Universitetet
i Stavanger

UIS BUSINESS SCHOOL

MASTER’S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
Innovation	Innovation and social economics IS THE ASSIGNMENT CONFIDENTIAL? (**NB**! Use the red form for confidential theses)

TITLE:

What are the key factors that will affect the future investments of renewable energy, in Norway?

AUTHOR(S)		SUPERVISOR:
Candidate number:	Name:	Ragnar Tveterås
3081	Martin Aanstad	
3012	Jacob Dean Hackman	

ABSTRACT

This thesis aims to identify which key factors that will affect future investments within renewable energy in Norway. Due to a rapidly expanding market, the first sub-question is formulated to find how the global trends within renewable energy influence the Norwegian market. The second sub-question proposes to find whether externalities can delay the development of wind power. The research is decisive since newer renewable energy sources are currently not sustainable from a business perspective as it is reliant on governmental subsidies. A multi-method explorative approach based on qualitative and quantitative data collection is employed. Results from the analysis show that the removal of green certificates and the establishment of new taxes will affect future investments, since instalments becomes less profitable. Development of hydropower plants at less optimal areas will result in lower income for the producer, since the LCOE of hydropower is expected to be stagnant towards 2040. A decrease in new instalments of hydropower plants and continuous improvements to existing power plants is expected. The governments will continue the expansion of renewable energy production, so it is expected that there will still be subsidies. Furthermore, nuclear power is not expected to flourish in Norway in the next 20 years due to the development time, investments costs and historical events of nuclear meltdowns.

Moreover, offshore wind power and wave power in Norway is still underdeveloped and would require subsidies for implementation. To solve the identified challenges of onshore wind power development the government should reduce the duration of a concession or set requirements for finished instalment within ten years. In addition, there should be a requirement on the maximum size wind turbines can have in concession approved areas to reduce the visual impact. To reduce the environmental externalities developers can utilize a smaller area by building larger wind turbines that generate the same amount of energy. Visual effects can be reduced if the locations are properly managed by NVE and the municipalities by avoiding building in populated areas. Subsequently, it is important that the protesting citizens are heard by the government, which implies that the Consequence Evaluation Program may need adjustments.

PREFACE

Our master thesis represents our last work of the two-year Master of Science in Business Administration study at the UiS Business School in the spring of 2020. This research is written in the field of innovation. The idea of wind power was brought to our attention as we are both interested in renewable energy. Accordingly, we are intrigued to find what is required for Norway to reach the objectives set by the Paris Agreement. Since renewable energy is an extensive topic, brainstorming and research became prominent to find the specific research topic. We chose to aim the thesis on a highly debated topic in Norway which is the development of wind power. We found that companies are not solely investing in wind power due to the environmental aspect, but also since there are governmental subsidies that make these projects profitable.

At the beginning of the year we expected our final semester to be filled with hard work spending most of our time at school, being social with friends and use the holidays for traveling. When the news about COVID-19 had reached Norway we quickly realised that this thesis was not something that we would only remember for our final work as business students. This thesis was written during the pandemic. However, since we are both adaptable and cooperative, the situation worked well despite the circumstances. We were aware that this semester would be demanding but it has been worth it as the educational value gained from this thesis outweighs the challenges.

We would like to thank our supervisor, Ragnar Tveterås. Ragnar has always been available for questioning and we appreciate the honest feedback. Additionally, we owe Katrine Wangen a dept of gratitude as she assisted us with proofreading and structure of the thesis. Finally, we are thankful for the time and expertise the interviewees shared with us; thank you Gorm Kipperberg, Øivind Anti Nilsen and Andreas Aasheim.

TABLE OF CONTENTS

1 INTRODUCTION ... 7

1.1 RESEARCH QUESTION ... 8

1.2 STRUCTURE OF THE THESIS ... 9

1.3 RENEWABLE ENERGY SOURCES ... 9

1.3.1 Wind power ... 9

1.3.2 Hydropower ... 10

1.3.3 Wave power ... 12

1.3.4 Solar power ... 13

1.3.5 Nuclear power ... 13

1.4 REFINEMENTS ... 15

2 THEORY ... 16

2.1 SUPPLY AND DEMAND ... 16

2.1.1 Supply ... 16

2.2 Demand ... 17

2.3 MARKET EQUILIBRIUM ... 18

2.4 MARKET EFFICIENCY ... 18

2.4.1 Deadweight loss ... 19

2.4.2 Externalities ... 19

2.5 PRODUCTION POSSIBILITY FRONTIER ... 21

2.6 PRICE ELASTICITY ... 22

2.6.1 Price elasticity of demand ... 22

2.6.2 Price elasticity of supply ... 23

2.6.3 Price volatility ... 23

2.7 INNOVATION ... 24

2.7.1 4 P´s of innovation ... 24

2.7.2 Incremental innovation ... 25

2.7.3 Radical innovation ... 25

2.8 CENTRALIZED AND DECENTRALIZED AUTHORITY 26

2.9 DEPRECIATION 26

2.10 LEVELIZED COST OF ENERGY 27

2.11 FULL-LOAD HOURS 27

3 RESEARCH METHOD 28

3.1 QUANTITATIVE DATA 28

3.2 QUALITATIVE DATA 30

3.3 LIMITATIONS AND CONSTRAINTS 31

3.4 RELIABILITY AND VALIDITY 32

4 EMPIRICAL ANALYSIS 34

4.1 GLOBAL RENEWABLE ENERGY 34

4.1.1 CO_2 per capita 35

4.1.2 Development 36

4.2 NORWAY RENEWABLE ENERGY 38

4.2.1 Installed capacity year 2000-2020 38

4.2.2 Import/export of electricity 40

4.2.3 Levelized cost of electricity 40

4.3 EXTERNALITIES 48

4.3.1 Annual mortality rate for birds 48

4.3.2 Environmental stewardship 49

4.4 PUBLIC POLICIES IN RENEWABLE ENERGY 51

4.4.1 Green certificates 51

4.4.2 Concessions in Norway 51

4.4.3 Taxes on wind power and hydropower 52

4.5 SUMMARY FROM INTERVIEWS 56

4.5.1 Regulations 56

4.5.2 Local consequences 58

4.5.3 Wind power 59

4.5.4 Hydropower 63
4.5.5 Nuclear power 64
4.5.6 Tourism 65
4.5.7 Others 67

5 DISCUSSION 70

5.1 HISTORIC AND FUTURE ENERGY PRODUCTION 70

5.2 ONSHORE DEVELOPMENT AND COSTS 71

5.3 VALUE CREATION 73

5.4 EXTERNALITIES 74

5.5 PUBLIC POLICIES AND TAXES 75

5.6 OFFSHORE POTENTIAL 77

5.6.1 Production possibility frontier 79

6 CONCLUSION 80

6.1 FURTHER RESEARCH 83

7 REFERENCES 84

TABLE OF FIGURES

Figure 1: Supply curve (Pindyck & Rubinfeld, 2012, p. 22) 16
Figure 2: Demand curve (Pindyck & Rubinfeld, 2012, p. 24) 17
Figure 3: Market equilibrium (Pindyck & Rubinfeld, 2012, p. 25) 18
Figure 4: Deadweight loss (NOU 2019: 16, n.d., p. 87) 19
Figure 5: Production possibility frontier (Snyder & Nicholson, 2007, p. 14) 21
Figure 6: Price elasticity of demand 22
Figure 7: Price elasticity of supply 23
Figure 8: Innovation space (Tidd et al., 2005, p. 13) 25
Figure 9: Milestones in the concession progress(Vindportalen, n.d. -c) 52
Figure 10: Neutral income tax (NOU 2019: 16, n.d., p. 87) 55
Figure 11: Concessions offshore opportunities 79

