of evidence that allows recreating a study was followed by having an organized filing system with the transcripts of all the interviews and literature used for this thesis.

The document analysis was continuously done from January throughout June, whereas the preparation for the interviews and survey, such as coming up with the preliminary questions and receiving NSD approval for the project, was completed by the end of February. The interviews lasted approximately 20-30mins and were conducted via video or phone call, depending on the interviewee's preference. Widening the option of how the interviews were conducted was due to a low response rate despite an initial meeting with a contact person at both Vindmøllebakken and Future Home, continued emails to the peopled that initially had agreed to the interview and a letter in the mailbox of the prospective participants. This also led to the decision to give participants the option to answer the same interview questions through a survey created through google forms and collected all data anonymously. By offering the option of a survey, an additional four responses were collected.

To get more comparable data and not distort results, it is advised to ensure the same settings for the interviews. In this case, both video and phone calls were used for the interviews, which provided slightly different settings but did not divert from each other to the extent if in-person interviews had been used. The choice of not using in-person interviews was grounded in the fact that settings can change an interviewees response by making them feel more comfortable in a homely setting and therefore gain more intimate answers (Rapley, 2004). Furthermore, the ongoing COVID-19 pandemic factored into the decision of conducting all interviews digitally. Before the interviews were carried out, an email with an information letter containing details about the research, the privacy of the interviewee's identity and data, and the planned method of recording the interview were sent out to all interview candidates to get consent before the interviews. A summary of the information letter was offered at the start of each interview if questions or concerns had to be addressed. Also, the option of an interviewee to withdraw at any time and access the recorded data was disclosed. These measures were necessary to ensure that informed consent, voluntary participation, right to privacy, and withdrawal were being upheld. This step also served to make candidates feel valued and safe (Blaikie & Priest, 2019).

The primary data source for the research question investigating industry barriers was the fourteen expert interviews with relevant industry stakeholders. The same applies to the research question regarding household barriers, for which the five research interviews conducted with homeowners at Vindmøllebakken provided the data. The document analysis and the surveys were used to supplement the research.

After every interview with a household, the transcript was coded manually and analysed for any emerging themes. This approach was used to guarantee that grounded theory methodology was incorporated throughout the data gathering phase of the study process.

Appendix C contains the initial interview procedure and subsequent revisions to the interview questions throughout the study.

During open coding, all interviews were manually coded. The interviews were evaluated right after the interview was conducted to give sufficient time for analysis before proceeding to the next person. Each transcript was coded and examined for categories or themes. Following the conclusion of the transcripts, more questions or clarifying questions were added to the interview technique. For further analysis, transcripts were imported into the qualitative data analysis program NVivo 12.

Each interview was then manually coded again using the program and compared to the first manual coding done during the interview collection. By coding the interviews again and comparing all eight interviews assisted in the continuous comparison analysis procedures necessary for grounded theory methodology. This procedure aided in stressing crucial areas consistently throughout the coding process.

The researcher then used selective coding to look for groups that emerged from the commonalities in the open codes.

The same procedure was applied to the fourteen interviews with the industry experts. However, in this case, the goal was not to build a theory based on the findings but to use the mixed-methods methodology to identify barriers towards automated smart homes in Norway.

The following section describes the different methods in more detail and how they were used for this research.

5.1.2.1 Document Analysis

The document analysis started by identifying and reviewing relevant data to close in and focus on specific articles and documents that would help to develop the research design and the research questions. Since there is somewhat limited available information about the exact subject of this study, the foundation is built on relevant information in related studies supplemented by the information collected through fieldwork.

Although relevant information was limited, it was important to base the research on reliable and well-researched data. Short heuristic evaluations of scientific documents were carried out to ensure the use of reliable data. The data extracted from the document analysis was noted down and later colour coded to be related to the results from the fieldwork and facilitate a chain of evidence.

For the question about ethical considerations, it was necessary to primarily rely on document analysis as there were only three relevant experts available, which were used to supplement and confirm the data collected from the documents.

5.1.2.2 Interviews

The interview is a critical source of case study evidence. Interviews can be particularly beneficial in terms of eliciting explanations (i.e., the "how´s" and "why´s") for significant occurrences, as well as insights reflecting participants' relativist viewpoints. Interviews for case studies are more akin to guided dialogues than planned questions. While following a continuous line of inquiry, the actual flow of questions during a case study interview is more likely to be flexible than rigid (Rubin & Rubin, 2012). This interview style has also been referred to as an "intense interview," a "in-depth interview," or an "unstructured interview" (Weiss, 1994, pp. 207–208). This implies that throughout a case study interview, the researcher has two jobs: (a) pursuing the own line of inquiry, as represented in the case study protocol, and (b) verbalizing real (conversational) questions in an unbiased manner that meets the demands of the line of inquiry.

A frequently asked question regarding conducting case study interviews is whether they should be recorded. Audio recordings are unquestionably more accurate than taking notes during an interview. However, a recording device should not be used if

a. the interviewee refuses permission or appears uneasy in its presence,
b. there is no specific plan for transcribing or listening to the contents of the electronic record systematically — a process that consumes considerable time and energy, and
c. the researcher is clumsy enough with mechanical devices that the recording procedure creates distractions.

A recording device was not deemed necessary for this research and was avoided to ease privacy and data protection.

Reflexivity

It is necessary to reduce the methodological risk posed by the interview's conversational nature. The talk may result in a slight reciprocal impact between the researcher and the interviewee—referred to as reflexivity: The researchers perspective has an unintended effect on the interviewee's replies, but those responses also have an unintended effect on the path of inquiry. As a result, the interview material takes on an unfavourable hue. While the interviewer is probably aware that lengthy interviews may establish a rapport between them and the interviewee, shorter interviews must be managed equally represent a reflexive hazard. While one may not eliminate the threat, simply being aware of its existence could help conduct more effective case study interviews.

The interview guides for this study were developed as a semi-structured "active interview", according to Holstein and Gubrium (1995), which emphasizes the meaning-making process between researcher and interviewee. The questions for the interviews were created with help from the literature and functioned as a guide to conduct the interviews, still leaving room for follow-up questions and adapting to each candidate.

The candidates for the interviews with homeowners were identified with the help of the supervisor and by talking to companies that were in the process of doing research themselves. These interviews were conducted to identify and understand barriers to automated smart technology adoption in homes.

The homeowners were chosen based on two groups of informants. The two groups consisted of interviewees from Vindmøllebakken and Future Home owners. The selection of the interviewees is described in the sample section.

For the second part of the study, expert interviews were used to investigate the current state and possibilities of and AI in the energy sector, what number of houses are needed to make an ML system feasible, and how ethical considerations were included in the work with AI.

Expert Interviews

Expert interviews have long been a staple of social research. While the precise role of expert interviews in particular research designs, their format, and the methodologies used to analyse the data may vary, there are some general, practical reasons for their appeal in research (Bogner et al., 2009).

First, speaking with experts at the exploratory phase of a project is a more efficient and focused way of data collection than participatory observation or systematic quantitative surveys. Conducting expert interviews may help speed up time-consuming data collection procedures, especially when the experts are seen as "crystallization points" for practical insider knowledge and are interviewed as surrogates for a larger circle of actors. Expert interviews also adapt to circumstances in which access to a specific social area may be difficult or unattainable (as is the case, for instance, with taboo subjects).

Occasionally, the expert will suggest other candidates with expertise in a specific subject throughout the interview. With the extra benefit of the assistance of an expert in a crucial position, the researcher may frequently find it simpler to obtain access to a larger circle of specialists (Bogner et al., 2009).

Apart from the obvious benefits, expert interviews enable researchers to acquire results quickly and, more importantly, obtain high-quality results. Often, the interviewer and interviewee share the same scientific background or system of relevance increasing the expert's motivation to engage in an interview. (Bogner et al., 2009)

The candidates for the industry interviews were selected by identifying key informants and experts of the fields through literature and contacting companies.

By conducting interviews across authority levels, it was possible to gather complementary and contrasting views on the issue (Rapley, 2004), which supported a less one-sided, biased data collection.

Due to the ongoing COVID-19 pandemic, interviews were conducted via phone and video calls, suboptimal but still allowed to capture both verbal and non-verbal clues.

After the interviews were conducted, the data was transcribed right after to capture as many details as possible when the information was still fresh. By using colour coding to categorise reappearing topics, and patterns into concepts. Data from the document analysis was compared to the interview and survey results to help ensure their validity and build a theory and answer the research questions.

The interview guide and transcripts are found in appendices D and F to allow other researchers to reconstruct and analyse the completed study.

5.1.2.3 Surveys

Another form of case study interview is the standard survey interview conducted using a standardized questionnaire. The survey may be incorporated into a case study and generate quantitative data to supplement the case study evidence (Yin, 2018).

This circumstance might be applicable, for example, if the researcher was conducting a case study of an organization and surveyed employees and management. This sort of survey would employ the same sample techniques and tools as traditional surveys and be evaluated in the same way. The distinction is in the survey's relationship to other sources of evidence (Yin, 2018).

The surveys were added later on in the research process for this study due to a low response rate. By offering the participants the option to answer a survey instead of partaking in the interview, four extra responses were collected.

The surveys for this research were based on interview questions. The first part was based on closed, quantitative questions such as age, wealth, and scale questions. The second part was based on open-ended, qualitative questions where the participants were able to describe and express their individual, more complex thoughts on the matter.

5.1.3 Study Participants

The data collected in this study was based on interviews and surveys from two different samples: Vindmøllebakken and Future Home, with eight interviews of households in total.

Fourteen interviews were conducted with experts in relevant fields and academia To investigate barriers associated with the industry.

This section shortly describes the process of sampling the participants for this study.

Sample

A population is defined as a collection of potentially observable persons and have comparable features (Leboea, 2003). The initial respondents in this case study had common features in the sense of having installed smart home technology in their homes or living in the apartment complex Vindmøllebakken, which is equipped with a heat pump for general water heating and a smart meter in every apartment.

It is impossible to elicit the involvement of every member of the population in each research (Leboea, 2003, p. 60). As a result, the behavioural or social scientist must rely on a population sample. As a result, respondents from Vindmøllebakken and Future home were chosen as a tiny segment of the population.

The sample was based on purposive sampling. It is frequently employed in qualitative research, where the researcher wants to obtain comprehensive knowledge about a particular phenomenon rather than making statistical assumptions or when the population is extremely tiny and specific. A successful purposive sample must have well-defined inclusion and exclusion criteria (Garg, 2016).

The sample criteria were based on the circumstance that both Vindmøllebakken and Future Homeowners had installed certain types of smart technology. In Vindmøllebakken, a smart meter was installed in all apartments before people moving into the building.

Future home respondents all have several smart technologies installed they purchased and chose themselves.

The participants for the expert interviews were chosen from purposive sampling due to their relevance for this research and snowball sampling by getting referred to other relevant industry players who would share their insights.

5.2 Data reduction and analysis

Data reduction and analysis is an integral part of a research project. This research includes qualitative data from interviews and surveys, memo writing, and colour coding, and Nvivo 12 was used to structure and code the data and make theory-building easier.

Using tools such as colour coding and Nvivo eases the analysis, gives a better overview of the collected data, and can help to reduce the data to its core concepts and information to interpret the results. The process of data reduction and analysis was done throughout the entire research project and was part of generating a theory (Blaikie & Priest, 2019). This process includes categorizing and coding the data using the grounded theory approach as described in the previous section. The data from the interviews and the surveys was categorized and sorted into different theoretical concepts and coded according to grounded theory practices. This measure gave a better overview and understanding of barriers and helped theory building.

The transcripts of the interviews were coded in the sequence in which they were done, allowing the researcher to reflect on and change interview questions as hypotheses emerged from the data. Coding aided the researcher in comprehending the participants' views and assessing their combined experiences. Throughout the study process, codes were generated based on the data to facilitate data analysis (Urquhart, 2013). Coding was carried out both manually and with the use of computer-aided qualitative data analysis tools.

Coding the transcriptions, or breaking them down into digestible pieces of data, was a crucial step in the data analysis process. The use of grounded theory coding aided in concentrating the interview analysis on the participants' experiences systematically. Coding aided in preventing the interviewer from overemphasizing any one component early in the research and ensuring a comprehensive examination of the whole interview (Charmaz, 2006; Stake, 2010)

Constant comparison is the process of examining, reanalysing, and comparing new data to existing data (Birks & Mills, 2011; Urquhart, 2013). As each coding step began, it was critical to continue analysing last phases' data to ensure that connections were formed until saturation occurred. The dissertation's coding language was adapted from Urquhart (2013), who defined the three stages of coding as open, selective, and theoretical.

Open Coding

The phase during which each line of recorded interview content is coded line by line is called open coding (Urquhart, 2013). Coding on a line-by-line basis is a fundamental component of grounded theory techniques (Birks & Mills, 2011; Charmaz, 2006; Glaser & Strauss, 1967; Urquhart, 2013). It is what its name implies, where each line of transcribed interviews is coded using a few words to explain the data, as Urquhart (2013), Birks and Mills (2011), and Charmaz (2006) propose. This classification system aided the researcher in delving deeply into each interview.

Additionally, this technique aided in instilling the discipline of grounded theory, in which the theory emerges from the facts. Coding line by line in open coding results in many codes (Birks & Mills, 2011; Urquhart, 2013).

Coding Strictly

When there are no new open codes or codes pertain solely to emerging core categories, selective coding occurs (Urquhart, 2013). The concepts, categories, and constructs are synonymous across grounded theory techniques (Birks & Mills, 2011; Urquhart, 2013). Certain selected codes may manifest themselves more frequently than others. Occasionally, a single selected code becomes a significant subject, or a theoretical code becomes a prominent theme (Birks & Mills, 2011; Urquhart, 2013).

The researcher uses selective coding to identify new categories but will ideally have fewer selective codes than open codes. Urquhart (2013) advised reviewing the categories of selective codes if an excessive number of selective codes arose during the first coding. To emphasize that coding is an ongoing process, Urquhart recommended that the researcher evaluates selective codes to see if the names of the selective codes best match the open codes or selective codes discovered. Urquhart further proposed that examining the features and possible linkages of selective codes might assist the researcher in differentiating between open, selective, and theoretical codes (2013).

Theoretical Coding

There is disagreement among grounded theorists on the precise point at which theoretical sampling begins. Charmaz (2006) states that theoretical sampling occurs following the emergence of categories. Birks & Mills (2011) claim that theoretical sampling can begin during open coding since early data reveals concepts that point to potential theories or explanations for phenomena. Theoretical coding happens when the codes and categories generated by open and selective coding are compared, and connections between the codes or categories are discovered (Urquhart, 2013). These connections give rise to the hypothesis or phenomenon. Iterative coding is used throughout. New codes should be compared to current data continuously to evaluate whether new categories develop and, if so, whether these new categories are densifying. Memos are critical to the theoretical coding process and should be constantly compared.

Tables 1 and 2 show the results from the coding process and include both barriers and opportunities identified within households and industry. The reference relates to the number of times the topic came up.

5.3 Reliability and Validity

Qualitative research faces the challenge to provide reliable and valid data, especially when the data comes from in-depth studies with a limited number of actors. Based on the character of qualitative research, the data collected comes mostly in written form, which makes proving reliability and validity cumbersome. Blaikie and Priest (2019) describe the validity and reliability of measurements as the fact that instruments "measure what they claim to measure and that they do so consistently (p. 211). However, the disposition of qualitative research makes validation and replication almost impossible. This matter is based on the fact that the instrument within qualitative research is the researcher herself, and therefore no two instruments are the same (Blaikie & Priest, 2019). Some confidence can be established by using well-used instruments such as objectivity. Reliability can be somewhat accomplished by establishing an accessible and well-ordered chain of evidence.

The data was validated using a mix of fieldwork and multi-method techniques. Throughout the fieldwork, semi-structured surveys and interviews were delivered in a digital setting to keep with COVID-19 guidelines and create the same environment for every interview. The multi-method strategy allowed for data triangulation across inquiry techniques. Diverse techniques provided unique insights into the subject at hand and bolstered the results' trustworthiness (McMillan & Schumacher, 2010, p. 331).

An additional consideration is that qualitative research's reliability and validity are contingent upon what the researcher sees and hears. Lincoln and Guba (1985) observed that trustworthiness is established through credibility, transferability, dependability, and confirmability. One method to guarantee credibility and transferability is to ensure that people questioned have relevant experience discussing the phenomena under investigation. Vignettes from the interviews were utilized to demonstrate essential topics for this study and provide context for the research's findings (Leedy & Omrod, 2013). One approach to assure confirmability is to verify that there are no researcher biases and that the facts are interpreted objectively.