TABLE OF TABLES

Table 1: Global - Trends in Renewable Energy (Workbook: IRENA RE Time Series, n.d.) 35
Table 2: CO2 Emissions per capita (Øvrebø, 2020) 36
Table 3: Nuclear electricity production (Nuclear Power in the World Today, 2020) 38
Table 4: Norway - Trends in Renewable Energy (Workbook: IRENA RE Time Series, n.d.) 39
Table 5: Trade surplus (SSB, n.d., -a) 40
Table 6: Levelized cost of energy (NVE, 2020 -b) 41
Table 7: LCOE 2019 vs. 2040 (NVE, 2020 -b) 41
Table 8: Solar power - Trends in Renewable Energy (Source (Workbook: IRENA RE Time Series, n.d.) 45
Table 9: Tax systems for hydropower and wind power (NOU 2019: 16, n.d., p. 148) 53

1 INTRODUCTION

Over the past 70 years the global economy has experienced a massive growth. A high intensity of innovation has resulted in new technologies, but also a vast demand for energy. However, the increased demand for energy has had a major toll on the environment, as the main sources of energy has been from coal and fossil fuels, the consequences through pollution have been severe. The past decade, world leaders have acknowledged the challenge and acted on the problem to prevent irreversible outcomes due to pollution. One of them is the Paris Agreement, where the main goal is that the participating countries, including Norway, will be entirely climate neutral somewhere between 2050-2100 (FN-sambandet, 2020).

The past years there has been massive debates concerning to what degree wind power is beneficial compared to the damages it brings. Currently some municipalities and residents are scared that the implementation could cause permanent damages to mountains, animal life, and their own wellbeing. Considering the vast water resources in Norway and that over 90% of the power supplied is generated from hydropower, questions arises regarding the investments of the Norwegian tax money towards wind power plants. Naturvernforbundet states that the investments and development of wind power plants in Norway has triggered a large portion of the Norwegian population, resulting in start-ups of several resistance organizations. With wind turbines being built close to housing areas there are certain externalities that inhabitants might be affected by, such as loud noises and shadow flickering. Additionally, wind turbines could cause a drop-in property value, and have a toll on nature and habitats (Naturvernforbundet, 2020).

Since year 2017 Norway have set records for wind power installations every year after and expect to achieve this in 2020 as well (Øvrebø, n.d.). If Norway is to maintain the increase in power production, increasing the grid and powerlines to Europe is necessary. Solberg states that one of the main factors that has contributed to this growth is the subsidies that wind power developers receive from the government, among them the green certificate system introduced in 2012 from the Swedish-Norwegian collaboration. The green certificate is a proof of that it is produced 1 MWh of electricity from a power plant encompassed by the green certificate arrangement. Power developers are obliged to purchase such certificates for a certain share of the power they sell, which results in increased revenue. The governments reasoning behind the implementation of certificates was to give incentives for power developers to invest in renewable energy, so that the goal of becoming climate neutral could be manageable (Solberg, n.d.).

1.1 RESEARCH QUESTION

The objective of this research paper is to identify key factors that may have an influence on future investments of renewable energy in Norway. The key factors may have positive or negative effects, however, this paper aims to investigate if something must change to continue the development of renewable energy in Norway. Some of the key factors are assumed to be externalities and costs. For a continuous successful expansion of renewable energy sources in Norway, one can assume that a set of regulations must be implemented so that people affected by the expansion are compensated fairly. Governments are creating incentives to invest in certain renewable energy sources through subsidies, which is causing market inefficiencies. Moreover, renewable energy sources that are dependent on subsidies to be sustainable, are not profitable from a business economic perspective.

The research question of this thesis is:

What are the key factors that will affect future investments of renewable energy, in Norway?

Based on the problem defined two supplementary questions is added to reach a conclusion:

- How does the global trends within renewable energy influence the Norwegian market?
- Can externalities delay the development of wind power?

1.2 STRUCTURE OF THE THESIS

This master thesis will consist of six chapters.

1. The first chapter will contain a brief introduction of the thesis, and the reasoning behind the research questions. A presentation of the different power sources is also added.
2. The second chapter will contain theories relevant to the thesis. Among the topics we will represent are microeconomic theories, theories of innovation and public policies.
3. The third chapter will put forth our choice of method for data collecting and limitations.
4. The fourth chapter will contain the data collected through the qualitative and quantitative methods that we have utilized.
5. The fifth chapter will hold the discussion of our case. The collection of data will be interpreted alongside the theory from chapter two, in order to reach an answer to our research question.
6. The sixth and final chapter will present the outcome of our discussion, and we will reach a conclusion for our research question.

1.3 RENEWABLE ENERGY SOURCES

An overview of renewable energy sources is presented for the reader's enlightenment. The overview includes wind power, hydropower, wave power, solar power, and nuclear power (which is a non-renewable energy source). There are other sources of renewable energy within the industry, but they are excluded from the research due to a low market share and limited research time.

1.3.1 Wind power

According to Vindportalen wind power has had a long history in the world, dating back to 5000 BC, where the technology was used as sails to travel through the Nile river. The first water pumping windmills were found in Asia as early as year 0. While the first European windmills got built in the 12th century, it was not before the 14th century the expansion reached thousands of water pumping and grain mills. Late in the 19th century, the first electric generating windmill was installed, and it was not until after the oil crisis in the late seventies, Denmark started innovating the modern wind turbines. Denmark has capitalized on this market and is still a front runner in wind power technology (Vindportalen, n.d.-g).

The U.S. Energy Information Administration states the American share of electricity generated from wind has grown from less than 1% to 7.3% in the last nine years. Europe has had a large expansion of wind power because of new regulations increasing the investment incentives. In Asia, China has heavily invested in wind power and now produces the highest amount of electricity generated by wind in the world. The improvement from producing 3.6 billion kWh of wind power in the nineties, increasing to 1.13 trillion kWh in 2017 worldwide, proves the world is leaning towards wind power (U.S. Energy Information Administration, 2020).