Transcribing and manually coding full interviews aided in ensuring a thorough grasp of the interview material and participant purpose.

Constant comparative analysis guaranteed that systematic comparisons were performed and that this study established connections between the analysis and the ensuing ideas (Charmaz, 2006). Constant comparative analysis was also essential in establishing the credibility of the ideas that emerged from the data, as the researcher was able to explicitly identify the codes and categories that possessed the analytical weight necessary for creating the theory (Charmaz, 2006).

The research must be readily available to ensure its credibility (Yin, 2018). While the data for this study will be accessible for five years following the study's conclusion, all transcripts are anonymised, and personal identifiers were removed. Due to the data being unavailable after five years, this study's future reliability and integrity may be jeopardized.

Another possible drawback of this study is that the interviews were conducted through digital meetings, phones and supplemented with online surveys rather than in person. Birks & Mills (2011) suggested that the researcher should focus more on verbal communication to compensate for the absence of non-verbal clues. All interviews were performed via telephone or an online platform, even when proximity to the subject permitted an in-person interview to ensure uniformity.

In various ways, bias was minimized in the phenomena or hypotheses that emerged from this investigation. Yin (2018) advocated for the establishment and enforcement of explicit standards to eliminate bias in research. Manually coding the interviews in accordance with grounded theory principles aided in ensuring an impartial interpretation of the data, therefore minimizing bias. Memos also aided the researcher in being responsible for the emerging theory by facilitating reflection and assessment during the research process (Birks & Mills, 2011).

5.4 Generalisation and transferability

It is worth noting that formal generalization, whether based on huge samples or individual examples, is vastly overstated as the primary source of scientific advancement. Blaug (1992) has proven that, while economists frequently preach generalization, they seldom implement what they preach in actual research. More broadly, Thomas Kuhn (1990) shows that the most critical prerequisite for science is that researchers acquire a diverse variety of practical abilities necessary for conducting a scientific activity. One of these is generalization.

The case study is suitable for generalizing using what Karl Popper (1959) referred to as "falsification," which is a component of critical reflexivity in social science. Falsification is one of the most stringent tests that a scientific claim may undergo: if even one observation contradicts the proposition, the proposition is deemed invalid in general and must be amended or discarded.

As mentioned at the beginning of this chapter, a single case study is unlikely to produce generalizable and transferable results. However, according to Yin (2018), case studies are not meant to provide statistical generalization but analytical generalizations.

5.5 Ethical concerns

The researcher made certain that ethics remained a primary concern throughout the investigation. Following the procedures given in this section was critical to ensure the study's validity and reliability. Appendices A and B contain the informed consent form that was sent to the participant before the interview. The informed consent letter adheres to NSD (Norsk senter for forskningsdata) guidelines. It includes a fair explanation of the procedures, a description of anticipated benefits, an invitation to inquire about the procedures, and an instruction that the individual is free to withdraw. The hazards to human participants in this investigation were negligible. All individuals were over the age of 18 and shown no signs of diminished mental capacity, as measured by their ability to execute the jobs they held. They were eligible to participate in this study if they met these requirements. Additionally, all data were recorded anonymously without any personal identifiers, and after final clearance by NSD, all recorded materials will be deleted after five years, limiting any future concerns associated with confidentiality.

The purpose of chapter six is to provide the findings and interpretation from the study and show that the approach specified in section five was followed.

6 Empirical findings and analysis

This section summarizes the findings of the case study using grounded theory to address the following research question:

i. *What are the most prominent barriers hindering the penetration of automated systems in the grid and homes?*

Furthermore, this section discusses the information collected from industry experts and the document analysis on barriers and ethical concerns of implementing a machine learning system, answering the research question:

ii. *How are possible ethical considerations concerning AI systems acting as intermediaries between households and the energy grid, addressed?*

This section details the process of analysing transcripts from the eight individual interviews of homeowners performed to find codes and themes and the fourteen individual interviews from industry and academia investigating the current state and possible future developments of AI within the electricity grid context. The study was conducted on three levels: (a) open coding, (b) selective coding, and (c) theoretical coding. Constant comparison was utilized further to distil the data at each level of analysis until themes emerged from the data. The section includes tables and visuals that illustrate comprehensive statistics on codes and themes and images and vignettes (in *italic*) from individual interviews that highlight important themes and the resulting theory.

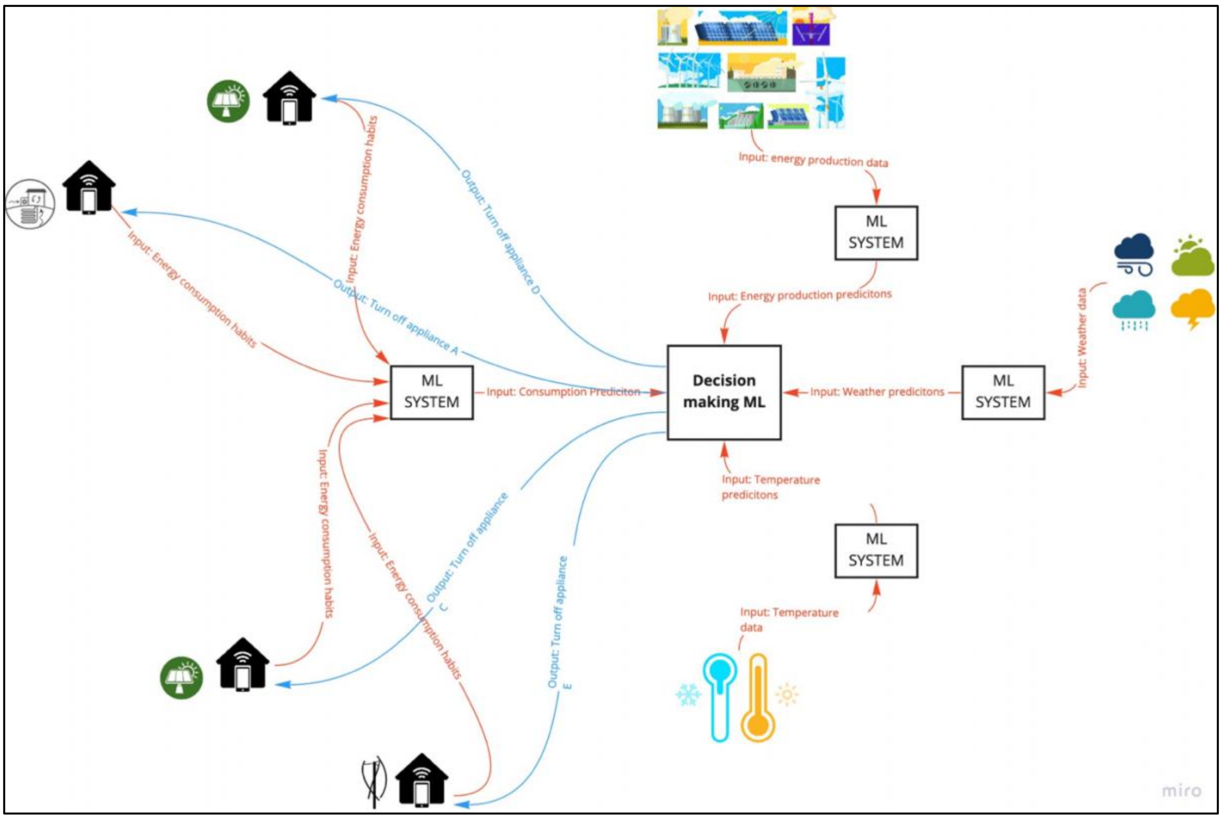

Figure 6: *ML concept investigated in the thesis*

Source: Own composition

Figure 6 depicts the concept that was explained to households and industry experts. The idea visualised in the graph shows how smart homes would provide electricity consumption and behaviour data, which is fed into an ML system that learns to predict behaviour from different homes and neighbourhoods. In addition to consumption data, potential small scale energy production prediction is included in the data provided by households to the ML system. Simultaneously, temperature and weather data are recorded and help predict weather conditions and energy needs. Lastly, energy production data helps to predict the energy mix and energy prices ahead of time. All the different predictions are assessed, and on their basis, the ML system makes decisions on which appliances to turn off in which households to increase the grid flexibility and help reduce grid load. For households, the main benefit from such a system would increase energy efficiency and lower electricity prices.

6.1 Households

The data collected from the households is used to answer the following research question

What are the most prominent barriers hindering the diffusion of automated smart home systems in private homes?

As the number of respondents exploring household barriers is rather low, all barriers that came up during the interviews will be reviewed and considered as legitimate reasons for non-adoption for this case. However, the results cannot be considered representative and transferable as the two groups of interviewees already belong to a more technology aware and environmentally concerned group. The number of respondents is far too low to consider it generalizable, even for a qualitative research project.

Table 1: *Summary of household participants and their willingness to adopt discussed technology*

Respondent nr.	**Age**	**Type of home**	**Income (NOK)**	**Has EV?**	**Nr. of people in home**	**Concern for electricity cost**	**Awareness of avail. Tech.**	**Concern for environ.**	**Would install automated technology**
1	45-54	Apartm.	500 000-601 000	no	1	7	3	10	No
2	65-74	Apartm.	600 000-701 000	yes	2	5	8	10	No
3	25-34	Apartm.	500 000-601 000	no	2	5	8	10	No
4	25-34	House	700-1mill	yes	4	9	8	4	Yes
5	25-34	House	500 000-601 000	no	2	9	10	10	Yes
6	25-34	House	700 000-1mill	yes	4	9	8	5	Yes
7	25-34	House	700 000-1mill	yes	4	5	6	7	Yes
8	65-74	House	retired	yes	4	8	9	9	Yes

Source: Survey and Interview data

Table 1 shows the quantitative data collected from the interviews and surveys and the likeliness of every respondent to adopt technology, which was identified during the qualitative part of the interview/survey.

The numerical data regarding concerns and awareness were based on a scale, where 1 represents low concern/awareness and 10 high concern/awareness.

As Vindmøllebakken is a closely-knit and small community, personal identifiers past *age*, *income*, and *number of occupants* in the households, are not included to prevent identification by other homeowners at Vindmøllebakken.

Despite the low number of respondents, a basic SPSS analysis was done to understand whether any of the quantitative answers were correlated to the willingness to adopt automated smart technology in the future. Table 2 below shows the correlation analysis of the different variables and the willingness to adopt the new technology.

Table 2: *Correlation of willingness to adopt smart technology and multiple variables*

	1	2	3	4	5	6	7	8
Age group	-							
Residence	.339	-						
Income	.606	.153	-					
Electrical vehicle	.264	.067	.827**	-				
No of people in home	.454	.305	.827**	.803**	-			-
Concern for electricity cost	.610	.238	.126	.055	.312	-		
Awareness of avail. technology	.474	.194	.208	.194	.348	.337	-	
Concern for environment	-.165	-.265	-.417	-.627	-.781**	-.463	-.067	-
Willingness to install smart technologies	.565	.600	.582	.467	.803**	.641	.452	-.627

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation Analysis

The relationship between willingness to install smart/automated technologies and age group, residence, income, ownership of electric vehicles, number of people in the home, concern for electricity cost, awareness of available technology and concern for the environment was analyzed through Pearson’s correlation coefficient. The outcome of the analysis revealed a positive and significant relationship between the number of people in the home and the willingness to install smart/automated technologies (r=.803*) (p<.01). Thus, it can be concluded that the more the number of people in a family, the higher will be their willingness to install smart/automated technologies. All other variables have a non-significant relationship with the willingness to install smart/automated technologies. However, it should be considered that the number of respondents is rather low, and the quantitative analysis might not be as reliable.

6.1.1 Barriers

The barriers discussed in this section

Table 3: *Themes emerged from Household Interviews*

CODES	References
Households	**68**
Barriers	**46**
Automation	6
Data	**9**
Fairness	2
Functionality	**12**
Individuals Characteristics	7
Saturation	**10**
Opportunities	**22**
Automation	6
Data	4
Functionality	12

Source: Household Interviews and Surveys coded with Nvivo 12

As seen in Table 3, 49 codes related to barriers and 22 codes related to opportunities were identified during the household interviews and surveys. The most prominent barriers relate to *saturation*, which includes other available technology making an automated system less desirable, *data* related to trust in how companies are handling private data, and *automation*. The latter was expressed as scepticism towards the greater number of AI and automation penetrating everyday life and replacing human labour.

The most prominent barriers towards adoption collected from the interviews were related to *Saturation, Data, Automation,* and *Functionality themes.*

The barriers will be reviewed according to their frequency, starting with the most frequent one to end with the least mentioned barrier.

The different barriers emerged as themes/categories after open and selective coding had been rereviewed and analysed throughout the whole coding process.

As seen in Table 1, five out of eight households were positive towards automated smart home technology adoption. However, even the respondents that would install technology had some concerns and reasons to refrain from doing so.

Functionality

The functionality of current and future technology seemed to be the main concern amongst all respondents.

This theme includes codes such as *ease of use, control,* and *reliability* and describes people's expectations of and experiences with smart technology and a total of twelve references relating to the theme were identified.

Respondent 1 believes that technology, as described above, would not be able to ease their life, as there is a "*lack of routine an ML system could learn from and predict behaviour*."

Respondent 2 points out that already "*current solutions in their home are not working as they should"* and that the system that is supposed to control the technology "*is too sophisticated and intricate for a layman to be able to use it."* Furthermore, the respondent felt that to make sense of such a system and use it to its full advantage, "*a lot of knowledge had to be acquired."* They also believe that people "*might not have a lot of patience when it comes to daily tasks such as washing clothes and dishes,"* which would defeat the purpose of an ML system controlling appliances and overall electricity use. Lastly, their experience with AI so far is "*that it performs poorly and is only used to increase profits by replacing human labour with machines."*

Respondent 3 recalls that the technology solutions in their home at VB have led to issues "*when it comes to billing the different tenants according to their consumption and the shared space costs.*" Even though the cost issue would not apply to houses, apartment buildings with a similar concept such as VB would have to introduce a clear pricing scheme before implementing any AI systems.

The respondent added further that if new technology is introduced, "*it needs to be properly explained and taught to the users in order for them to benefit properly*".

Respondents 4 and 5 both think that "*ease of use and control of smart technology is key for their success*" and that "*an automated system that does not allow user interference would not be welcomed.*" Whereas **respondents 6 and 7** both emphasize the importance of "*reliability of current and future technology solutions.*"

Saturation

This barrier is related to the fact that current, other technologies might be good enough, making an automated system obsolete. It also refers to saturation within the living condition of the respondent, meaning that the home has sufficient energy-saving technologies or has no room for further technologization.

A total of ten references refer to the topic of *Saturation.* It is important to consider that most answers regarding saturation were from respondents at Vindmøllebakken, which is a unique case as the building has the best energy efficiency rating possible and is catered to people that are more environmentally conscious already. Still, as new buildings will be more energy-efficient and tailored to different types of people, the responses related to saturation are valuable to consider to understande how these kinds of buildings and their occupants' factor into future adoption of automated smart homes will become more common.

Among the respondents from Vindmøllebakken, there was a clear agreement that additional technology would not benefit their lives.

Respondent number 1, for example, explained that "*Vindmøllebakken is small, and the living costs are meager, which makes new technology, that costs money to install, not worth it for them.*"

Respondent number 2 added that "*no extra technology is needed as the building (VB) is already so well insulated, and their apartment is small.* Furthermore, as *Vindmøllebakken already has a button for "holiday" mode, they cannot see the value of* increased automation *in their lives.*" In other words, they cannot see how this new system would "*produce enough benefits for them to decide to install it*". An additional point of respondent 2 was that "*more and more gadgets enable the increase of energy efficiency in houses and that there is a lot of saving potential that is not connected to AI.*"

Respondent number 3 agrees with the previous respondents by explaining that they *"do not see the benefit in additional technology at Vindmøllebakken"*. They further elaborate that there "*is no place for AI in their life* and that *they already have enough technology.*" In addition to having enough technology in their life, **respondent number 3** voiced the concern that the focus should not be "*on adding further technology but rather teach people how to use less of everything*". The last point regarding saturation was made, which mentioned the *"availability of apps that can check electricity prices for users and lets them decide when to run certain home appliances, depending on the current and predicted energy prices."*

Overall, the respondents living at Vindmøllebakken could not see how an automated system could further benefit them.