According to Vindportalen, wind energy is not a new phenomenon in Norway, and the first offshore electric wind turbine was installed on a boat during the Nansen's Fram- expedition between 1893-96. Norway has a large coast with exceptional wind conditions, causing most of the wind parks to be built in these areas. In 2012, Norway implemented the green certificate system that increased the incentives for developers to start building wind parks, which has had both positive and negative consequences. Some examples of the negative consequences are oppositions from the local communities, litigation, and the loss of essential biotopes. On the other hand, the positive consequences brought in a new production of renewable energy and a reduction in CO_2 emissions (Vindportalen, n.d.-g).

1.3.2 Hydropower

According to the International Hydropower Association, hydropower dates to China between 202 BC and 9 AC, where trip hammers were used to pound ore, process grain, and even in papermaking. Through hundreds of years, modern hydro turbines were invented through steady innovation, continuously improving these technologies (International Hydropower Association, n.d.).

The International Hydropower Association states that countries with the availability of waterpower are associated with kick-starting economic growth, which has been seen since the first development. Richard Arkwright, who set up a cotton spinning factory in 1771 in Derwent valley England, which was one of the first factories run by hydropower in the world. In 1849, a turbine was developed by British-American engineer James B- Francis adaptations of these turbines are what is most frequently used today (International Hydropower Association, n.d.).

Moran et al. (2019) mentions that several large dams were built until 1975, in North America and European countries. After this implementation both continents abandoned a large part of their installed hydropower. Hydropower caused environmental damage, which led to negative social effects. Thus, there was a drastic change in behaviour. In recent years, a new trend of large-scale hydropower dams is being built in developing countries. However, these implementations are causing greater socioeconomic and environmental damages than the early costs in North America and Europe. Even with all the negative impact hydropower brings to the world, it is a well-established renewable energy producer in the world, producing roughly 71% of the supply within this segment as of 2016 (Moran et al., 2018).

Regjeringen (2019) states that hydropower is Norway's backbone within power generation and believed to be for generations to come. With the right amount of renewable resources, it places Norway in a competitive advantage against most other countries. The government saw an advantage and let the industry flourish within the hydropower industry. At the end of the nineteenth century, the Norwegian engineer Samuel Eyde got permission by the government to capitalize on Norway's massive waterfall in Telemark and used the power generated to supply the industrial production. This action led to the establishment of Norsk Hydro and Elkem. The Norwegian water reserves have allowed the industrial sector to evolve, innovate, and provided light and heat for over one hundred years (Regjeringen, 2019-a).

1.3.3 Wave power

According to the National Renewable Energy Laboratory (2020), Monsieur Girard and his son created the idea of wave power, and in Paris year 1799, wind power received its first patent. The idea was to drive heavy machinery using direct mechanical action. Once this invention hit the market, thousands of patents followed. In 1919 Bochaux Praceique created a device to power and light his house. A Japanese naval commander, Yoshio Masuda, is the pioneer for modern wave power with his research within multiple wave power machines at sea. His research resulted in the government using hundreds of machines to power navigation lights in the 1940s (National Renewable Energy Laboratory, 2020).

National Renewable Energy Laboratory (2020) explains that during the oil crisis in 1973, a new interest in alternative energy occurred, since a member of the Organization of Arab Petroleum Exporting Countries (OAPEC), put a prohibition on oil exports. As a result, wave power came back on the table, and multiple new pioneers started innovating new technology to convert wave power into electricity. Through these innovations, five main types of technology within wave power, which include Attenuators, Absorbers, Overtopping, Oscillation water columns, and Inverted- Pendulum devices. Countries currently using wave farms are The United States, Australia, United Kingdom, and Portugal. Since the technology within wave power is relatively new, fewer countries are investing in the segment, but it has great potential to develop (National Renewable Energy Laboratory, 2020).

Mjønerud (2019) states that in Norway, wave power did not have any improvements before 2016 when the Swedish company Waves4Power installed the test buoy WaveEI 3.0. The most crucial factor for this project was to keep enough power while sending it through power lines. The project did turn out successful. In 2017, this project was the first in the world to generate electricity for the mainland. The main issue with wave power is to solve the problem with financing, as the research is expensive, and the technology is new. Waves4Power is currently working on a more efficient generator that could improve efficiency by roughly 100% (Mjønerud, 2019). The Norwegian company Sea Motion Energy has developed a new type of WEC, and the main difference between this system and others is the reduced costs of building and installing the product (Sea Motion Energy, n.d.).

1.3.4 Solar power

According to Richardson (2018), Solar power can be traced back to as early as the 7th century BC when humans used sunlight with magnifying glass material to light fires. Greeks and Romans during the 3rd century BC used solar power with mirrors to light torches referred to as “burning mirrors”. “Burning mirrors” became a normalized tool, as seen in Chinese civilizations in 20 A.D. Another use of solar power is known as “sunrooms” in buildings, which is a room with large windows to direct sunlight into a concentrated area. Researchers and scientists managed to use sunlight to power ovens during the late 1700s and 1800s during long voyages. Edmond Becquerel found that electricity generation by light could increase when two metal electrodes got placed into a conducting solution, known as the “photovoltaic effect.” Willoughby Smith discovered selenium had a photoconductive potential in 1873. In 1876 William Grylls Adams’ and Richard Evans Day discovered that selenium created electricity when exposed to sunlight. Charles Fritts produced the first solar cells in 1883 made with selenium wafers. However, in 1954 the first silicon photovoltaic (PV) was invented at Bell Labs (Richardson, 2018).

Statkraft is Europe’s largest generator of renewable energy, including solar, wind, and hydro. As stated by Statkraft (2019), “The world is embracing solar power on a scale we have never seen before.” Statkraft has been developing solar power over the last ten years and has high ambitions for the future. Statkraft estimates that the renewable share of power could reach 80% by 2050 and that solar power would cover almost 40% of all electricity generated by 2035 (Statkraft, 2019).

1.3.5 Nuclear power

The U.S. Department of Energy states that the idea behind nuclear power was developed by Greek philosophers stating that all matter is composed of invisible particles called atoms. However, it was not before the 18th and 19th century scientists started to research the subject. By the year 1900, physicists knew that the atoms contained a high amount of energy. Ernest Rutherford had a theory of atomic structure that made him known as the father of nuclear science (U.S. Department of Energy, n.d.). Rutherford stated, “If it should even be found possible to control at will the rate of disintegration of the radio-elements, an enormous amount of energy could be obtained from a small quantity of matter” (Rutherford, 1905, p. 467). The U.S. Department of Energy explains that the following year Albert Einstein developed the mathematical formula (energy equals mass times the speed of light squared) within his theory of the relationship between mass and energy, however it took almost 35 years to prove Einstein’s theory (U.S. Department of Energy, n.d., pp.1-3).