Data

The *data* category includes codes such as *trust* and has nine references in the interview transcripts.

The respondents seemed to share a distrust towards cooperation's and company's handling their private data. They believe that, for one, people are too trusting of governments to handle their data appropriately. Secondly, they generally believe that companies use private data to benefit themselves and hide behind empty words and promises.

Respondent 1 believes for once that "*Norwegians are generally a little naïve and trusting when it comes to how authorities and the government handles and protects private data"*. The respondent adds that in their experience, "*people believe these organisations mean well, trust what they say is true, and do not question their intentions which is due to laziness and lack of interest."* The respondent also explained that they had observed the same on themselves which can also be since they never ended up with a scam so far.

Respondent 2 has an apparent distrust when it comes to cooperation's handling private data. They give the example of Facebook, "*which uses private data to customize advertisements and the like."*

Respondent 3 shares the sentiment of the other respondents and voices their scepticism by explaining that "*companies always try and paint the best picture possible and show how they are doing the right thing but are usually using the collected data to benefit themselves by learning about the customer, selling more products, or selling the data to other parties."*

Respondents 5, 7 and 8 all have mistrust towards data handling. **Respondent 2** explicitly explained that the only dislike they have with smart technology is "*that they are sharing their data with others, in this case, the company that provides the technology."* **Respondent 7** voices that "*cybersecurity is always a factor they are concerned about."*

Only **respondents 4 and 6** trust that the handling of their data is done appropriately.

The overall feedback concerning data is a feeling of mistrust and scepticism towards private companies being honest and transparent about how they handle and use user data.

An inquiry at the end of some interviews whether respondents were aware or knew of the GDPR showed that people either did not know of the regulation or were not informed how it affects their private data.

Individuals Characteristics

The theme of *individuals characteristics* includes the codes such as *lifestyle* and *interests.* A total of seven references were connected to this theme.

The responses related to this theme were solely received from the interviews with homeowners at Vindmøllebakken.

Respondent 1, for example, explained that they are "*a very analogue oriented person and has no interest in gadgets in general."* They further specified that they, due to a lack of interest, "*are not very informed about new technology solutions."* Furthermore, the respondent expressed that they already "*had good energy habits and their unpredictable life would make it difficult for an ML system to work."*

Respondent 2 shares the sentiment of **respondent 1** in terms of "*not being the keenest on new gadgets"*. Whereas **respondent 3** also feels that they are "*already very aware of consumption behaviour and habits*," which again implies that additional technology would not create further benefits for them.

Automation

The category of *automation* has five references in the transcripts and looks at how people *feel* about further automation in their lives and in general.

Once again, the answers regarding concerns towards automation come exclusively from respondents at Vindmøllebakken. The other respondents either did not mention *automation* or did not have negative feelings or thoughts about that topic.

Respondents 1 and 2 believe that, for one, *"life is already enough digitalized"*, and both share the sentiment that "*they do not wish people to lose their jobs due to further automation."* Furthermore, the two respondents also add that "*human interaction is important"* and that a greater focus should be on using "*social sciences in connection with technology to ensure fair and safe systems."*

Respondent 1 adds that they "*feel sceptical towards AI making decisions in certain areas of life (such as autonomous vehicles)."*

Fairness

The theme of fairness was more of a selective code than its category but is worth mentioning as it sheds light on distributive justice. **Respondent 3** noted that their concern with smart technology does not only lie within the use of it but the fact that *"people of lower-income that would need smart technology to decrease their energy bill do not have the monetary capacity to purchase it."* They add that currently, smart technology *"only benefits the richer people."*

6.1.2 Opportunities

Despite focusing on identifying barriers towards smart technology adoption, opportunities that came up during the interviews will be briefly discussed.

The most frequent opportunity was related to *automation* and was mainly voiced by people that had already installed smart home technology in their homes. **Respondents 4, 5, 6, 7, and**

8 were all optimistic towards more automated smart home technology if there was a high level of reliability and the possibility to interfere and make changes when needed.

Respondents 1, 2, and 3 could see the benefit of automated smart technology for either their future selves *“maybe in 20-30 years to make it easier to live at home longer and have a good life* or for other people and uses such as *people with complicated and hectic lives, for example, families with cars.”*

Respondents 4-8 who already have smart technology in their homes emphasised the benefits of their smart home technology by explaining that the “*configuration options increase the possibility of a simpler and more efficient life*” and makes *consumption easier to control and more transparent.* Another comment on smart home technology was that “*it feels like “the future”/cool) and allows controlling the entire house via one app, making life easier.”*

6.2 Industry

This section presents the findings from the industry interviews and reviews barriers and opportunities related to automated smart home diffusion in Stavanger, Norway.

As mentioned in the previous section, fourteen experts were interviewed to better understand the current state of AI systems in the electricity grid context and discuss future developments and ethical considerations.

The table below visualizes the different themes and codes that emerged during the data analysis. A total of six themes, which are in *italic*, and 17 selected codes, were identified during the analysis process.

Table 4: *Codes and Themes form Industry Interviews*

Codes and *Themes*	References
Industry	**105**
Barriers	**105**
Ethics	**10**
Market	**14**
Complexity	3
Saturation	6
Monetary	**22**
Policy	**18**
Incentive	1
Power	1
Regulations	0
Transparency	4
Social	**22**
Comfort	2
Communication	3
Control	1
Environmental	1
Knowledge, Awareness	10
Learning	3
Trust	1
Technology	**19**
Complexity	4
Ease of Use, Functionality	5
Reliability	2
Saturation	3

Source: Industry Interviews coded with Nvivo 12

While the fieldwork related to households was focused on identifying emerging themes and developing a theory on technology adoption, the fieldwork related to industry experts was more of an explorative and investigative nature. The fieldwork was focused on understanding the status of AI in the energy context and possibilities of the deployment of such systems, figuring out the critical mass of households needed to make an ML system feasible, and how ethics are currently incorporated into processes regarding AI systems by answering the following research questions:

i. How are possible ethical considerations concerning AI/ML systems acting as intermediaries between the homeowner and the energy grid addressed?

However, as AI is still a very new concept within the energy distribution context, the data collected related to AI systems acting as intermediaries was insufficient. The topic will predominantly be discussed based on the findings during the document analysis.

However, information collected regarding smart control systems, especially related to flexibility efforts, is very relevant for this research as they face similar or the same challenges as a more automated system would.

The barriers and opportunities identified during the expert interviews are reviewed in this final part of the section

6.2.1 Barriers

The barriers are presented in the order of their frequency, starting with the most frequently mentioned barriers, and ending with the least identified difficulty.

Six themes with a total of 103 references were identified as barriers. The themes are *ethics, market, monetary, policy, social,* and *technology.* Whereas *social* and *monetary* account for 22 references each, followed by *technology* with 19, *policy* with 18, *market* with *14,* and *ethics* with 10.

Monetary

The category *monetary* includes all topics related to costs. This can be *end-user costs*, *costs for grid companies* or lack of *monetary incentives*.

Respondent 3, which has insight into Vindmøllebakken´s technology solutions, explained that the division of costs for shared spaces in the building is not clear, *"if evenly divided among households, some will pay more than they use, and some will pay less than they use."*

A personalized pricing solution for common areas does not seem to be possible at this point. The respondent also explained that "*the cost of smart technology is higher than what customers would be able to safe by installing it,*" which goes hand in hand with the responses from the interviews with households. Both **Respondent 6 and 9** explain that ML systems that offer energy efficiency, as well as grid flexibility, are only welcome among end-users "*if there is a monetary incentive.*" As grid flexibility needs the possibility to turn appliances and electricity off, "*there is an upfront cost for both hardware and software which no one wants to take. There is a lack of incentive, especially for homeowners as flexibility will not make back the money spent on smart home appliances.*" **Respondent 12** adds that the "*flexibility load in households is so little that it is not a money-saving project especially as the cost of the needed equipment is high. Even a project working on flexibility with industries that have larger flexibility loads available has run into pricing challenges.*" This issue was also taken up by **respondent 13**, who explained that "*it is unclear whether the incentive for different groups within the flexibility markets is big enough. An effort was made to map out acceptable prices for the different groups involved in the flexibility market. However, no consensus could be found thus far.*"

According to **respondent 6**, "*households are not a very good business case,*" and **respondent 9** believes that "*figuring out the price/making it worthwhile for the client will be one of the biggest barriers.*" **Respondent 7** elaborates on that issue of cost by explaining that the multitude of electricity providers and the ease to switch between them depending on electricity cost "*creates no incentive for users to invest in energy-saving technologies.*" Furthermore, "*there is a lack of incentive to buy back flexibility from users, which is why surplus electricity is currently amassed and sold back to grid companies through so-called aggregators.*" **Respondents 10 *and 14*** further explain that the "*price of power (demand) is very low in Norway and is taken for granted, making it difficult to have a market for* *flexibility."* **Respondent 14** further explains that a project working on energy management in the Stavanger region *"needed incentives and offer compensations to get people interested enough to participate in the project. The idea of saving electricity alone was not a high enough incentive for people to join."* The respondent went on to illuminate the issue that "*installation time was long, cost-intensive and complex. However, as this project was initiated several years ago, it might be different now."*

On the topic of including smart charging and using the car battery as energy storage for increased flexibility, the respondent voices the concern *"that there is no value for the car owners and no will from energy companies to compensate for using the battery."* The respondent adds that "*despite the technology being available, it is too expensive, and the business model is currently too challenging."*

Another issue on pricing was raised by **respondent 11**, explaining that "*consumers tend to optimize based on comfort, but how can optimization based on comfort participate in a system that either is optimized for technical purposes or profit."* In other words, the respondent does not see how the different groups can find a consensus on pricing and needs. The respondent further elaborates that currently, the "*cost that grid companies have to upgrade the grid can be put back onto the consumer, however when it comes to buying flexibility, the costs lie with the grid companies, which gives no incentive to focus on flexibility rather than expanding the grid."*

Social

The theme that emerged as *social* included *comfort, communication, control, environmental, knowledge/awareness, learning,* and *trust.*

From a company's perspective a social barrier related to new technology adoption is related to a *"low understanding of and low interested in new technology from the consumer side and* *that the threshold to learn about the technologies are often too high as consumers cannot clearly enough see their benefits as"* **respondents 1 and 2** explained. They additionally add that there is generally little understanding among consumers how "*electricity prices work and that they do not trust the industry to have their best interest at heart."* But when there is interest for the solution offered by respondents' company, people do not care about the "*environmental benefits of the solution."* Quite the opposite, green technologies only seem to be interesting for some business customers *"as it is popular among more and more of their clientele"* (green washing). **Respondents 12 and 14** added that many *"people are not conscious about energy efficiency and grid flexibility,"* and even if they are conscious about it, "*households mostly care about energy efficiency and do not understand the concept of flexibility, which is not about reducing the use of energy but moving it around to a time of lower demand, which has been a complex message to explain to people."* **Respondent 14** talked about their experience with an energy management project and how difficult it was to get enough people to participate and the ones participating were "*already more aware and interested in new technologies (early adopters) and cannot be compared to everyday people."* This shows that these technologies do not get as much traction as needed for a more extensive diffusion.

Respondent 3 reports that "*the providers supplying the different technologies at Vindmøllebakken do not communicate with each other, which has led to the overall system not working as seamlessly as it could and should."* **Respondent 6** also raises the issue of a lack of communication. In this context, they have experienced that the "*communication between customers and grid companies are insufficient."*

A lack of knowledge among the industry players regarding "*at what time flexibility should be triggered, and how to find the right amount of volume available in specific parts of the grid* *and at the right time"* has made flexibility efforts difficult, according to **respondents 8 and 9.**

Another issue raised by **respondent 9 and respondent 11** is about the fact that "*comfortability will be crucial to make such projects work for homes, which in turn makes it difficult for grid companies to rely on flexibility as they cannot rely on fixed agreements with customers."* Despite ML systems predicting consumer behaviour over time, these predictions are not always as reliable as grid companies would need them to be.

Current projects concerning "*energy management are not AI but rather rule-based"* (**respondent 10),** and therefore, "*little knowledge about AI in connection to energy management was available*."

The last barrier related to the *social* theme came from **Respondent 13 that** argued that "*if the strategy to move electricity use away from peak times by using tools such as nudging is too successful (many households/businesses adopt new behaviour) one will end up with the same problem just at a different time of the day."*

Technology

The category of *technology* included the codes *complexity, functionality, reliability,* and *saturation.*

Respondent 3 explains that current technology solutions are "*too complicated and complex to be user friendly and that a lot more work and development is needed before it can serve its purpose."* Every apartment at Vindmøllebakken has its technical room that is supposed to give users the ability to control the different technologies; however, "*the interface is not user friendly and leaves homeowners unable to control the energy systems."*

The fact that there is a myriad of technology providers and grid companies that need to be connected and compatible has created challenges to provide seamless transitions between the different technologies and companies.

Both **respondents 6 and 9** describe that there is "*no standardized software or program that can connect and accommodate the different suppliers of technologies and solutions, which"* creates a bottleneck as it is difficult to accumulate enough mass to make flexibility efforts feasible create reliable and seamless solutions.

When it comes to vehicle-to-grid, the respondent shared the concerns that there are currently not enough cars participating and that the hardware in cars currently "*does not allow discharging car batteries to contribute to grid flexibility."*

Currently, there are no projects actively using AI for grid flexibility, but some projects working on testing flexibility options have raised concerns regarding how reliable these systems are and can be. Reliability was raised as an issue by **respondents 8 and 9**. They explained that, as a grid company, they need to be able to "*trust that the system works and is reliable* and *if the flexibility system is not reliable enough, they will investigate other alternatives."*

Respondent 8 further explains that there are currently many uncertainties about how flexibility could be integrated into the grid. Questions such as "*how to keep control and track of the different levels of customers"* and how these systems should be activated are yet to be solved. Should the activation be done *"daily and manually, or should there be an automatic "switch" that activates flexibility measures depending on load and capacity available?"* These concerns show that there is still a lot of knowledge needed regarding how grid flexibility can be solved on a technological level. These flexibility projects are yet to consider AI and ML for automation. The issue of a lack of background data and understanding how possible ML systems could work and how other "*factors such as weather could create* *disturbances in the grid making predictions more complex and difficult*" is an unresolved issue according to **respondent 12,** who is working with energy management pilot projects. The issue of complexity with these systems was also emphasized by **respondent 13.** However, they believe "*that it will be successful, if necessary."* Whether or not these systems are a necessity depends on whom one talks to. **Respondent 14** points out that in their experience of working with energy management projects for five years, apartment buildings need significantly less energy than houses. Firstly, this is due to new apartment buildings being *well insulated. Secondly, "heat from other parts of the apartment building often reduces the need for excessive heating in individual apartments."* This observation reflects the theme of *saturation* that emerged during the household interviews, especially from respondents living at Vindmøllebakken.

Policy

The consensus among the respondents was that flexibility needs to be anchored in policy, which it is not at this current time.

Respondent 1 shares the difficulties they have experienced with spreading their technology among users *"as they need to formally accept to share their consumption data which is strictly regulated in Norway."* On the one hand, this measure enforces user privacy and safety and is in line with ethical guidelines, but on the other hand, it hinders the diffusion of AI systems that could help with energy efficiency and grid flexibility improvements.

Relatedly, **respondents 5, 6, 8, 10, and 13** explain how regulations are either *"currently hindering the implementation of smart control systems"* or that, despite flexibility being allowed, "*regulations and rules are not yet addressing and handling it well enough."* An example given by **respondent 6** is that neighbourhoods could potentially group and arrange a flexible trade between them to reduce the overall electricity need of the neighbourhood.

However, "*regulations are currently prohibiting the trade between different households, making local flexibility efforts fruitless*." In addition to this, even if regulations would allow electricity trading between houses, the issue would be that "*neighbouring houses are often connected to different parts of the grid, " making* trading impossible. To solve this, grid companies rely on aggregators that collect available flexibility for a number of homes to then sell it back to the grid companies.

Respondent 8, working in a local grid company, explains how the lack of regulation and awareness on flexibility at Norges vassdrags- og energidirektorat (NVE) leaves the respondents company no choice to bet on grid expansion rather than increasing flexibility to earn money. Another possible future barrier mentioned by **respondents 9 and 10** relates to the GDPR. Most flexibility projects in Norway are focusing on larger businesses and industry which makes it easier as they "*do not have to worry about the GDPR,"* for projects involving private users, any automated system accessing or relying on user data would have to be compliant with the GDPR, which will be a challenge of its own.

Another issue related to policy is *transparency,* described by **respondent 11,** who works with establishing a trading market for flexibility**,** as being "*key to make flexibility work."* According to their understanding, transparency relates to *grid operators knowing what other grid operators on the different levels are doing and making the price for flexibility commonly available. By having transparency, everyone can compete on a levelled playing field and depending on where actors are in the grid, they will be able to see the different flexibility offers and prices."*

Lastly, **respondent 11** raises the question of "*who is deciding how, how much and when flexibility is accessed and distributed."* This issue is related to ethics and power and is discussed in detail in section 7.3.

Market

Market related barriers were identified as *complexity* and *saturation.*

An issue related to *saturation* mentioned by **respondents 6, 8, and 9** is "*that for flexibility to be worth considering and able to make an impact, 1MW"* is needed. However, households generally work with much lower numbers, so aggregators are needed to make flexibility projects feasible for grid companies. Another issue related to *saturation* is that there are still too few households *with smart technology installed,* as **respondent 6** explains. Additionally, not all areas of the grid need flexibility. This means that *equipping households with smart technologies is useless when located in zones that do not struggle with an overloaded grid*. Grid companies will have no interest in buying back flexibility

The issue of *complexity* is touched by **respondents 7 and 11**, who elaborate on the complexity of implementing flexibility in Norway by showing that *"being able to switch between grid companies easily enables users to pick the cheapest electricity price available without installing further technology makes flexibility less attractive."* In addition to this, the current market seems somewhat saturated with "*apps that can inform people when to use appliances in their homes depending on the electricity price (e.g., tibber)."*

Ethics

Ethical concerns amongst the interviewees were mostly regarding data safety and privacy and less about how processes of designing AI systems could stop existing inequalities and biases being translated into algorithms. This could be due to a lack of awareness or experience with AI in the energy context discussed during the interviews. Data safety and privacy are a procedural justice concern and are among the most common topics within technologies and justice (Dencik et al., 2019).

Smart homes and homes, in general, are susceptible to consumption data misuse and energy thieves, which is why private data needs to be protected sufficiently. However, AI and especially ML require the continuously feeding of large amounts of data to make accurate predictions and decisions. This conflict of interest makes it particularly difficult to find suitable solutions that protect users and provide enough AI systems data. This issue was raised by Jobin et al. (2019) in the literature review as well and can be connected to Fraser (1998) stream of representative justice, as discussed in the literature review. In this case, the households connected to AI systems should be included to determine a fair balance.

Respondent 8 gives an example as their company provides user consumption data to an energy management system. Currently, they are sharing energy consumption data as this is a pilot project. However, they are not sure how "*to solve the issue of data sharing in the future as they cannot provide as much information as they do now."* Another concern is how to fully *secure private data in the future.* This is an unsolved problem for this company and relates to both distributive and procedural justice by pointing out the imbalance of access to information (even though this is among companies, not users) and how procedures regulating the fair of data need to be established.

Respondent 11 adds to that discussion by arguing that for AI systems, "*the private user data would be traded for increased comfortability,"* which has become common practice in the time of the internet.

Respondent 12 explains that they "*have access to consumption data on an individual level for the devices that will be turned off in case of flexibility needs."* This will be necessary to make AI work but does not comply with the GDPR unless the data is anonymized. Once again, finding the balance between collecting data and user privacy will be crucial to realise AI systems.

On the subject of nudging, offering benefits to change one's behaviour, **respondent 12** believes that "*there would be a possibility for grid companies to make use of user consumption data to understand people's needs and preferences and 'nudge' them into different behaviours."* However, the respondent does not believe that" *it will be feasible for grid companies to make individual offers depending on identified needs and user preferences. What could happen is that a grid company offers certain benefits to all of its customers if they agree on switching of appliances at a specific time".* Despite the unlikeliness of nudging being realised in the energy context, according to **respondent 12**, if profits can be made, one must assume companies and organisations will find a way to make use of tools such as nudging. One could argue that nudging provides a fair distribution of benefits as receivers of nudges would profit from lower electricity prices or other benefits such as coupons etc. Nevertheless, nudging could lead to vulnerable groups being pushed towards unfavourable use of appliances or electricity (e.g., at night) as they are more dependent on the offered benefits and decrease their quality of life (e.g., irregular/ lower quality of sleep).

These might be trivial concerns but should be kept in mind when developing systems that encourage behavioural change to ensure a just distribution of benefits and harms.

How flexibility and shutting off appliances is distributed amongst households has not been clearly defined. Currently, systems work based on urgency. People that connect their car to a smart charger can define the time it has to be charged, as **respondent 6** explains.

Opportunities

An opportunity or argument for ML systems is the observation on behaviour of people adopting new energy habits made by **respondent 14.** Their project on energy management showed that the "*newly installed energy saving technology was only interesting and used in the beginning and that at least half of the participant stopped using it completely and the rest* *used it significantly less."* The results go hand in hand with other studies that have observed that people tend to revert to their old habits (Batalla-Bejerano et al., 2020; Bhati et al., 2017). Furthermore, a project comparing manual and automatic energy management systems in households showed that the automatic testing group was double as effective as those who had to switch off appliances manually. This demonstrates that automated systems could positively impact energy efficiency and grid flexibility in the Norwegian energy context but would need further investigation and scaled up pilot-projects to ensure it is a viable solution.

***Table 5**: Summary of Findings*

Barriers	***Summary***
HOUSEHOLDS	
Functionality	For private homes, flexibility is no necessity and might even diminish their comfort at home
Saturation	Other, current technology might make an interconnected AI system redundant
Data	Mistrust in data management of companies and authorities might slow down or hinder diffusion of AI systems
Individuals Characteristics	People with unpredictable lifestyles and good energy habits, might not see the need for such a technology
Automation	General scepticism towards further automation could slow down diffusion
Fairness	Concerns of injustices related to distribution of energy technology could lead to unwillingness to support new tech.
INDUSTRY	
Monetary	Lack of monetary incentives or profitable business cases for flexibility involving AI, might hinder implementation
Social	Mistrust, unawareness, need for learning, and reduced comfortability for users might make diffusion difficult
Technology	Complexity of technology needed, reliability of tech, and low saturation of smart homes in grid, makes adoption unlikely
Policy	For policymakers, flexibility still seems to be an inferior alternative to expanding the grid
Market	Complexity of market and actors involved in flexibility and lack flexibility capacity on consumer end, complicates adoption
ETHICS and JUSTICE	
Procedural	Experts are aware of data safety and privacy issues but no procedures/processes to decrease inequalities or ensure ethical AI systems, GDPR not yet needed as projects mostly for businesses
Distributive	Nudging seems to be of low concern, awareness around it is limited; how flexibility is fairly distributed is yet to be determined

Table 5 summarises the main findings from the interviews with households and industry experts. Chapter 7 discusses these findings in connection to the literature and the theory of energy justice.

7 Discussion

The objective of the qualitative grounded theory study was to discover the factors that impede the adoption of smart home technologies in homes. The qualitative multimethod approach was used to investigate industrial hurdles to home automation and the ethical implications of AI systems in the energy grid context. The section discusses current research and fieldwork results in relation to the theory that emerged from the grounded theory methodology and energy justice.

i. *What are the most prominent barriers hindering the penetration of automated systems in the grid and homes?*
ii. *How are ethical considerations concerning AI systems acting as intermediaries between households and the energy grid, addressed?*

This section is divided into four main sections. Section 7.1 discusses the key findings from the fieldwork with households in relation to UTAUT2 and other relevant literature and the implications for lawmakers, businesses, and firms working with smart home technologies and/or artificial intelligence. Section 7.2 discusses the industrial obstacles, and section 7.3 the ethical concerns identified during fieldwork and document analysis. The debate on ethical considerations is organized around the concept of energy justice. The section closes with a discussion of the study's shortcomings, future research directions, motivation for the study, and finally, a summary in section 7.4.

7.1 Household barriers and opportunities

The theory that emerged from the grounded theory methodology of what hinders smart home technology adoption is composed of five major themes:

(a) technology´s functionality made new technology (un)attractive

(b) technology saturation owing to existing technologies or living situations renders new technology unattractive

(c) lack of confidence in data management stymies AI technology dissemination

(d) individual qualities and personalities impacted people's readiness to accept technology, and

(e) overall attitudes toward automation influenced adoption.

Certain variables are largely related to the individual, while others are related to the social environment, and yet others are a mix of the two. All these elements play a role in the acceptance or non-adoption of automated smart-home technology.

Before deciding on a grounded theory approach to identify barriers in households, multiple technology adoption theories were considered, especially the modified unified theory of acceptance and use of technology, short UTAUT2, with the modification of replacing the moderating variable ‘gender’ with ‘technology awareness’ after consulting relevant literature such as A. Khan & Qudrat-Ullah, (2021) Abubakar & Ahmad (2013), Bardram & Hansen, (2010), Reffat, (2003), and Venkatesh et al. (2003, 2012). Figure 7 visualises the modified UTAUT2 considered as technology adoption theory, and the following paragraph clarifies why UTAUT2 was not a suitable theory for this case.

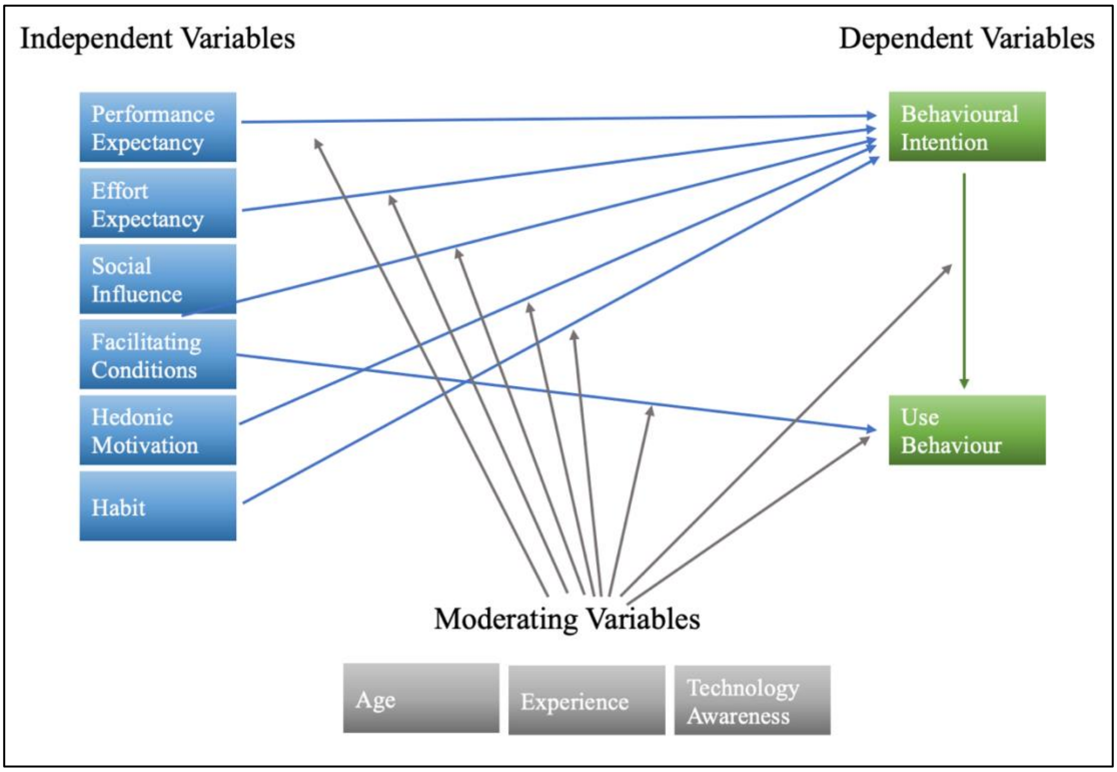

Figure 7*: The UTAUT2 with adapted moderating variables*

Source: (A. Khan & Qudrat-Ullah, 2021) and own modification.

The study's analysis showing that *functionality* was a determining factor for technology adoption in homes aligns with the UTAUT2 model, indicating that 'performance expectancy' and 'effort expectancy' affect adoption behaviour.

Furthermore, 'hedonic motivation' or the joy of using technology as a variable influencing adoption, as mentioned by one respondent, as the technology is "*cool* or "*feels like the future.*" However, contrary to the results from this study, UTAUT2 does not account for the barriers identified as *saturation*, *data*, or *individuals' characteristics*. Furthermore, 'age', 'experience' and 'technology awareness' did not seem to influence the likelihood of technology adoption in this case. In the UTAUT2, these are considered moderating variables that increase or decrease the adoption behaviour of people.

As the research was based on a different type of technology, which depends on large amounts of data, topics such as *data* and *individuals characteristics* might not be as relevant in other adoption methodologies such as UTAUT2 (A. Khan & Qudrat-Ullah, 2021; Venkatesh et al., 2003, 2012) but seemed significant for the adoption of automated smart home systems.

Functionality and *Individuals Characteristics* are somewhat interlinked. For this study, functionality included usefulness based on people's lifestyles. Meaning that people with more irregular routines would likely not benefit from an ML system or already had good energy habits, making such a system useless. Still, an ML system that could help increase grid flexibility would benefit from having a diverse data set that mirrors real-life energy use across all types of households to make the most accurate and reliable decisions and predictions in the energy grid. If people with flexible lifestyles do not see the energy efficiency potential, it might present a barrier towards an effective ML system. The industry interviews have shown that grid flexibility is somewhat difficult to grasp for homeowners, and even if understood, without benefits for the consumer, people are not willing to install further technology or ease up on control of their appliances. This implies that it might be difficult to get enough houses to participate in such a project to make it feasible. The industry barriers are detailed in section 7.2.

A focus for companies developing smart home technology and eventually AI systems to aid energy efficiency should be on user-friendly interfaces and reliable solutions. The main concern for respondents with and without smart home solutions is learning how to control and use the technology and how reliable it is. Unreliable energy control systems will increase the stress and frustration amongst homeowners, which can lead to a decrease in the adoption of new technologies and halt the use of current technology. Current smart home technology does already not live up to its full potential, partially due to people returning to old energy behaviour patterns as shown in research presented in the literature review (Bhati et al., 2017; Poznaka et al., 2015; Reinisch et al., 2015) and the answers from industry experts alike. Even though an ML system would take away the need for constant control of appliances and energy use in homes, a transparent and easy to use interface to view energy consumption and interfere with decisions would be incremental for such a technology to be attractive.

The fact that *saturation* distilled itself as an important barrier amongst households at Vindmøllebakken and during the industry interviews shows the importance of a solution that could seamlessly integrate technology from multiple providers and be connected to already existing solutions. An ML system should not necessarily need additional technology installed in homes if smart home technology has already been installed. For cases such as Vindmøllebakken, it would be necessary to install "off" switches in the homes and common areas prior to people moving in as the benefits for the individuals are too low to make up for the additional costs. Even though ML systems for places like Vindmøllebakken might not increase consumer benefits, they could contribute to more grid flexibility by offering greater diversity in the grid. Even if occupants would not be able to increase their energy efficiency, a system that could control shared spaces (such as the laundry rooms) could help with peak shaving.

Data safety and privacy are unique to this technology adoption as other technologies do not necessarily need private data to function. The interviews showed that people generally mistrust how companies handled their data and were unaware of how the GDPR addresses their data protection. This issue was also raised by Sartor (2020) and Wolford (2019) in the literature review. The topic of data raises the concern of data protection itself and how to communicate rights and regulations transparently and understandably to consumers. People do not always have the time or interest to inform themselves on current data regulations and even if they do, getting insights into private data records is not always an easy task.

For an ML system to be attractive to consumers, data collection and use would have to be made very clear and accessible from the get-go. This would have to be anchored in regulations, such as the GDPR, but would need clearer and less lawyerly language to make it accessible to everyone.

Personal views on *automation* and a lack of *interest in* gadgets, in general, could furthermore halt the diffusion of ML systems connected to private homes unless these systems are pre-installed in homes or government-funded as it has been done for smart meters across countries (Callanan & Department for Business, Energy and Industrial Strategy, 2020). Changing the view of automation in people goes beyond the scope of this study, but theories on social imaginaries (Taylor, 2003) could help understand how AI systems could become part of a new social norm and increase adoption across sectors.

Overall, the qualitative results from the household interviews do not align with the UTAUT2. Furthermore, contrary to UTAUT2, the quantitative analysis using SPSS did not show a significant correlation between age, experience, awareness, and the willingness of technology adoption.