According to the U.S. Department of Energy, the first self-sustaining nuclear chain reaction occurred at the University of Chicago in 1942. On August 1, in 1946, the Atomic Energy Act created a Commission to control the development of nuclear energy and explore peaceful uses of the source. The first town powered by a nuclear powerplant was in Idaho with a population of 1000 in 1955, and by 1974 the first 1000 MW nuclear reactor was built. In 1979 the first nuclear accident happened on Three Mile Island, US, the second was in Chernobyl in 1986, Ukrainian Soviet Socialist Republic, and the last happened in Fukushima in 2011, Japan (U.S. Department of Energy, n.d., pp. 15-19). These major accidents have brought attention and worry to the people, causing fear towards nuclear power. Bill Gates states that nuclear power is a source that could deal with climate change, as it is the only carbon-free scalable energy that is available 24 hours a day (Gates, 2018).

Nuclear power has been in development for over 70 years, using Uranium-235 since it is an isotope that fissions easily (U.S. Department of Energy, n.d.). Jensen (2019) mentions that Norway has discovered that Thorium-232 could generate 120 times more energy than all the oil and gas available in the country and could be a solution to reduce global emissions. Nuclear power still struggles to get through the political barriers, as the Norwegian government has divided opinions. However, there is still funding within the subject. A noteworthy person is Eirik Eide Pettersen, a Norwegian entrepreneur nominated for the European innovation award, based on his adaptation using liquid salt within a thorium reactor (Jensen, 2019).

1.4 REFINEMENTS

This research paper investigates four of the renewable energy sources currently available worldwide, which is wind-, hydro-, solar- and wave power, in addition to the non-renewable energy source, nuclear power. As these sources currently dominates the production of renewable energy, this paper has intentionally excluded other sources, such as bioenergy and geothermal energy.

The research paper transpires in a social economic perspective, with a superficial elaboration of the technological development that this industry has experienced. An in-depth analysis of how innovation ensued has been excluded, rather investigating how innovation has improved the technologies to make them sustainable.

2 THEORY

This chapter introduces the theoretical concepts of microeconomics and innovation, which are essential business/economic functions in the industry. Application of theories are fundamental for discussing the conducted research, as well as for analysis of the data. The micro-economical part of the chapter mainly consists of microeconomic, including supply and demand, market equilibrium, and price elasticities. Theoretical concepts of innovation are also explained, including different types of innovation that is relevant as it holds a large spectrum of definitions.

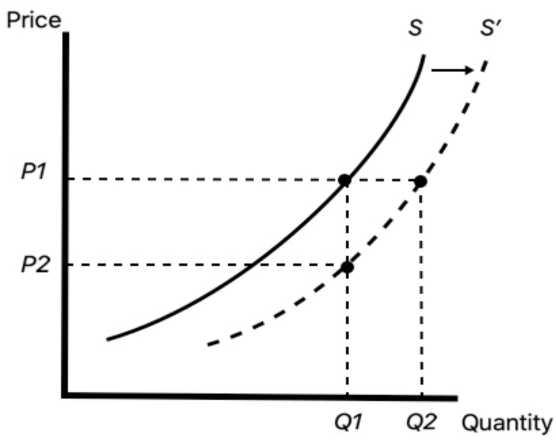
2.1 SUPPLY AND DEMAND

The theory behind supply and demand helps to understand why and how prices change. It can reveal how prices could be affected when governments intervene by, for example, adding a tax or setting a regulation (Pindyck & Rubinfield, 2012, p. 22).

2.1.1 Supply

Pindyck & Rubinfield (2012) states that the supply curve is an indication of the relationship between how many goods a firm is willing to sell for a given price in a competitive market when all other factors that may have an affection of the supply are held constant. In figure 1 we have introduced an example of a supply curve, marked as S. The price of the good is marked as P, and the quantity sold is marked as Q. For a given price, the firm will produce at such a level that the profit is maximized, which means that the price of the last sold good is higher than the costs by producing and selling one more unit of the good (Pindyck & Rubinfeld, 2012, p. 22).

Figure 1: Supply curve (Pindyck & Rubinfeld, 2012, p. 22)

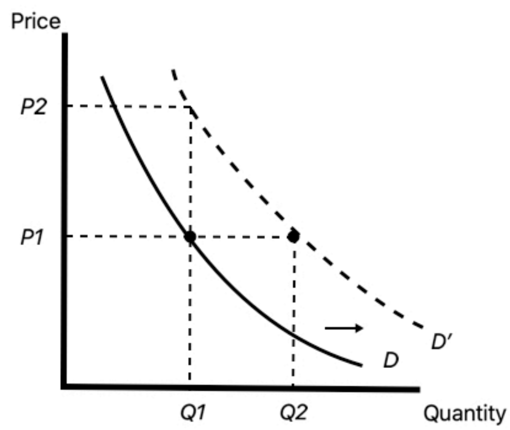


The supply curve in figure 1 shows how a change in price will affect the quantity offered for sale. According to Pindyck & Rubinfield (2012), the supply curve is upward sloping, which means that the higher the price of the good, the more the firms are willing to produce and sell. If the cost of producing reduces the firms can choose to either produce at the same level as before for a lower price or produce more at the same price, as seen when the S moves to S' (Pindyck & Rubinfeld, 2012, pp. 22-23).

Pindyck & Rubinfield (2012) mentions that other factors than price can affect the quantity supplied to the market. The quantity firms are able and willing to produce, is also a result of production costs, wages, accessibility of raw materials (price and availability to resources). Additionally, the government can intervene by setting regulations for certain products (Pindyck & Rubinfeld, 2012, pp. 22-23).

2.2 Demand

Figure 2: Demand curve (Pindyck & Rubinfeld, 2012, p.

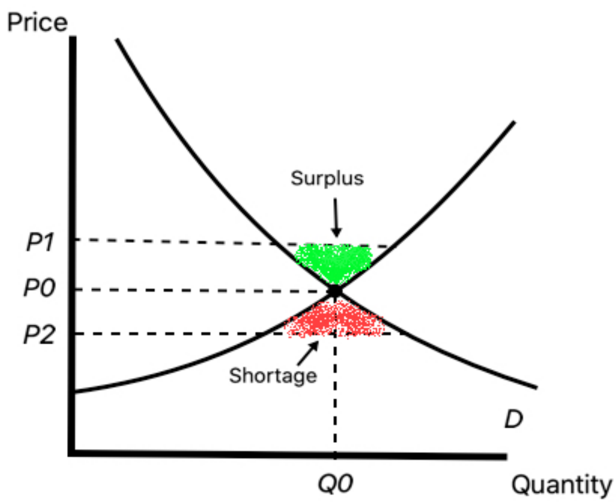


Pindyck & Rubinfield (2012) asserts that the demand curve illustrates a consumers' willingness to buy a good as the price changes. In figure 2, the demand curve *D* is downward sloping. The curve then indicates that the consumers are typically willing to buy more goods as the price decreases. This behaviour can be an example of a consumer that is already buying the product can afford to consume larger quantities and could also attract consumers until the price reduction could not afford the good. As seen in figure 2, when shifting from *D* to *D'*, the consumer can buy larger quantities for the same price, or the same amount of quantities for a lower price (Pindyck & Rubinfeld, 2012, pp. 23-24).