The SPSS analysis showed that the more people that live within a home or apartment, the more likely they were to adopt the technology. This trend also emerged during the interviews as an "opportunity" in the sense that people that lived alone or with one other person could see the benefit for families with more complex and hectic lives.

However, as this part of the study was performed with a limited number of participants (8), it should be kept in mind that the respondents are not representative of the population and that the results cannot be generalised. A larger number of respondents with greater diversity – not early adopters and people living in places such as Vindmøllebakken – would be needed to make this study more reliable. The results can be taken as a possible trend and should be considered when thinking of developing and implementing AI systems for electricity control.

Another option would be to do longer studies with larger numbers of respondents to see how these trends correspond to the general population in a country such as Norway.

According to these results, the adoption of AI connected smart home systems is mainly depending on their *functionality*, *saturation*, and *data* concerns.

In the UTAUT2, *functionality* plays an important role in adoption, whereas other studies have shown that the cost of technology, data concerns, and a lack of awareness are important factors for adoption (Statista, 2021). A different approach was used by Hong et al. (2020) that focuses on resistance towards adoption. Here the main contributors to resisting technology adoptions were related to usable products (*functionality*), a lack of awareness, and price and data. The studies have similar results to the findings of this case, which increases the confidence that the collected data and the resulting interpretations are somewhat reliable. Still, it needs to be repeated that the low number of respondents makes generalisability unviable. Nonetheless, the results from this case can help inform and support further studies on household adoption of AI-based technologies.

7.2 Industry barriers

The barriers identified during the expert interviews are highly relevant for companies and organizations looking into more automated energy control systems. Additionally, as the industry relies on regulations to pave the way and support the transition towards more flexibility, this section can also inform policymakers on gaps and needs in current and future regulations.

Many of the barriers overlap, and it is not always possible to draw clear lines between the different types of barriers, which only shows the complexity of an ML system, the interlinkages between the sectors it touches, and the holistic approach needed to make it work.

Economic obstacles

The interview results regarding monetary incentives are in line with Sønju & Walstad´s (2019) findings concerning barriers to flexibility.

Whereas Sønju and Walstad mostly talk about end-consumer incentives, industry experts in this study explained that monetary barriers could be found on the consumer, grid company, and regulatory levels.

Essentially, if there is no monetary gain for consumers and providers in producing grid flexibility and energy efficiency, large scale applications are unlikely.

On the one end, there are costs for the end-user to install the necessary technology to enable energy efficiency and grid flexibility. Prior to the introduction of a potential demand tariff, the savings from shifting usage will be minimal, given the spot price of energy in Norway changes very little during the day. Thus, the client will have little financial incentive to invest in extra equipment when the increase in energy efficiency is so small. End users should be reimbursed for the costs associated with acquiring new equipment, such as a control system that makes the customer's loads available to an aggregator. Although it is not yet determined who will shoulder this expense, it is apparent that an end-user will be averse to paying for it as projects run by industry experts and the study by Sønju and Walstad indicate.

On the other end, an economic barrier concerning flexibility on the grid level is the cost of flexibility. An industry expert explained that an effort was made to identify acceptable prices for different actors involved in the flexibility market. A consensus could not be found at this point.

One possibility would be that the network's load decides the cost of acquiring flexibility. Flexibility can be triggered under certain circumstances, such as when the network's load reaches a certain level. The amount by which the load exceeds the threshold may dictate the price at which the aggregator can offer the flexibility. Another economic barrier is that flexibility is currently not profitable compared to grid expansion due to a lack of adjusted policies. This barrier is further discussed under ‘regulatory obstacles.’

Technical obstacles

A technological barrier that could thwart the diffusion of automated control systems is the multitude of technology and software providers currently not compatible with one another. In addition to this case study, the study done by Sønju and Walstad (2019) showed that AMS meters used in Norwegian houses are not all manufactured by the same company. Kamstrup, Aidon, and Nuri are three distinct providers of AMS meters that have been picked by Norwegian grid operators for installation. Additional equipment beyond an AMS meter is required to regulate individual loads. Due to the absence of standardization in the equipment that may be connected to the AMS meter, multiple vendors might provide equipment that is only compatible with their AMS meter. This means that diffusion of an interconnecting ML system will only be possible when technologies and software are standardised or highly compatible with one another.

A more easily solvable technological barrier is the circumstance that there is a lack of background data available to implement AI and scale current flexibility projects. This bottleneck will disappear with time when more and larger projects work on similar plans unless the data needed is private consumption data, which is a barrier discussed in section 7.3. Lastly, current uncertainties about how and when to “activate” the flexibility measures still need to be figured out. Should it be done depending on the load and capacity available? Moreover, what exactly is the threshold that needs to be passed to activate flexibility? These are questions yet to be answered.

Mentioned during the household as well as the industry interviews was the need for user-friendly technology and equipment to achieve a high enough saturation of technology adopters in the market. Even if a satisfying saturation is achieved, current hardware and software do not always allow electricity to move both ways. For example, car charging software is not usually built to release stored electricity in the batteries back into the grid when demand is high. Apart from that, charging and discharging privately owned batteries brings along its own set of issues, such as compensation for reduced battery life.

Lastly, if homes become more and more energy-efficient by using better materials, insulation, and energy management, the incentive for end-users to install new technology decreases substantially. This does not mean that energy-efficient buildings get in the way of AI-controlled energy management, but the narrative around flexibility and its usefulness would have to change to ensure great enough adoption among households to make flexibility feasible. How discourse can influence AI adoption would have to be the subject of future research.

Regulatory Obstacles

According to the interview results and Sønju & Walstad (2019), there are no current policies for companies providing provision for an aggregator in the market.

Most reserve markets are intended for producers rather than consumers. As a result, the regulations must be amended to provide access to the aggregator, but it is difficult to modify regulations without affecting other parties somehow.

As mentioned in the monetary section, by purchasing flexibility from suppliers, a grid company will incur a loss of revenue under existing rules and regulations. This is because the cost of purchasing flexibility is considered an operational expense. If a grid company has greater operational expenses, it is deemed inefficient and will likely perform poorly compared to other network companies. This results in a loss of revenue for the grid company. If the grid company decides to invest in the network rather than use flexibility, the end-consumer will partially pay the investment expenses, as explained by the industry experts. Therefore, laws must be adjusted to make it advantageous for network businesses to employ flexibility, as interview results and Sønju and Walstad´s (2019) study shows. Furthermore, regulations need to accommodate electricity trade between neighbouring houses and neighbourhoods to enable small scale flexibility efforts. However, this is hindered by the complexity of grid connections from households to girds, making it a technical and regulatory barrier.

A future barrier toward automated control systems can be the GDPR. Current projects in Norway mostly work with businesses and do not involve private data, but if flexibility projects are scaled up, companies will have to abide by GDPRs. However, as the literature review on GDPR and AI have shown, certain unclarities in the GDPR could provide loopholes for companies to implement AI systems without breaking with regulations (Sartor, 2020). This, however, would go against ethical principles, which are discussed in detail in section 7.3.

Lastly, without transparency on the different levels connected to an ML system, it will not be possible to implement flexibility. The grid operators must know what other grid operators on the different levels are doing to make the price for flexibility commonly available. By having transparency, everyone can compete on a levelled playing field. Depending on where actors are in the grid, they will be able to see the different flexibility offers and prices. However, transparency is tricky. For an ML system to work, large amounts of consumption data are needed, which interferes with data privacy regulations. A solution to this problem is to anonymize data further and add "noise" to the datasets. This again reduces the effectiveness of ML systems. How to balance these contradicting needs is a topic for future research. Levels of transparency should be regulated by law and monitored by an independent institution, ensuring adequate privacy and security measures and a fair and levelled market.

Market Obstacles

The most consistent barrier that emerged among industry experts concerning the market is the mass of flexibility needed to make it worthwhile.

In Norway, the average electricity use in a house is around 20 000 kWh per year and 1 666 kWh a month. It lies at around 15 000kWh per year and 1 250kWh a month for a townhouse, and an apartment uses around 9000 kWh per year and 750 kWh a month (Fjordkraft, n.d.). To make flexibility attractive for grid companies, they need to have at least 1 MW available to "produce" enough flexibility. This means that many houses would have to be available for daily flexibility measures to make it feasible. According to the industry experts, current smart home technology diffusion in Norway is not great enough to consider it a market for flexibility. In addition to this, areas with a high smart home technology penetration might not be areas where flexibility is needed, possibly creating a larger gap between where flexibility is available and actual required, making implementations more cost intense, as flexibility needs would have to be mapped and the corresponding area equipped, with the needed infrastructure and technology.

Another obstacle is implementing flexibility trading in the network between an aggregator and a DSO, a TSO, or a power supplier and the lack of a well-established market model for this sort of transaction. Trading in flexibility might occur via a marketplace or directly between an aggregator and a buyer. NODES is an example of such a marketplace. Trading flexibility is a novel idea in the electricity grid, and as a result, stakeholders lack expertise with how the various market models operate in practice.

Bilateral agreements between two parties could serve as a first step in establishing a flexible marketplace.

7.1 Energy Justice and Ethical Considerations

AI at the distributor and producer level of the energy grid of Norway is virtually non-existent. The limited information gained from the expert interviews is therefore heavily supplemented from the document analysis.

The ethical considerations that emerged during the fieldwork are connected to the four streams of energy justice identified in the literature review and the theory section.

The stream of procedural justice emerged as a main theme during both document analysis and industry interviews. This might be caused as it is more tangible than discussing distributive injustices throughout the lifecycle of AI or how ML systems could aid unfair distribution of efficiency. Recognition justice and cosmopolitan justice were not part of the discussion surrounding AI in the energy system, as more local and immediate injustices were already difficult to grasp.

This section is structured according to the four streams of energy justice discussed in the literature review: procedural justice, distributive justice, recognition justice, and cosmopolitan justice. The context of this thesis has resulted in an interlinkage of distributive and recognition justice, as the ones benefitting from ML energy control systems belong to the wealthier groups in Norway already, unjustly distributing energy efficiency and.

Procedural Justice

“The story of Hans is now used in machine learning as a cautionary reminder that you can’t always be sure of what a model has learned from the data it has been given”(Crawford, 2021, p. 14). This quote visualises how we can, with the best intentions, manipulate the outcomes of models and why just processes surrounding AI development are so incremental to a fair implementation of these systems.

The procedural justice stream within energy justice peruses whether AI's energy transitions are instigated fairly and democratically.

During the fieldwork for this thesis, the topic of processes and procedures surrounding the design and operation of AI systems was limited to data use, privacy, and the GDPR due to the few established AI systems.

Procedures around data in AI include both ends, the production and collection. On the one end, customers should

1. Treat the data from their smart meter as though it were personal data
2. operate with the assumption that all entities are untrustworthy
3. ensure that they can revoke consent for all parties to collect and process the smart meter data at any time (Ibrahim, 2020)

On the other end, there are methods for ensuring the privacy and fair use of consumption data and the just development of AI systems.

Modern AI systems are based on statistics and data. Statistics are developed to provide generalizable knowledge and measurements of quality. They are used to provide incentives for performance improvement. The data used to provide statistics is often the source of ethical problems. Therefore, the ‘when’, ‘where’, ‘how’, and ‘why’ are important questions that need to be asked when collecting data.

In addition to possible missteps during the data collection, the formulation of algorithms and whether the purpose of the AI code agrees with the purpose of the data collected might nurture social inequality and ethical concerns. A further concern is connected to the reality that AI and computer algorithms are hackable and can be manipulated externally. Data manipulation techniques could help to contain the privacy of consumption data to prevent data leaks and misuse. These techniques include 'data obfuscation,' which means adding noise to metering data. This simply implies that the statistics on private energy usage will be changed for the benefit of other parties. This approach conceals the real usage level, therefore minimizing information leakage. However, the utility provider requires this type of data for forecasting and control purposes. The second technique, dubbed ‘data aggregation’, is the consolidation of various metering data prior to transmission to the electricity provider. This helps to eliminate the trail of origin, resulting in a decreased chance of privacy invasion. The gateway will collect and process the data. As a result, the smart meter's cost is reduced, as less computational power is required. The third approach is referred to as 'data anonymization .' The data is identified using pseudonyms rather than the consumer's identity. The more data is manipulated, the harder it becomes for ML systems to make accurate predictions. This conflict of balancing user protection and collecting enough data for reliable AI systems was mentioned by Jobin et al. (2019) and during industry interviews. Whether there will be a standardisable answer is yet to be discovered. Until then, policy should continue to guide the processes of designing and operating AI systems.

In that regard, the literature review discussed the influence of the GDPR on AI systems and showed the missing specifications and clarity needed to ensure fair and just AI development and implementation. Internal company guidelines, e.g., as presented by the European Commission in section 2.4.1, could supplement ‘hard’ laws, such as the GDPR, with additional measures to ensure fairer and more reflected processes around AI systems. However, by who and how these guidelines are established would be a concern on its own.

As Jobin et al. (2019) identified in the literature review, there are divergences across ethical principles on fundamental factors such as how ethical principles are interpreted; why they are believed to be essential; the topic, domain, or people to whom they apply; and how they should be applied.

Justice theories, such a social justice, environmental justice, energy justice etc., should be used to help inform the developments of internal guidelines but do not eradicate the issues raised by Jobin (2019).

Therefore, to ensure the justest and democratic evolvement of AI, people that are impacted by AI systems should be included in the processes surrounding AI, including establishing guidelines. As discussed in the literature review, Fraser´s (1998) stream of representative justice addresses this concern. In this case study, the households connected to AI systems should be included to determine a fair balance. This can also aid in avoiding so-called ‘surveillance capitalism' and ‘surveillance state' extremes, as Sartor (2020) stated in the literature review.

Therefore, we must generally ask: Where are the civil society organizations, organizers, and campaigners tackling problems of climate justice, worker rights, and data protection? How are they to be included in these discussions? How are impacted communities to be included?

In other words, how can we engage in a far more robust democratic discussion about how these technologies currently influence the lives of billions of people in mostly unaccountable ways.

Further procedures around AI anchored in the GDPR include that people providing data should be informed about its use and can retract their agreement to share it (Intersoft Consulting, 2016; Spyridaki, 2020). As White (2020) pointed out in the literature review, both individuals and authorities can hold the controllers and processors accountable in the case that data or data methods are not in compliance with the GDPR (White, 2020).

However, as Wolford (2019) and the interviews with households have indicated, users are often not aware of relevant data protection laws, and even if they are, they often do not comprehend the regulations due to their sheer volume and complexity and simply a lack of interest for them. Simple and clear explanations should be provided to counteract unawareness among users. By informing data subjects about the goal and boundaries of each AI process in which their data is involved, GDPR can steer AI processes, as Sartor (2020) explained.

Another issue related to the processes of ethical AI is linked to the characteristic of organizational culture, which tends to prioritise competitiveness in the market and therefore often moves faster and distributes products instead of taking the time to consider aspects such as fairness and privacy (Madaio et al., 2020). A "productive restraint" could be implemented into the lifecycle of the development and deployment of AI-based technology to prevent such developments (Madaio et al., 2020). Furthermore, muddled thinking in boardrooms and governments as a result of people's sci-fi vision of artificial intelligence can cause overlooking very real, unresolved issues — such as how racial bias can be encoded into AI through skewed training data, the lack of transparency about how algorithms work, or the question of who is liable when an AI makes a bad decision — in favour of more fantastical concerns about things like a robot takeover (Heaven, 2020).

Distributive Justice and Recognition Justice

The distributive justice stream contends with the just allocation of benefits and detriments of energy transitions. Whereas justice as recognition pinpoints marginalised and disadvantaged groups already at risk or worse off due to the energy transition. It focuses on the equality of outcome rather than the equality of opportunity.

Herein, distributive justice is used to analyse the fair distribution of energy efficiency and the benefits offered by machine learning systems in the energy context. In comparison, recognition justice serves as a guide to ensure that the most vulnerable are being considered and satisfied first before enhancing the well-being of the rest.

The vicious cycles of vulnerability introduced in the literature review by Nordholm & Sareen (2021) focus on how already vulnerable groups get further disadvantaged through energy transitions. In the case of this thesis, these vicious cycles exist on multiple levels. The most obvious one might be that wealthier households can invest in energy-saving technology and save money. On the other end, the less wealthy groups that would need the technology more but do not have the monetary capabilities to buy the technologies or lack knowledge and awareness of new solutions. This goes hand in hand with recognition justice, which calls for satisfying the needs of the most vulnerable groups first. However, there are no current initiatives or subsidies available in Norway that could provide energy-saving technologies to disfavoured groups (Enova, n.d.).