2.3 MARKET EQUILIBRIUM

The market equilibrium occurs where the supply curve meets the demand curve. As shown in figure 3 below, the intersection is where market clearing price and the quantity supplied are equal (Pindyck & Rubinfeld, 2012, p. 25). With the electrification on a global level, the demand curve will face an outward shift, this will cause a shortage unless energy suppliers increase production to meet the required demand.

Figure 3: Market equilibrium (Pindyck & Rubinfeld, 2012, p. 25)



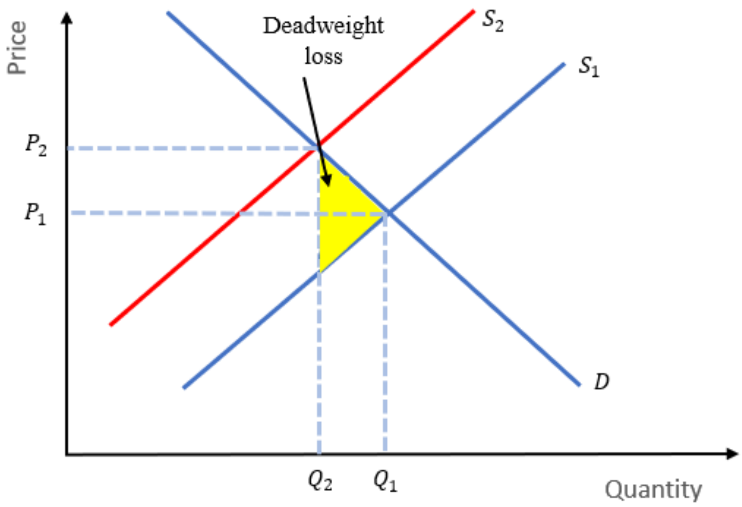
2.4 MARKET EFFICIENCY

In an efficient market, product prices are always reflected by its true value. However, Hayes (2020) argues that most markets are not efficient, which can be explained by several reasons. Market inefficiencies occur when a product's price does not accurately reflect its true value, which often results in a deadweight loss. Information asymmetries, transaction costs, market psychology, and human emotions can be some of the reasons that market inefficiencies occur, which can cause products to be over- or under-valued, creating opportunities to make additional profits (Hayes, 2020).

2.4.1 Deadweight loss

As mentioned above, market efficiencies can lead to deadweight losses. Tuovila (2019) asserts that the deadweight loss arises when a shift in the supply or demand lead to a fallout from free market equilibrium. A shift in either one of these curves can occur in context of a new tax or regulation on a product that reduces the trade level, which may lead to inefficiency due to the allocation of resources in the society. Externalities can be a source to deadweight loss as it creates a net loss of total surplus. Additionally, price controls, environmental damage and pollution reduce both consumer and producer surplus within a market (Tuovila, 2019).

Figure 4: Deadweight loss (NOU 2019: 16, n.d., p. 87)



2.4.2 Externalities

Externalities transpires when an economic actor's activities affect the activities of another third party that is not a part of the market transactions (Snyder & Nicholson, 2007, p. 670). For example, when power plants are installed in municipalities externalities are not reflected in market prices, meaning they can be a source of economic inefficiency. Excess production and unnecessary social costs are results of when firms do not take harms associated with negative externalities into account (Pindyck & Rubinfeld, 2012, p. 662). However, not all externalities have a negative outcome, which is why externalities are separated into categories (Snyder & Nicholson, 2007, p.670).

2.4.2.1 Interfirm externalities

Pindyck & Rubinfield (2012) states that interfirm externalities occur when an increased production output of one firm affects the production output of another firm. To illustrate how this would function within a market, two firms located on a river will be considered. Firm x is located a couple of kilometres up the river from firm y. When firm x produces a unit, chemical waste is released in the river reducing the production output of firm y.

Equation of interfirm externalities:

Equation 1: $$y = f(k, l; x)$$

Hence, when the production output of *y* decreases due to an increase in production output of *x,* the marginal physical product of *y* is negative, $\frac{\partial y}{\partial x} < 0$ (Snyder & Nicholson, 2007, p.671).

2.4.2.2 Beneficial externalities

Nicholson & Snyder (2007) states that when two firms make a positive impact on each other due to externalities that occur between them, they are called beneficial externalities. Nicholson & Snyder (2007) argue that the example made my J. Meade is one of the most explicit scenarios where beneficial externalities occur. The example includes two firms, where firm one produces honey from bees, and the other one producing apples. The bees are known to feed on apple blossom, which makes them well-nourished in such an environment. A well-nourished bee could improve the productivity of honey making. Thus, an increase in apple production could result in more well-nourished bees, which in return should increase honey production. The marginal physical product for honey is now positive $\frac{\partial honey}{\partial apples} > 0$ Snyder & Nicholson, 2007, p. 671).

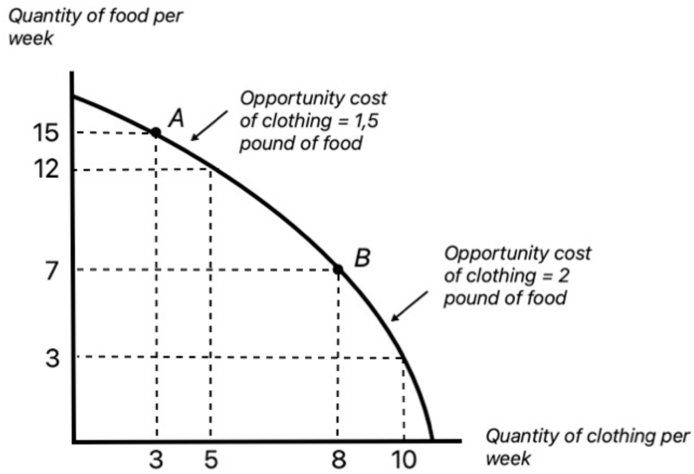
2.4.2.3 Externalities in utility

Externalities can directly affect an individual's utility due to an economic actor's activities (Snyder & Nicholson, 2007, p. 671). In most cases, if the utility has been affected, it is by environmental externalities, for example, a loud radio or noise, litter, or wind turbines. However, externalities can have a beneficial impact on the individual's utility function if the song of the radio enjoys him/her or if the individual enjoys the view of a wind turbine (Snyder & Nicholson, 2007, pp. 671-672).

2.5 PRODUCTION POSSIBILITY FRONTIER

With nature as a limited resource, the government must choose an allocation to where they can maximize production of renewable energy for a given area. According to Nicholson & Snyder (2007), the production possibility frontier represents a two-good production scenario with limited resources. Figure 5 displays a graph with two different sets of goods – food and clothing. With a limited amount of resources, the consumer can choose to position himself at different allocations to maximize his benefit. For example, in point *A,* the allocation is 15 pound of food and 3 units of clothing per week. However, if the consumer chooses another allocation where he obtains 2 more units of clothing, an opportunity cost of 3 pound of food would arise. Essentially what the production possibility frontier represents is that with a limited amount of resources, one must reduce the production of one good to increase the amount of the other (Snyder & Nicholson, 2007, pp. 13-14).