A further distributive justice implication mentioned by industry experts is the fact that flexibility is not needed everywhere in the grid. This could result in people investing in additional hardware and software to support grid flexibility and reduce their energy bill, only to realise that their neighbourhood or local grid barely needs flexibility. To avoid malinvestment, providers of technologies would need clear and updated insight into flexibility needs across the region and communicate to all interested households.

An additional consideration concerning distribution and recognition is the upcoming demand tariff discussed in the literature review. This demand tariff is supposed to encourage lower overall consumption in households by charging not per kWh but depending on how large the total consumption in a household is. This puts people with immigration backgrounds and lower education in an unfavourable position. First and second generations with immigration backgrounds and lower educations tend to have slightly larger families and are less stable financially than other groups (European Commission. Joint Research Centre., 2016; Statistisk Sentralbyrå, 2018; Westphal & Kamhöfer, 2019). These groups would greatly benefit from energy-saving technologies to increase ease of life and reduce energy bills, yet they might be the last group to receive them.

This addresses the “how” question of distributive justice, which asks if the commodity should be distributed based on merit, utility, need, property rights, entitlement, or other features (Sovacool and Hess, 2016). According to Nordholm and Sareen (2021), distributive justice is meant to address geographical inequalities and address the processes of recreating and intensifying energy injustices, which aligns with recognition justice and the need to increase the well-being of the less fortunate first.

Lastly, the distribution of benefits and disadvantages of AI systems in general and in the energy, context goes beyond the immediate effect of these systems. The topic of these inequalities was shortly discussed in the literature review and has been thoroughly investigated by Kate Crawford in the book ‘Atlas of AI’. Having a more holistic look at the lifecycle of technologies will help eradicate injustices accurately.

When we consider AI systems on a larger scale, and over a longer time horizon, we can move away from narrow definitions of "AI fairness" and "ethics" and towards a discussion of power and realise that these systems will cause profound and lasting geomorphic changes to the planet, as well as exacerbate existing forms of inequality (Hao, 2021).

Cosmopolitan Justice

Cosmopolitan justice applies the concepts of procedural and distributive justice on a global scale by acknowledging the equal worth of every individual, which must be respected and protected independently of their national affiliations.

This stream gives insights on whether and how the lessons learned from this case study could apply to all humankind, critically reviewing the lack of consideration of local cultures, morals, and preferences.

Two of the fundamental flaws of AI are the generalised categories of the environment and the benchmarked datasets artificial intelligence depends on. According to Kerner (2018), benchmark datasets used in AI and ML are not in touch with reality. ML models are generally measured against large and arranged datasets that assume a categorized and stable world. However, these categories are in constant flux, depending on geographical and cultural settings. For the world to benefit from ML, the question of "What is the field´s objective?" needs to be moved back into focus (Kerner, 2018).

The categories used to make sense of the environment are not objective either. They establish social order, normalize hierarchies, and exaggerate disparities. AI can no longer be regarded as an objective or impartial technology when seen through this lens (Hao, 2021).

How can insights from this thesis concerning cosmopolitan justice be transferred to other countries and cultures?

Every country has less and more vulnerable groups, and lessons learned from social justice theories teach us to look more closely at how new technologies and developments can further disadvantage vulnerable groups. In the context of AI for energy efficiency and grid flexibility, certain injustices could be manifested if awareness and just processes are missing. However, when examining the idea of AI for energy control on a global scale, the injustices do not only lie with the skewed distributions within a country. There is a global inequality of distribution of benefits because industrialised nations reap the benefits of technological developments on the backs of developing nations providing the raw materials and labour. These materials often require mining and work in toxic environments, which can be detrimental to the health of the workers. Additionally, working conditions are often unsafe, and workers are seldomly receiving a living wage. To achieve truly fair and just AI systems, one must open the discussion to a more holistic analysis and consider the complete lifecycle of AI systems.

Summing up, the different stages of energy, the cradle to the grave, have both fairness and justice implications. The cost of climate change is worse for the poor and developing nations, whereas rich countries receive the potential benefits. If we are to achieve eudaimonia and increase the well-being and happiness of human lives, as described by Aristoteles, nothing short of a holistic, socio-technical approach to AI systems and technologies, in general, is necessary (Kraut, 2018).

7.2 Conclusion

The aim of this thesis was to investigate and identify barriers to the diffusion of AI energy management systems for households and industry and analyse the ethical and justice implications for the people involved and impacted by the systems.

The fieldwork has distilled six main barriers to household adoption: *functionality, saturation, data, individuals' characteristics, automation, and fairness.* Five themes concerning industry barriers, which are *monetary, social, technology, policy, and market.* And relevant input on inherent injustice of AI systems in the energy context.

The consequences of the study results extend to policy, technological, and ethics. At the policy and technology level, increased collaboration among all stakeholders is necessary to harmonize divergent technologies, software and AI ethics agendas, and pursue procedural convergence, not just on ethical concepts but also on their execution.

While global consensus on ethical standards might be desired, it should not come at the expense of cultural and moral heterogeneity and may need the establishment of deliberative processes to resolve disagreements amongst stakeholder groups from various global areas. Intergovernmental organizations can mediate and facilitate such initiatives, supplemented by bottom-up measures engaging all relevant stakeholders, inlcuding households. The challenge raised by the procedural justice stream demonstrates the importance of democratic and representative decision-making in procedures involving AI. For Norway, the Norwegian Water Resources and Energy Directorate (NVE) is the national regulatory authority, accountable for holding public hearings and ensuring that public interest is considered in decision-making. However, what role the government should play to address the barriers identified at the household scale is unclear.

It remains to be seen whether campaigns informing and raising awareness about the potential benefits and risks of new technology, as well as inclusive discussions about how guidelines and processes for AI should be established, are useful and implementable. Either way, household barriers need to be taken seriously and must be addressed by policymakers as these barriers can halt the diffusion of AI energy management systems and other smart grid applications altogether.

In addition to this, the relationship between AI ethics principles and current national and international laws should be defined. The global community's next steps should include translating principles into reality and pursuing harmonization between AI ethical guidelines (soft law) and legislation (hard law). Moreover, injustices of AI are not limited to the development of algorithms and the operation of AI systems, but permeate the entire lifecycle of AI and the hardwarded it is based on. A holistic approach to AI will enable a better graps of injustices that are otherwise past stakeholders awareness horizon.

Finally, ethical structures such as independent institutions will be necessary to examine the ethical soundness of AI applications.

The thesis concludes that, while AI can aid in the transition to low-carbon societies, failing to account for the humans involved and impacted by its implementation risks causing more harm than good.

Shortcomings

Shortcomings of this study include the already mentioned low number of respondents, which affect the reliability of the data collected from households and industry experts.

Furthermore, Norway is a wealthy, and relatively small country with high living standards. The results from this thesis can help inform AI implementation in countries with similar structures but should not be relied on for countries with differing organizational and governmental structures and cultures.

The circumstance that the topic of AI was a new subject to the researcher should also be considered a shortcoming as grasping the complexity of this technology takes years. This might have led to less informed and precise questions and explanation during the fieldwork.

Future research

The fieldwork has identified unanswered questions and need for further research.

First, how to balance the contradictory needs of AI and user safety needs further investigation to find a way to satisfy both ends.

Second, this thesis has shown that the perception AI itself is a hinder towards adoption. How the view of automation could change, and how AI could become part of a new social norm could be a study of looking into Taylor´s (2003) social imaginaries and discourses around AI.

Third, the thesis touched upon the subject how governance and fair representation could aid with establishing ethical guidelines. The practical implementation of such a system is not yet defined and needs further research. Last, how standardisation or compatibility could be achieved in a local or national context, is a needed field of research if energy efficiency in homes and grid flexibility are ever to be implemented on a large scale.

There might be other nuances and issues within this subject that would benefit from more research. The complexity of AI systems and the interlinked nature of it, makes a vast field for future studies.

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9 Appendix

9.1 Appendix A

NSD information letter and consent for households

Are you interested in taking part in the research project:

“The dissemination of automated smart homes”?

This is an inquiry about participation in a research project where the main purpose is *to help understand what barriers and challenges the proliferation of smart automated systems can encounter*. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project
This master thesis looks into social/technological/policy barriers of implementing smart automated systems (machine learning systems connected to smart homes) that are capable of making better decisions for users in relation to electricity use. The implementation of smart systems is thought to be beneficial in terms of increased energy efficiency of the local grid and is part of the transition to a low carbon society. However, certain challenges and dangers are associated with such a transition, which will be examined by conducting a case study of the local grid in Stavanger, Norway.
The research questions touch upon what barriers can be met when implementing such a system, how to circumvent translating inequalities into AI, and how user data is protected.

Who is responsible for the research project?
University of Stavanger is the institution responsible for the project.

Why are you being asked to participate?
The sample for this study is based on purposive, non-probability sampling due to the fact that the focus lies on learning about the experiences and opinions of households with smart technology.
So far, around 20 households have been asked to participate, including yours.

What does participation involve for you?
If you choose to take part in this project, this will involve that you will fill in an online/on-paper survey. It will take approximately 20mins. The survey includes questions about smart home technology and the concerns and barriers associated with it.
Your answers will be noted down on paper/electronically depending on the type of survey you choose.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

No personal details will be recorded/noted down during the interview/survey.
The only, somewhat individual, information that is of interest to this study is the age group the participant is in, and how many occupants live in the same household as the participant.

Email addresses that might have been acquired, will be coded and stored separately on an external hard drive.
No identifiers, which could make participants recognisable, will be published in the thesis.
Only the student and the supervisor will have access to the unpublished notes/information obtained.

What will happen to your personal data at the end of the research project?
The project is scheduled to end *15.06.21*
Personal data will be anonymised or deleted if possible. Anonymised data will only be kept if it is needed to verify the results/conduct future research.
The anonymised data will be kept on a private server, inaccessible to the public.
Data will be anonymised as soon as the interview/survey data has been transcribed.

Your rights
So long as you can be identified in the collected data, you have the right to:
- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with *University of Stavangr,* NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?
If you have questions about the project, or want to exercise your rights, contact:
- *University of Stavanger* via *Siddharth Sareen.*
- Our Data Protection Officer: University of Stavanger, Department of Media- and Social Sciences
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader	Student
Siddharth Sareen	Rebekka Stumpf

Consent form

I have received and understood information about the project "*The dissemination of automated smart homes*" and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in *an in-person interview*
- ☐ to participate in *an online interview*

I give consent for my personal data to be processed until the end date of the project, approx. ~~*15.06.2021*~~ 20.07.21

(Signed by participant, date)

9.2 Appendix B

NSD information letter and consent form for industry

Are you interested in taking part in the research project:

***"The dissemination of automated smart homes"*?**

This is an inquiry about participation in a research project where the main purpose is *to help understand what barriers and challenges the proliferation of smart automated systems can encounter*. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project
This master thesis looks into social/technological/policy barriers of implementing smart automated systems (machine learning systems connected to smart homes) that are capable of making better decisions for users in relation to electricity use. The implementation of smart systems is thought to be beneficial in terms of increased energy efficiency of the local grid and is part of the transition to a low carbon society. However, certain challenges and dangers are associated with such a transition, which will be examined by conducting a case study of the local grid in Stavanger, Norway.
The research questions touch upon what barriers can be met when implementing such a system, how to circumvent translating inequalities into AI, and how user data is protected.

Who is responsible for the research project?
University of Stavanger is the institution responsible for the project.

Why are you being asked to participate?
The sample for this study is based on purposive, non-probability sampling due to the fact that the focus lies on learning from industry expert and their experience with with smart technology.
Around 15-20 industry experts are asked to participate in this study to gain a sufficient understanding of the barriers and opportunities within smart technology developments.

What does participation involve for you?
If you choose to take part in this project, this will involve a in-person or online interview. It will take approximately 30-45 mins. The interview includes questions about smart home technology and the concerns and barriers associated with it.
Your answers will be noted down on paper.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

No personal details will be recorded/noted down during the interview.
Email addresses that might have been acquired, will be coded and stored separately on an external hard drive.

Email addresses that might have been acquired, will be coded and stored separately on an external hard drive.
No identifiers, which could make participants recognisable, will be published in the thesis.
Only the student and the supervisor will have access to the unpublished notes/information obtained.

What will happen to your personal data at the end of the research project?
The project is scheduled to end *15.06.21*
Personal data will be anonymised or deleted if possible. Anonymised data will only be kept if it is needed to verify the results/conduct future research.
The anonymised data will be kept on a private server, inaccessible to the public.
Data will be anonymised as soon as the interview/survey data has been transcribed.

Your rights
So long as you can be identified in the collected data, you have the right to:
- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with *University of Stavangr,* NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?
If you have questions about the project, or want to exercise your rights, contact:
- *University of Stavanger* via *Siddharth Sareen.*
- Our Data Protection Officer: University of Stavanger, Department of Media- and Social Sciences
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader	Student
Siddharth Sareen	Rebekka Stumpf

Consent form

I have received and understood information about the project "*The dissemination of automated smart homes"* and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in *an in-person interview*
- ☐ to participate in *an online interview*

I give consent for my personal data to be processed until the end date of the project, approx. ~~*15.06.2021*~~ 20.07.21

(Signed by participant, date)

9.3 Appendix C

Interview and survey questions

The dissemination of automated smart homes

This survey is designed to understand social barriers of implementing smart automated systems (machine learning systems connected to smart homes) in households that are capable of making better decisions for users in relation to electricity use.
The implementation of smart systems is thought to be beneficial in terms of increased energy efficiency of the local grid and is part of the transition to a low carbon society.

* Required

1. Please indicate which age group you belong to *

- ○ 18-24 years old
- ○ 25-34 years old
- ○ 35-44 years old
- ○ 45-54 years old
- ○ 55-64 years old
- ○ 65-74 years old
- ○ 75-84 years old
- ○ Prefer not to answer

2. Do you live in an apartment or a house? *

- ◯ House
- ◯ Apartment
- ◯ Other

3. What is your gross annual income in crowns? *

- ◯ Less than 150 000
- ◯ 150 001 – 300 000
- ◯ 300 001 – 400 000
- ◯ 400 001 – 500 000
- ◯ 500 001 – 600 000
- ◯ 600 001- 700 000
- ◯ 700 001 – 1 million
- ◯ Over 1 million
- ◯ Prefer not to answer

4. Do you have an electrical vehicle? *

- ◯ Yes
- ◯ No

5. How many people (including you) live in your household? *

6. On a scale form 1-10 (1= not important; 10= very important), how important are
low electricity prices for you? *

1 2 3 4 5 6 7 8 9 10

7. On a scale form 1-10 (1= not aware; 10= very aware) how aware are you of current energy saving technologies (apps, smart home technology etc.) *

1 2 3 4 5 6 7 8 9 10

8. On a scale form 1-10 (1= not concerned; 10= very concerned) how concerned are you about the environment? *

1 2 3 4 5 6 7 8 9 10

9. Do you have any smart technology installed in your household (e.g. smart-meter)? *

Yes

No

10. What type of technology is currently installed in your home?
*

11. Who are the providers of the technology?
*

12. What does the technology control? *

13. From a scale from 1-10 (1= difficult, 10 = very easy) how easy is the technology to control? *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

14. What do you like about smart technology?
*

15. What do you dislike about the smart technology?
*

16. Imagine a smart home with all the smart technology we currently have. Temperature, lighting and shading are controlled according to your schedule and outside temperatures. The dishwasher, washing machine, coffee maker, and car charging are automated and run when electricity prices are lowest. How do you feel towards such a system where you give away control but gain more comfort? *

17. How about a fully automated system as described above, but where you as user
still have the possibility to easily interfere with the systems decisions when necessary? *

18. From a scale from 1-10 (1=unlikely; 10 = very likely), how likely are you going to install smart-technology in your house in the near future? *

1 2 3 4 5 6 7 8 9 10

19. What is the biggest barrier for you to install smart technology?
*

20. How do you feel about a fully automated system that controls appliances such as washing machine, dishwasher, but also heating and lighting to increase energy efficiency in your home?
*

21. How about a fully automated system where you as user still have the possibility to easily interfere with the systems decisions when necessary? *

22. Do you trust that your user/consumption data is handled appropriately by your provider? *

- Yes
- No

23. How satisfied (1 = not satisfied; 10 = very satisfied) are you with the transparency of how your personal data is being handled by private companies/organisations? *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

24. Are there any other concerns or points you would like to add?

9.4 Appendix D

Interview questions industry, questions were adjusted depending on the company that was being interviewed

Interview Guide

1. As I understand, the electricity usage/appliances in houses can be controlled from a remote location. How does that work? Is it controlled by a software or manually, a completely different way?
2. How have households responded to the external control?
3. Are there any concerns from households regarding the data collected by using the app?
4. Has the app/system contributed to higher energy efficiency and grid flexibility?
5. Is there a critical mass of houses in the local grid that needs to participate to make the app reach its full potential/make a difference in flexibility and efficiency?
6. Are the different smart home appliances and flexibility software's on the market compatible with each other?