Figure 5: Production possibility frontier (Snyder & Nicholson, 2007, p. 14)



2.6 PRICE ELASTICITY

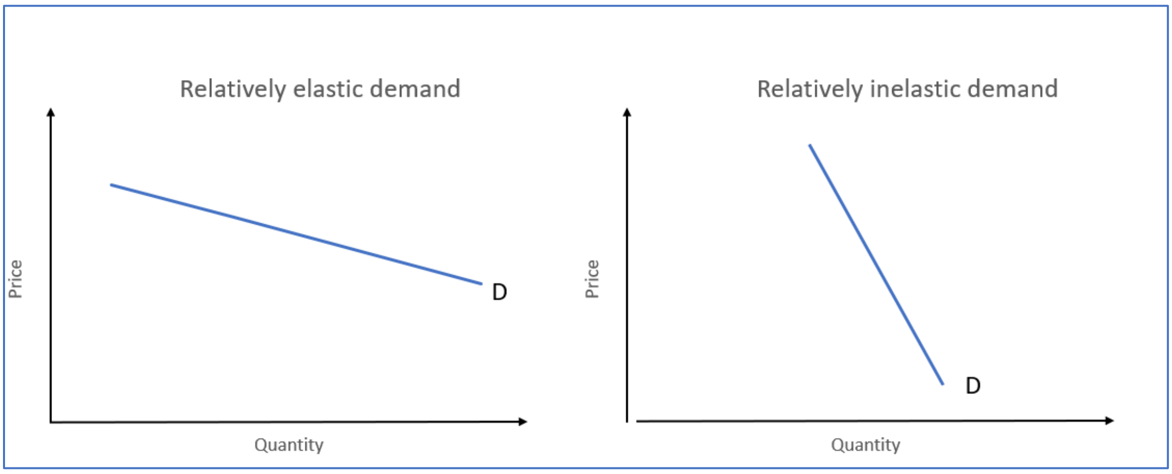
Electricity has a volatile pricing market as there are several influential factors that may have an impact. Therefore, understanding if electricity pricing is elastic or inelastic is beneficial for this research. Pindyck & Rubinfield (2012) states that elasticity is a measure of a percentage change in one variable as a result of a 1-percent increase in another variable. Thus, price elasticity is a measure of the percentage change in demanded quantity following a 1-percent increase in the price of the good. Steep curves can be referred to as inelastic, while curves with a more horizontal graphic are elastic (Pindyck & Rubinfeld, 2012, p. 33).

2.6.1 Price elasticity of demand

Pettinger (2017) states that in the short run, consumers demand of a product does not change as one cannot find a substitute in time, i.e. inelastic demand. However, the consumer may find alternatives to the product in the long run (Pettinger, 2017). According to Pindyck & Rubinfeld (2012), if the elasticity of demand is price elastic, then a 1-percentage change in price for a specific good will result in a larger percentage change in demand. If the percentage change in quantity is less than the percentage change in price, the price elasticity of demand is price inelastic. The following formula can be used to calculate the price elasticity of demand:

Equation 2: $E_p = \frac{\Delta Q/Q}{\Delta P/P} = \frac{P\Delta Q}{Q\Delta P}$ (Pindyck & Rubinfeld, 2012, p. 33).

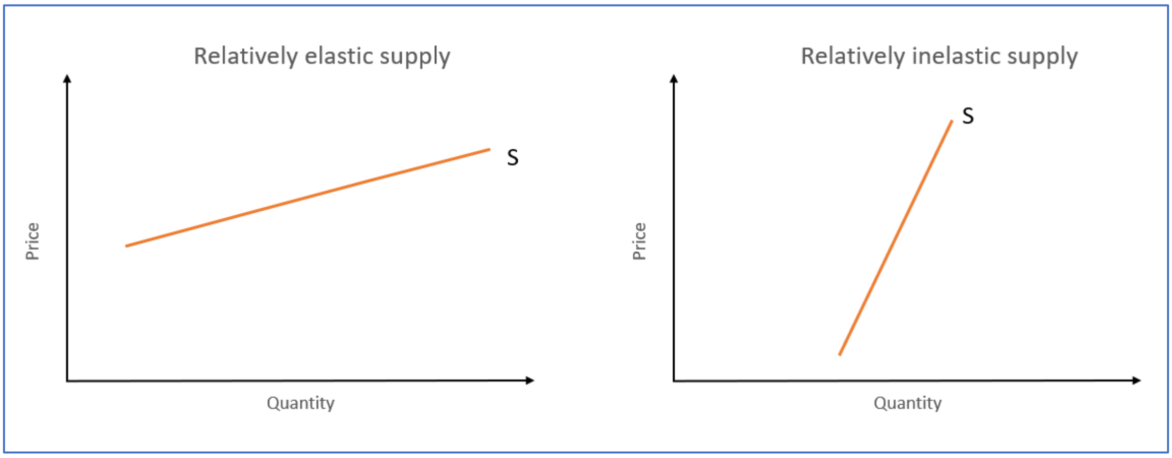
Figure 6: Price elasticity of demand



2.6.2 Price elasticity of supply

Pindyck & Rubinfield (2012) states that if the price elasticity of supply is elastic, then a 1-percent change in price will result in a larger percentage change in quantity supplied. If the price elasticity of supply is inelastic it will result in a less than 1-percentage change in quantity supplied. (Pindyck & Rubinfeld, 2012, p. 36).

Figure 7: Price elasticity of supply



2.6.3 Price volatility

According to Riley, price volatility is measured by a day to day percentage difference in the price fluctuation of a commodity. A volatile market is defined as the degree of variation and not the level of prices. Since price is a function of supply and demand, volatility is a result of the underlying characteristics of the markets supply and demand. If the supply and demand are inelastic, market prices tend to be volatile (Riley, n.d.), leading up to why energy prices are generally more volatile compared to other commodities. Volatility in markets can cause firms to delay decisions, investments, or increase risk management activities (U.S. Energy Information Administration, n.d.).

U.S. Energy Information Administration states that there are a few factors that could cause volatility within the energy market. Severe weather changes are a strong determinant of short-term demand or affect the supply as it might shift the production levels and could lead to higher import. Severe weather changes could also cause drainage to hydropower magazines. Another factor is the constrains in the pipelines, which is also possible to remove causing a change to supply and distribution. This distribution change is a fluctuation in amount of available electricity (U.S. Energy Information Administration, n.d.).