About the controlling of energy consumption in households:

1. Are there any possibilities for unequal/unfair energy distribution amongst households that you are aware of?
2. Who/what decides how, and which appliances are running/off in the different households?
3. What are your thoughts on a Machine Learning system that can predict consumer behaviour and control electricity usage/appliances in a home depending on learned behaviour and factors such as energy production, prices, weather etc.?
    - Is this at all realistic?
    - What could endanger the ethical and socially equitable use of such a system?

Policy:

- Are there any policies hindering the full rollout/reaching its full potential of flexibility apps such as the one from FutureHomes?

Interview Guide for Industry

1. Can you explain what your company is about and how the technology works?
2. What exactly is being installed in homes/businesses?
3. Is it connected to the internet? And are you working together with the internet provider?
4. Is there a certain energy cost for these systems?
5. How about the initial installation cost?
6. In your experience, is the demand for these technologies growing?
7. Can you tell me a little bit about the worries or concerns from potential/actual users?
8. How are users introduced to the technology and its use?
9. Do users easily understand the technology and how to control it?
10. How does the user interact with your technology?
11. Is any data collected through these systems? Such as electricity use/consumption?
12. How is that data protected?
13. Are you aware of any barriers that make the spread of these type of technologies more difficult?
14. Is your system compatible with technologies from other providers?
15. To your understanding, how concerned are your customers with the environment?

If the respective company is working with AI/machine learning systems

16. Do you develop your own algorithms or are you collaborating/using open-source material?
17. What measures are taken to avoid translating social inequalities into AI?
18. Have you experienced any biases in AI after a system had been rolled out?

9.5 Appendix E

Interview transcripts households

Respondent nr.	Age	Type of home	Income (NOK)	Has EV?	Nr of people in home	Concern for electricity cost	Awareness of avail. Tech.	Concern for environ.	Would install automated technology
1	45-54	Apartm.	500-601	no	1	7	3	10	No
2	65-74	Apartm.	600-701	yes	2	5	8	10	No
3	25-34	Apartm.	500-601	no	2	5	8	10	No
4	25-34	House	700-1mill	yes	4	9	8	4	Yes
5	25-34	House	500-601	no	2	9	10	10	Yes
6	25-34	House	700-1mill	yes	4	9	8	5	Yes
7	25-34	House	700-1mill	yes	4	5	6	7	Yes
8	65-74	House	retired	yes	4	8	9	9	Yes

Interview results and survey results

Respondent 1

Age: 45-54, f, apartment, 500 000-600 001, no EV, 1 pax, elcost 7, techaware 3, environ 10

- No additional technology installed in apartment, The person is a very analog orientated person, life is enough digitalized already, no interest in gadgets
    People that are naturally interested in these things are usually more informed about what is going on, has not put a lot of energy into finding out
- Very interested in sustainability and saving money, and interested in effect of how smart technology can help reduce energy consumption/price
- Apartment at VB is small and cheap, and has good habits already (turning off lights, and using little heated water)

- ML concept: has unpredictable life, has cabin close to town, if nice weather they go to cabin rather than home to VB, thinks an app would have difficulties to predict their behaviour, thinks that it might be beneficial for families (many teenagers charging phones, coming home from school at same time etc)
- How do they feel about AI making decisions: more skeptical towards it, might be useful for medical things, but not for autonomous vehicles, likes people to do things, bit against automation everywhere e.g., automation in grocery stores (payment done by cashier) also to keep jobs alive, in some areas it could be beneficial! And human interaction is important
- Data handling: bit naïve, and Norwegians in general very trusting towards authorities and government, believe they mean well and trust what they say and do not really question their intentions, and they feel they are the same (laziness and lack of interested), but has never ended up with scam as they are still rather easy to spot
- Automation: maybe not for their age but maybe in 20-30 years when older: for people to live at home for longer and have a good life, automation might be a good solution

Respondent 2

Age: 65-74, m, Apartment, 600 000-700 001, has EV, 2pax, elcost 5, techaware 8, environ 10

- No extra technology as building is so well insulated and lives in a small apartment, and not the keenest on gadgets
- The technicians that installed heating system: there are a lot of complaints as the power supply to the heating system has not been completed yet,
- Tech room has a lot of handles and gadget and is too sophisticated for own use.
- Barrier to get new gadget apart from VB already having it: no real value for them but not against it just does not produce enough benefits, and VB has already a button for "holiday" mode which reduces over electricity use
- AI system: nephew has EV and charges it during night when electricity process is lower, needs a lot of knowledge, but it is not something they feel like doing, should be up to the next generation,

- More and more gadgets (system see show how houses leak energy- loads of saving potential)
- Usually, people park their cars for some time so there is some flexibility, but maybe people are not as patience when washing clothes/dishes
- need to get used to new tech/idea
- Feelings: mixed about AI tech, (chatbots are still not very useful). AI used to replace human labour, but performs poorly but increase profit
- "AI janitor" is something they would support
- Personal data: no trust in fb (selling data very obviously: customized advertisement)
- Governmental sites: so much data available at fingertips which is fantastic and useful
- Do not want people to be unemployed due to automation/AI
- More IT but also more social sciences in the future

Respondent 3

Age: 25-34, m, apartment, 500 000-600 001, no EV, 2pax, elcost 5, techaware 8, environ 10

- Currently no extra smart technology in home apart from vindmøllebakkens solutions,
- The house manager keeps track of the installed technology, issues have occurred when it comes to billing the tenants accordingly to their own consumptions and shared space costs,
- Smart tech: had smart meter in previous home
- Does not see the benefit in additional technology at Vindmøllebakken, they are already very aware of consumption behaviour and habits, and VB does the rest.
- There is no place for AI in the life of respondent 3, already has enough technology
- However, they can see the benefit for people with complicated and hectic lives (families with car(s), etc.)
- Concern about Smart technology: people of lower income that would actually need smart technology do not have the monetary capacity to purchase them (would have to be provided by government to be fair), at this point it benefits the richer people
- Also, new technology needs to be properly introduced and taught how to use it by provider

- Data safety: skeptical, companies always try to paint the best picture and show how they`re doing the right thing, but usually use the data to benefit themselves (learn about user and sell more products, or sell data)
- Another concern: the focus should probably not be on adding more/new technology, but teach people how to use less (in all ... of life)
- App available that checks electricity prices for you, and you can decide when to run appliances depending on low/high prices

Respondent 4

Age 25-34, m, house, 700 00-1mill, has EV, 4pax, elcost 9, techaware 8, environ 4,

- Has smart technology: yes

  Type of tech: FutureHome, Heating cable control, Heat pump control, hot water tank,

  Providers: Futurehome, Tibber, Sensibo

  Controls: hot water tank, heat pump, heating cable

  How easy to control: 8 (easy)
- Like: Having control of technology via an app/phone
- Dislike: No dislikes
- Automated system: very comfortable with that
- Automated system with app: Sounds good
- Trust handling of data: yes
- Concerns: --
-

Respondent 5

Age 25-34, House, 500 00-600 001, no EV, 2pax, elcost 9, techaware 10, environ 10

- Has smart technology: yes

  Type of tech: Smarthub from futurehome, google nesthub, sensibo-smartair sensing control

  Providers: FutureHome, google, Sensibo

  Controls: FH: controls appliances like air conditioner, fridge etc.

- How easy to control: 9 easy
- Like: The fact that it helps you to have control over all your house through on device onl y(mobile), makes life easier, helps you to have an overview of your energy consumption, and feels like “the future” (it`s cool)
- Dislike: The fact that I am sharing my data with others (company that provides it)
- Automated system: This would be very effective and would make me happier, of course! It is less stress when you don`t have to think about everything related to recude cists, But that is not very “real” because sometimes I need to use the dishwasher, or coffeemaker etc in a certain time when it fits me best
- Automated system with app: I would like to interfere ofc. That is a better scenario: this way I can set everything according to my comfort
- Trust handling of data: no
- Concerns:

Respondent 6

Age 25-34, House, 700001-1 mill, has EV, 4pax, elcost 9, techaware 8, environment 5,

• Has smart technology: yes

Type of tech: heat pump control, control of heating cables, control of light and hot water tank

Suppliers: Futurehome, sensibo, phillips hue

Controls: Light, Heat

• How easy to control: 9 easy

• Likes: Makes consumption easier to control and more transparent

Dislikes: when it falls out

• Automated system: fits me perfectly

• Automated system with app: Fits me well

• Confidence in data management: yes

• Concerns: -

Respondent 7

Age: 25-34, House, 700001-1mill, no EV, 4pax, elcost 5, techaware 6, environment 7

• Has smart technology: yes

Type of technology: Futurhome hub with control of vvb and heatit thermostats for regularization of heating foil

Suppliers: Futurhome and Heatit

Controls: Heat

• How easy to control: 8 easy

Likes: The configuration options increase the possibility of a simpler and more efficient life

Dislikes: Stability and solutions that can fail when you need them

• Automated system: Sounds great, as long as it works almost 100% of the time, and that I can make changes myself, if needed

• Automated system with app: See answers above

• Trust management of data: no

• Concerns: Cybersecurity is always a factor I am concerned about

Respondent 8

Age: 65-74, house, ev, elcost 8, environ 9, techaware 9

- Has smart technology: yes
  - Type of tech: heat pump, heat tank
  - Providers:
  - Controls: heat
- How easy to control: 9 easy
- Like: Do not depend on grid
- Dislike: -
- Automated system: do not mind
- Automated system with app: think it would be useful
- Trust handling of data: no
- Concerns: electricity production itself, do not believe it is good for humans the way it is at the moment.

9.6 Appendix F

Interview Transcripts Industry

Respondent 1

Company that helps customers to reduce electricity cost by controlling their electricity consumption,
There is a low interest in solutions: low understanding of technology, high threshold to implement new technology,
Company comes and assesses needs and reduction possibility and programs system to match needs, considers public holidays etc., turns off/down temperature/ventilation when business does not need it
Some businesses do not want to turn off ventilation due to smells/cooling needs etc.
App with possibility for customer to control/override settings everything else is fully automated, small business niche (lacking automated central ventilation system)
Warns customer if "window open" or other possible reasons for increased ventilation/heating needs
Gives an overview of consumption habits for customers and has helped to reduce peak consumption for customers
To spread technology: need to register customer which must accept and share their (consumption) data with them, (strict rules in Norway), people seem to be opened to do this.

Customers do not understand how electricity prices work (not paying for electricity but for infrastructure needed to transport electricity) and do not trust the industry to have their best interest at heart
Environmental aspect of app is virtually non- existing, people don't not care but business want to be greener (cause it's a trend), and it attracts customers
Following EU regulations, governmental run company and ethical and legal business is extremely important and cannot take risk in being shady/unethical

Respondent 2

Solution currently only for businesses but thinking of expanding in the future
Barriers: people do not know enough about the technology,
threshold to learn is too high as benefits are not clear enough to them

Respondent 3

System in Vindmøllebakken is complicated and complex,
the suppliers of the different technologies do not talk to each other which makes the system not work as seamless as it should and could,
overall system is missing
Every apartment has own control tech room, but the interface is not user friendly,
Homeowners do not have control over energy systems in Vindmøllebakken,
How to divide the price for electricity use in common area is not clear, if evenly divided among households some will pay more than they use, and some will pay less than they use.

The apartment building has highest energy efficiency rating for the building and additional smart technologies do not really help reduce any more energy use
The cost is smart technology is higher than what customers would save by installing them,

Respondent 4
Provides smart technology for households for increased energy efficiency, security, and comfort,
The provide hub for integrating all types of technologies

Respondent 5
Machine learning could work as link between homeowners and the grid
But there are policies that are currently hindering the implementation of machine learning systems that could provide more gird flexibility and energy efficiency in homes
Need data to define tipping point for technology to be activated

Respondent 6
large project for grid innovation, flexibility is a way of connecting the dots (customers/business with grid),
but there is no one standarised software/program and end-user only want to offer flexibility of there is an incentive(money), need to but software and hardware to turn OFF things in homes which means there is an upfront cost to flexibility
To get flexibility there is a need for a SCA (seasonal capacity agreement)
A more traditional flexibility is a type of trading
Season capacity agreement; more traditional flexibility: shortflex
flexibility platform (stock exchange for energy, cheapest price wins), all about connecting software for customer with the grid, short distance flexibility (flexibility trade with your neighbours), stay within a lower electricity need by cooperating with neighbours (not allowed in Norway today), flexibility is allowed but rules aren't handling it quite well, yet which is why this company is working with that (many use cases before they change law; are solutions/providers compatible? The numbers of households having smart technology is still too small (grid company laughs: too little energy they can provide) need big numbers to provide end-user flexibility, therefore: need aggregators: company that collects flexibility (10k houses with smart tech and connection) but not many people want smart homes cause expensive, so investments is quite a lot and flexibility won't make you that money back, so there is no money incentive for flexibility (not an economic incentive) but reduce energy use over time (battery) and sell electricity to grid, household are not a very good business case,
Therefore, research is moving to companies (aggregators) for flexibility,
Household maybe in future when smart devices are pre-installed in households

How many households would it need to make it work? Lowest number aggregators needs are 0.5Mw for a grid company to consider buying back, can't collect houses from whole city, (grid is problem here), needs to be neighbors and they need to be connected to same part of grid (neighbors might eb connected to different parts of grid) grid company only one that knows, they must tell aggregators where they want flexibility from,
It makes no sense to have flexibility available if grid companies do not actually need it (need to map out flexibility needs), not good communication between customers and grid companies,
Their company: control system for car charging, but in another company has own systems that need to be integrated in system
Schedule for charging cars: smart charging is about keeping energy usage at correct level (different than flexibility),; smart charging: reduce the energy you use plus flexibility: prioritize cars that are on a tighter schedule (only charge 80% then do flexible charging), other company concept: sell flexibility from the charger, but grid pays for the charger (transfer money from grid to owner: get paid for not charging> incentive for homeowner), not many cars are doing vehicle to grid(discharge battery to feed into grid) and hardware in car does not allows it, but if car actually allows that and the battery adds capacity to the grid: meaning that grid company has to pay for connected cars (when battery are betters this might be an option in about 20years)

Respondent 7
Forecasting household consumption combined with solar power production: how has it affected grid flexibility: forecasting helps increase flexibility
Different electricity providers (no real incentive to buy flexibility back from users which is why aggregators aggregate electricity from households and sells it back to grid companies)
Implementing flexibility in Norway is very complicated (compared to other companies. Respondent did a lot of studies internationally) In Norway it is easy to switch providers quickly
Trading energy is a future subject, not sure how Norway will adapt to this
Ethics: data comes from smart meters which is confidential data and company only provided data for research and data was anonymized which makes predictions more difficulty but protects user

Biases: there might be biases into model (to get result that you want). But if topic of data privacy is preserved all the information ai gives can be useful for households and grid companies/operators (adjust price of electricity in terms of electricity consumption pattern), AI is a good thing in general but has also its negative sides
AI system treating certain groups differently: data could be used by energy thieves. Needs to be protected very well! But advantages are greater than disadvantages; inherent in AI: if data is used to push people to use appliances when cheapest? But there are apps for that (tibber)
AI system possible/feasible

parameters for that (but everyone sets parameters differently: grid companies might do it one way, homeowner might do it in a different way, people owning assets might do it in a different way, this creates a complexity that needs to be dealt with) this is what their company works with, four different projects, for their company´s transparency is key (grid operators need to know what lower and higher grid operators are doing and it has to be common knowledge what is being paid for flexibility) this is where the complexity comes in (AI systems/ grid software/petc could all be addressing this but there needs to be a common language which is location, price, quantity e.g. 10 households that can react on same price signals and you know how much how they can turn up or turn down then you can put that location, the price in order to do it and put the quantity of how much you have and make that known to buyers (their company creates bottom up integrated market design (offers flexibility from where it is and grid companies can buy it top down) grid companies define locations at different grid levels where they might have flexibility needs; the households offering flexibility at a certain price after being defined as an area that needs flexibility could be controlled by AI system

By having transparency everyone can compete on leveling playing field and depending on where you are in the grid you will see the different flexibilities

Activation market short flex: commit to deliver a deviation from their baseline did a project for domestic flexibility: one manual dispatch and an automatic dispatch

Grid company put a bid of wanting to buy flexibility between 5-6 to the aggregator which sent out a SMS to the participants, and the nr of people that said yes was multiplied by Kw then sent out the order on their companies' platform which was picked up by the grid company

So, people had a commitment to turn off electricity consumption sources.