2.7 INNOVATION

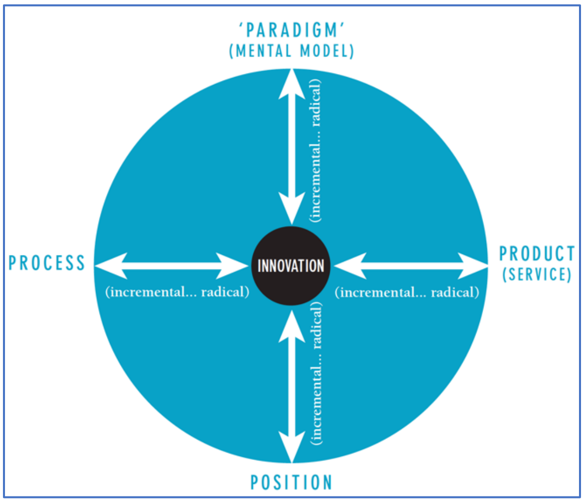
According to Fagerberg (2015), the term innovation is broadly defined, which can confuse. One common misunderstanding is that innovation is the same as invention, which it is not. However, John Schumpeter points to the vital relationship between the two; the invention is the idea for the new product, service, or process, while innovation is the attempt to perform/complete it in practice. Yet, the innovator needs typically to have several types of characteristics to be able to turn the invention into an innovation, such as knowledge, skills, capabilities, and resources. It is also important to elaborate on which type of innovations occur within the 4 P's (Fagerberg, 2015, p. 6).

2.7.1 4 P´s of innovation

Tidd et al. (2005) states that the 4 P's of innovation are essential as it provides a deeper understanding of where innovation can occur. That is why the 4P's of innovation is relevant for analysing the renewable energy industry. The 4 P's of innovation represents four different categories. The first one is *product innovation*, which is a change in the products or services that the organization is offering. The second one is process innovation, which is a change in the process of creating products or services and how they are delivered. The third one is position innovation, which is a change in the context of how the products or services are introduced to the market. The last and forth P is paradigm innovation, which is about changing the underlying mental models, which are essential for the organization's output generation (Tidd et al., 2005, p. 10).

Figure 8 is an illustration of how an organization can position themselves around the 4 P's. Tidd et al. (2005) mentions that for some businesses it may be more common to take a position where their product innovation is more radical than incremental and prioritize incremental innovation for radical for process innovation (Tidd et al., 2005, pp. 12-13).

Figure 8: Innovation space (Tidd et al., 2005, p. 13)



2.7.2 Incremental innovation

The renewable energy market has in the past been identified by high costs in both investment and operational costs. Incremental innovation is by Bessant & Tidd (2013) defined as "doing what we do, but better." The term incremental innovation originates from performing continuous minor improvements to what may be technology, products, or services. It is also worth mentioning that it is possible to utilize incremental innovation in the process of producing the product or service to optimize the process (Bessant & Tidd, 2013. p. 30).

Incremental innovation can result in less costs associated to the production process, while also increasing productivity by adding small changes, especially within scale economies. Additionally, there is less risk linked to incremental innovation in processes because it can be managed on a day-to-day basis (Tidd et al., 2005, p. 15).

2.7.3 Radical innovation

The renewable energy industry has experienced a large degree of radical innovation the past 20 years. Wind power is a fairly new technology in the energy market and has expanded from onshore to offshore production. According to Innolytics, compared to incremental innovation where small changes are implemented, the concept of radical innovation is to make changes that can replace an existing market. Radical innovations as new products, services and business models are created or implemented with a goal of having a long-term growth over the next five to ten years (Innolytics, n.d.).

2.8 CENTRALIZED AND DECENTRALIZED AUTHORITY

There is an ongoing discussion of whether the concessions in Norway should be imposed on centralized or decentralized authorities. Hansen (2015) states that centralized authority can be described as when the decisions and regulations are imposed at one authority, for example the government. The process of planning activities and making decisions will then be the responsibility of the authority, while the actors underneath the authority will have to follow set decisions. The authority then has the advantage of being able to balance and regulate activities. However, in centralized authorities there is a risk of ineffective decision-making causing processes to proceed longer than necessary (Hansen, 2015). Hansen (2019) explains that decisions made by the centralized authority can be transferred to horizontal decentralized authorities for them to initiate the activity, such as directorates. At a vertical decentralized authority structure the decision making and planning is transferred to subunits such as counties or municipalities. In this authority structure the subunits have the possibility to control the relevant decision-making and activity planning (Hansen, 2019).

2.9 DEPRECIATION

Currently, there is a gap between how different renewable energy sources are imposed on depreciation rules (NOU 2019: 16). Depreciation functions as an accounting method to distribute the costs of physical or intangible assets over its economical lifespan (Tuovila, 2020). Gårseth-Nesbakk (2019) argues that a normal accounting period is usually one year, while the lifespan of an asset has a longer economical lifespan. During the accounting year only a part of the investment will be exhausted, therefore, only a part of the investment should be accounted as an expense. The lifespan of the asset is decided with depreciation rules from the government (Gårseth-Nesbakk, 2019). According to Touvila (2020) one can depreciate an asset linearly with equal sums every year, or with the declining balance method where a percentage rate of the investment is deducted every year until there is only a low balance left. A depreciation of an asset will lead to a reduced taxable income, which means lower tax expenses for the owner during the lifespan (Tuovila, 2020).

2.10 LEVELIZED COST OF ENERGY

The Corporate Finance Institute explains levelized cost of energy (LCOE) as a measurement of an energy-generating asset's average cost of investment and operation over an assumed lifetime. LCOE can be essential in evaluating the decision of whether to proceed a project, as it can predict if it will become profitable or breakeven. Moreover, LCOE is a useful tool to compare different renewable energy sources such as hydro, wind, solar and nuclear power (Corporate Finance Institute, n.d.).

Equation 3: $$LCOE = \frac{NPV\ of\ Total\ Costs\ over\ Lifetime}{NPV\ of\ Electrical\ Energy\ Produced\ over\ Lifetime}$$

2.11 FULL-LOAD HOURS

The production of wind power is dependent on wind. According to Vindportalen, the wind is naturally unstable, causing it to be an unreliable resource. One of the disadvantages of wind power is that there is not a method to save wind energy the same way as hydropower. The wind power producer is required to report the production for each hour the next day, 12-36 hours before planned production. An essential factor to include within the production of wind power is full-load hours. Full-load hour is a term used to explain how many hours of production one wind turbine has been producing at full effect. Even though one turbine has been producing energy 6 000 out of 8 760 hours, it does not mean that it has been operating at full effect. Formula X shows how to calculate the full-load hours of one year (Vindportalen, n.d.-a).

Equation 4: $$Full\ load\ hours\ (h) = \frac{Produced\ energy\ of\ one\ year (MWh)}{Installed\ turbine\ effect\ (MW)}$$

3 RESEARCH METHOD

To conduct a reliable research, it is required to collect data and information in the most accurate sense. The research method comprises the learning of collecting, organizing, processing, analysing, and how to interpret social facts in such a systematic aspect that others can apprehend the research (Halvorsen, 2003). Data retrieved from earlier research is collected and applied for the basis of the quantitative analysis. The qualitative data is collected from interviews of actors in the industry of renewable energy, as well as professors in the field of the research. The literature base on renewable energy are used as a foundation for the discussion, by creating an interpretation of the status quo on the global renewable energy industry.