Other participants with smart homes system: process bit different. areas put in deal and picked up isakskraft and because they control the assets through a computer system, they could immediately accept the bid, and on the day, they reduced the use of electricity not the actual user

In average the manual test yielded 1.2 Kw in production reduction, whereas automatic group yielded 2Kw in reduction

There is a wide specter of flexibility which is depend on where one is in the value chain: value chain looking at assets behind the prosumer and how you can identify the flexibility but what you do with it when it has been identified?

Who is deciding? e.g a local community: but someone must manage that as well and consumer should have the option to switch/choose who is representing their flexibility assets

Where do we have the flexibility, what do I have to pay to access it, and how much can I access

Next thing: all of this must be done automatically, assets in grid are being aggregated and controlled then offers a baseline to grid company (what you plan to consume and what you did)

Flexibility has high value in emergency, Cheapest flexibility always wins

Project: manual vs automatic customer satisfaction

But consumers tend to optimize based on comfort, but how can optimization based on comfort participate in a system that either is optimized for technical purposes or profit? How can an optimization of comfort do that?

Trade info/private data for comfortability

Barriers: buyers of flexibility are grid companies and historically they waited for the regulator to say 'build grid' So they did, cost that grid companies have to upgrade grid/put in hardware can be out back onto consumers but if they buy flexibility they need to take that cost themselves (cannot put in on consumers at this point, except in UK: regulators treat operational cost same as capex: all goes into one big pot, incentives have started (clean energy package states that demand response customers should be treated as the as generators in that respect it should be market based and their company is such a market)

Respondent 12

Today has become a buzzword and we think we can solve every problem with ML,

They can see benefit of ML in relation to energy efficiency and grid flexibility (households care mostly about energy efficiency and do not understand the concept of flexibility), ML should solve both problems, energy efficiency is good for flexibility as it reduces consumption at peak times. But flexibility is not about saving energy it is about moving it around to a time of lower demand which is a complex message to explain to people but it also a complex to make those decisions for people manually,

they did some tests with automated system (about to be changed for new project) it helps to read energy efficiency on daily basis but also allows to take out water heater and heating cables in the floor and their company had access over these with the permission of the owner (manual and automated test) automated system worked WAY better than other system (comfortability?), people like things that are automated when they work (dishwasher, vacuum cleaner) we like to get help from machines,

Flexibility with water heaters and floor heating is easy: borrow load from that type if equipment without people noticing at all (they function as a sort of battery), and most cases people do not know when it is on or off (most people think it is on all the time), easier to get people to accept systems like that,

It is not really a money saving project as the flexibility load is so little that it won't make a difference (does not make sense for consumer especially because cost of equipment is currently too high),

They do not have that much background data yet (project just started)

Flexibility project with industry: different system with a marketplace where they offer flexibility but also very immature still (pricing seems to be a big challenge), they did some simulations but without pricing it is difficult to get any real data
And the project areas for them are both very small and have one major business in each which makes flexibility almost impossible as the big business have same needs and there is nothing to really move around (need a number of different businesses and needs to make it work)
ML is used for prediction: flexibility market is based on prediction (need to do trades some time in advance)
Overload is easy to predict but some of the disturbances in the grid are caused by other factors (most likely weather is one of them) which makes the prediction process is a lot more complex,
A lot of wind can make the cables swing and touch which can cause disturbances in the grid
In project they had "blink" disturbances which are barely noticeable for households but cause problems in industries that use electronics, even though the interruption might be less than half a second it can cause some of the controlling and monitoring electronics in the production line to fall out/stop working and it can take up to an hour to get it online which leads to higher production costs. initially the idea was that it was caused by overconsumption, but as equipment and data increased it looks like there are other factors in play (some cannot be explained by overconsumption)
This project will also be used for private households later
The utility company (company that people buy the electricity from) they own the flexibility among the consumers and the bundle it (aggregate it) and offer it on the flexibility market similar to any other business (idea how it could work) and then need approval from the consumers (either consumer agree when writing the contract to a certain amount of flexibility (20 breaks a year) or if they have to ask for approval every time), suspects that people would prefer the breaks to happen without them knowing about it as it is an inconvenience to answer every time
In project: once approved flexibility consumers could not back out but even if you ran out of hot water in that time it would take time to get it back so the flexibility would not make that much difference/would not feel the difference even if you had an override button.
Old systems: ripple effect control (from Germany and Czech Republic) had a switch on equipment (not sure how they were economically motivated but New Zealand has system on water heaters and customers get a little lower rent on grid lower grid fee on electrical bill)
Old systems used the grid frequency and sent morse codes/signal that communicate with the switches (different categories of switches) and then one of the categories was always off, good part of this: no data was collected, the company did not even know who had the equipment but only that there was a certain amount of switches out there; would that be possible today? Equipment today is much more sensitive to manipulation today
In Britain: it comes with equipment already installed but it operates through the internet not the grid frequency

Respondent 8

developing platform for flexibility (have direct contact with the customers, but in future they cannot keep doing it manually), related company contributes with information for their company (smart meters) and gives input on users energy consumption, but in future: not sure how to solve it as they do not want to give as much information as they do now (the company would have more info than other companies which gives them an unfair advantage), has also provided historical data on energy consumption patterns, set some boundaries: at what limit the flexibility should be triggered, (for test have set imaginary limits), for company: it's important that system is reliable and when they need it that they can use it (need to be able to trust that it works, and have to test it to see if it works), to see if it makes sense they compare it with an alternative: e.g. upgrade grid which takes long time and result in customers not being able to connect to grid because there is no capacity, flexibility can give access to consumers earlier before they have upgraded grid sufficiently, if load is too high: there can be small blackouts which results in high costs for grid companies (kile: cost for not delivering energy) which again is an incentive to go for flexibility (cost can be very high!)

Other barriers?: NVE regulate network/grid companies and they set how they can earn money, for now they compare their company to other network companies (they make up a network company that is similar to their company which results in an ideal company and compare performance of their company to ideal company and depending on performance decides how much money their company can make, but in that model flexibility is not included yet which means their company can only get better paid-/more money by building out the grid), the issue is being discussed but they do not know how to solve this which is another reason why their company does not know if they can rely on betting on flexibility

Another barrier: how they going to keep control of this, fields with different customers to keep track off, if e.g., an energy management company aggregates most of the electricity it would be easier for grid company to deal with it,

But how do they use it daily (is it activated manually, or does it go on automatically depending on how the load is and what capacity is available)

User data provided by related company: data is not fully secure yet a lot of things in this project are just being tested and they just must see how to best solve it

How many households are needed to make an impact? 1Mw which means a lot of houses need to be aggregated to make a difference in grid flexibility, also depends on location of flexibility (some places: enough capacity and flexibility not needed and other way around)

Respondent 9

Smart platform system: contract module: put in info: what every flexibility bidder can put in what cost they will sell their flexibility for and when (plus rest periods between flexibility being delivered),

Prediction part: need for flexibility should be in the next 48h. there should be a flexibility operator and dispatcher controlling flexibility in real-time, also billing and settlement part that takes care of the money transfer after flexibility has been delivered,
This system is for aggregator service and supposed to deliver system for big clients and not meant for private customers yet but could be used for that as well (with some adjustments)
It is an automatic on/off switch for client which needs there needs to be technology in the houses/businesses
Still working on connecting in a seamless way because atm they are working with all types of equipment's which makes seamlessness difficult
There is no marketplace today for private homes selling their grid flexibility and the price of installing the equipment is high and is not worth it
AI/data: measuring on grid station level every 2.5 seconds on consumption of customers that use energy on that grid station and combine it with weather sources, by combing different sources they make predictions for consumption, use prediction for next 24h to make some decisions on what to prepare for possible flexibility deliverance (use large batteries by making sure they are completely full before peak consumption appears)
Privacy concerns: this project does not measure data on private level, data on grid station combines data from several customers,
Barriers: testing on low critical loads (ventilation systems that are not high risks) but as they progress and more critical loads are included then discussion about safety of data will be had, they will be an agreement, but GDPR is not relevant while. Working with businesses, but if with private homes they will have to think about it

Critical mass: TSO has minimal limit (1mw) but in project they work with 500Kw but that is just for testing, how do we measure flexibility and that they have received the promised amount of flexibility as this is still a financial transaction,
How to measure flexibility: tested next week, will see it on the grid station and see if consumption goes down when customers turn off load
Fixed agreements/long-term agreement: how much flexibility you can deliver in a season, and you need to turn off in the times you said you will! User cannot override this agreement: customers must think carefully when and how much they can provide
Later: day to day market or week to week market should be possible
In Stockholm they are texting them
This project is only looking at the season (winter as consumption is highest)
This is done to create more security for grid company
Comfortability will be crucial to make it work for homes, but this makes it difficult for the grid companies to rely on the flexibility, if flexibility is not reliable, they will investigate other alternatives

Finding right **volume** in grids at right time is important and difficult (UK they use diesel generator to provide flexibility)
Volume and price will be the biggest barrier (make it worthwhile for the client)
They are not including price as an advantage for the businesses at this point

Respondent 10

Management system to handle different loads on customer's side (for business atm) only offer smart charging for private people (charges when price is lower or when consumer produces own energy, or when consumption in home is lower*) there has been only pricing based on Kw hour used but next year the overall consumption in homes will be priced as well (effect tariff)
Smart control platform: that is the load management system and currently it is more rule based than AI based, AI is meant to be used when project is scaled up,
Barriers: regulations are not on their side, TSO cannot use flexibility as an asset in the grid, price of power (effect) is very low in Norway which makes it difficult to have a market for flexibility.

Integrated with inverter that is collecting energy from solar panels and thereby know total of consumption of house, when excess of solar power is present power on charger can be increased (put it into car rather than feeding it back into the grid)
Smart charger a battery? Does not see value for car owners (there needs to be a will form energy companies to pay for battery) if it is an energy island it might be a good idea, they think it would be better to use industrial batteries for flexibility efforts, Technology is there but it is too expensive and business model is too challenging right,

Consumer data privacy: all data is anonymised (do not know users), but they are not working with households atm, but with small business there are some concerns, but it is dealt with by having the GDPR

Respondent 11

Topic: interface between local grid operators (local issues) and national TSOs (frequency and balancing on national level), there is so much renewable energy connected lower in the grid than what the grid is designed for which creates instability in the grid
Company: creates a marketplace for future that helps to support the transition to a low carbon society by unlocking true value of flexibility (so it gets a price) doing this by establishing/facilitating a market where the buying and selling of flexibility between (energy) systems (such as AI) that are controlling private households and the people that needs deviation from the forecasted load
Market: way to establish a price based on supply and demand which makes it possible to calculate when to use private consumption /starting and stopping car charging/electrical heating: need to set

Respondent 13

Goal of system**:** Make buying and controlling flexibility as autonomous as possible

Current state: decision engine that investigates which providers have how much flexibility available and what the price for that flexibility is.

System is monitoring load at substation level (for now): meaning that when load at substation level reaches a certain threshold, the system tells that there is a need for flexibility and actions are taken from there

Respondent is working on creating forecasts for load on substations, this means that if it looks like there will be an overload on a certain substation there is more time to plan how to avoid an overload (charge batteries connected to grid prior to overload to then use stored energy when overload is happening)

Substation: usually: aggregated data from users connected to that station but can also be only one large customer (e.g., airport), no individual data is collected unless only one customer connected to substation

Data source more on individual level: consumption data for device that is being turned off to contribute to flexibility is available

Possible ambition for flexibility project is to include households later as well (not currently a goal)

But This project must be tested first and then can see from there

Ethical considerations: should be a concern as most data sets are biased somehow but respondent cannot see how it could affect people in this case as the forecast does not affect how transactions are made later, project´s goals is just to be more prepared for overload

Can user data be used to nudge people to adapt different behaviours? yes there is a possibility (smart meter in houses and consumption data fed to electricity company) but respondent does not believe that it will be feasible to make offers to everyone depending on the preferences that can be read from their consumption behaviour,

What could happen: a grid company offers a lower price or gives other benefits to all customers if users agree to switch off appliances etc. at a specific time (is happening already?!, New Zealand has a project like that)

But grid companies cannot decide these things alone, but NVE must back it up, regulate this

If strategy is too successful (many households/businesses adapt new behaviour) you end up with the same problem just at a different time of the day

Prediction for project is focused on consumption behaviour, energy production is not yet factored in but at a later stage it might include small scale energy production and car charging

weather and temperature are included in consumption prediction (important for solar PV production predictions later)

Respondents' opinion is that project is focused on flexibility, electrifying transport sector, and how to better use local grid and small-scale energy production in grid,

Barriers? complex system so it will take time but will be successful, if necessary,

big question: is incentive for different groups big enough for flexibility market? This has not been answered yet

There was an effort to map out what price seems acceptable for the different groups involved in the flexibility market and for now no consensus could be found

Respondent 14

EU project working how to turn increased urbanization into a benefit/asset, so that people can lead a better life despite the density of cities,

Focus of 100 houses project was on ICT, mobility and energy and testing solutions (can it be replicated, does it make sense, is it scalable, does it make everyday life better)

Tried to get homes/houses that could be representative of not only Norway but also Europe.

Try out solutions in real environment and how it would play out on the technological side and whether people really use this things and benefit from the installed technology, what can they learn, and further application opportunities in other cities.

It was not easy to "sell" this project here as power is already so cheap in Norway and it is being taken for granted, not many people are conscious about these things (energy efficient, grid flexibility), providing measures often end up being automated without needing active decisions from customers (they are lazy)

Was difficult to get enough people to participate/recruit, the people participating were already more aware and interested in this type of technology, early adopters, cannot really be compared to everyday people

Needed incentives/compensation to get people interested in this project and join, also had to promise that homes would not get compromised/damaged/changed

Installation was time and cost intensive and complex (needed people with competence and to know how to program these solutions> might be different now, more diy solutions to plug into socket and program on phone, easier to use and user friendly and electrician and programming costs fall away)

electrician was told to adapt solution to apartments/homes/gave idea how to place sensors for them to be as useful as possible (not necessarily lightning but heating> more impact)

there were contracts with the homes with no commitment on part of tenants to actively change behaviour, but they could collect data on how users behaved, but no incentive to "get up in the night and wash your dishes", tried to be as close as possible to real behaviour to get the most honest data app made it possible to control unit and tablet in hallway of household to have easy access to scenario buttons (home, away, season, holidays etc.) that turned off or down certain parts of the home

could control household remotely, feedback from households was that that function was helpful

but for apartment homes (broad specter of user groups), was very interesting in the beginning and they were good at using the technology as it was intended but then lost interest and returned to previous behaviour (possible to set weekly programs on when heating etc. should be up/down, after a few weeks the use of that function decreased!)

in apartments: power needed is not as much (new, well insulated homes and heat from other parts of apartment building makes heating less energy intensive

best results came from the big houses

were the decrease of new behaviour habits the same across apartments and households? Seems like it as 50/50 of user in apartments and households wanted to keep the equipment after the project had ended (for free), those with a cabin liked to be able to remotely control their homes

believes that the demand tariff would result in more dramatic changes of consumer behaviour (as electricity is currently too cheap)

there is not really an incentive to do anything (need), it was cool new technology,

survey in middle of project (how often they used it, how much they would be willing to pay for such a solution if it was offered as a service> no limit to what they`d like to pay for it)

energy consumption lower? was not easy to draw clear conclusions, there was no significant movement in terms of consumption (50% stopped using it overall, some other used it from time to time, programming longer periods allowed users to less involved> ease of use/comfortability)

they did not have a comparable period before project started on energy saving

ML system: INVADE project: how can you manage the demand for flexibility in the energy chain with measures such as algorithms/AI. How this would look like with different appliances in home and how to manage flexibility

Weather was planned as adaptive control for project (was not activated), was used in other projects

Believe that ML/AI is central to managing future energy demand both for the challenges of increased electrification and digitalization)