A mixed method procedure is employed by utilizing qualitative and quantitative analysis. The qualitative analysis is based on open-ended data which contains data from the interviews and the literature, while the quantitative data is close-ended data which contains numerical data retrieved from the industry. Utilizing solely one of the methods could not provide a comprehensive analysis (Creswell, 2014, p. 264). Thus, the chosen research design aims to provide an in-depth analysis of the topic.

3.1 QUANTITATIVE DATA

Quantitative secondary data is collected from Norges Vassdrag – og Energidirektorat (NVE), Energi og Klima (Energy and Climate), Faktisk.no, International Renewable Energy Agency (IRENA) and Statistisk Sentralbyrå (SSB) with the purpose of evaluating historical and future trends of the industry. The data collected from NVE, Energy and Climate and SSB was downloaded into Microsoft Excel with a purpose of visualizing it in graphs and tables to create an explicit overview by leaving no room for confusion. Furthermore, the sources of the selected databases are presented, which provides a basis for discussing the reliability and validity.

NVE is a governmental directorate under the ministry of Petroleum and Energy that grants concessions to energy developers under the Water Resources Act, Watercourse Regulation Act, the Energy Act and the industrial Licensing Act. The applications for concessions include construction of hydropower plants, wind power, district heating and other energy plants (NVE, 2020-a). The data collected from NVE showed the installed capacity in 2020, the LCOE for all relevant renewable energy sources in Norway in 2020 and estimated LCOE in 2040.

Norwegian Climate Foundation main task is to disseminate knowledge and proposals from acknowledged research environments to guide public and private sectors to reduce or stop human created emissions. Additionally, the foundation works towards measures that can mitigate the effects of future climate change. This research includes data acquired from Energy and Climate which is a magazine run by the Norwegian Climate Foundation that publishes their extensive work (Norsk Klimastiftelse, n.d.). To gain knowledge of the trends of CO_2 emissions, there is collected data from Energy and Climate, that show the historic development of CO_2 emissions per capita for certain countries in the world.

Faktisk.no is a non-profit organization, with an independent editorial board for the purpose of fact checking public debates. The organization's goal is to prevent the spread of fabricated information which can give indications to be real news. Faktisk.no has been accepted into the International Fact-Checkers Network (IFCN), which requires them to be neutral, politically independent, with full transparency in their methods, sources, funding, and organizational structure (Faktisk, n.d.).

IRENA is an intergovernmental organization that serves as a platform too increase international cooperation through the promotion of adaptation and sustainable uses of renewable energy. IRENA aims to assist countries transition over to a sustainable future, through policies, resources, financial knowledge of renewable energy and technology. IRENA'S mandate include countries from around the world, and there are over 180 countries engaged (IRENA, n.d.-a). Relevant illustrations and tables are collected from IRENA as a contribution to the data collection. The data collected from IRENA consists of a yearly balance development of installed capacity of several renewable energy sources, in a global and national perspective for Norway. The different balances used from the development includes installed capacity of the renewable energy source, and the percentage share each source holds in the market.

SSB is the national statistical institute of Norway. SSB is an independent governmental institution, and producer of official statistics. SSB is responsible for collecting, producing, and communicating statistics related to the economy, population, and society at local, regional, and national levels (SSB, n.d.-b). The data collected from SSB consists of import and export of electricity between 2010 and 2019.

Furthermore, historical numerical data is applied to provide a perspective of the development in the last 20 years, including a future prognosis of the industry in the next 20 years. Moreover, future prognosis can be figuratively speaking a straight drawn line. The problem is that the trends will vary from the straight line by creating deviations from reality (Saunders et al., 2009, p. 465).

3.2 QUALITATIVE DATA

The purpose of collecting the qualitative data is to illuminate the topic from different perspectives, by finding how key actors identifies the main challenges in the industry. Qualitative primary data is collected from three interviews of actors and experts in the industry of renewable energy in Norway. The interviewees were chosen based on their background and profession. Two of the interviewees had a public debate on the development of wind power plants in Norway; Andreas Aasheim, a special advisor at Norwea, and Øivind Anti Nilsen, a professor at NHH Norwegian School of Economics. Aasheim is an advocate for wind power, and Nilsen is an advocate for environmental and social economics. The third interviewee is a professor within social economics at UiS Business School, Gorm Kipperberg. He is an independent third party with high competence in social and environmental economics. The statements of the interviews are analysed and compressed into a summary in empirical analysis.

The interviews were conducted via Microsoft Office Teams with an audio-recorder and video functionality with their permissions and subsequently transcribed into a written text. The initial approach, face-to-face interviews were requested, but were cancelled due to the social restrictions from the COVID-19 pandemic. Saunders et al. (2009) argue that telephone interviews are beneficial due to lower costs and more efficient data collection. Accordingly, telephone interviews may facilitate reaching individuals who would be more difficult to meet face-to-face because of the distances, costs, and time required to conduct the interview. However, Saunders et al. (2009) claims that one of the challenges of telephone interviews is the missing trust between the parties, which one usually establish when meeting face-to-face. When meeting face-to-face, one can read the body language of the interviewee and analyse their confidence when answering. These issues have somewhat reduced as we still could see each other over web-camera. Moreover, Saunders et al. (2009) mentions is the pace of the interview, and points to the problematic matter of interviewing while taking notes. With the permission of the interviewees, the interviews were audio-recorded, which eliminated that issue.

In addition to the qualitative data collected from the interviews, several research papers on renewable energy were analysed. Moreover, relevant literature is applied to find how the Norwegian government has maintained the growth of renewable energy regarding the laws and regulations. Also, information on governmental regulations have been collected from Vindportalen and Regjeringen.

3.3 LIMITATIONS AND CONSTRAINTS

The current literature base lacks conducted research on wave power in Europe, which is a limitation of this study. Thus, the reliability and validity of the analysis on wave power is reduced as it is not possible to confirm the results with earlier conducted research. To expand the literature base on renewable energy, research on wave power in Europe is suggested for future research.

Data prior to year 2000 is not relevant for the research topic, as the goal of the paper is to identify key factors that can affect future investments of renewable energy. Thus, the period for collection of quantitative data is mainly limited from year 2000 to 2020. Furthermore, the 2040 forecast of LCOE have also been included with the aim to gain a perspective of how the costs of the technologies will develop. However, forecasts are difficult as the future can hold cannot be entirely certain as the future uncertain.

3.4 RELIABILITY AND VALIDITY

Since the thesis employs a multi-method explorative approach based on qualitative and quantitative data collection, the validity and reliability are considered strengthened (Jick, 1979). The collected qualitative data received is considered reliable, as it is first-hand information from experts on the field. The interviews were prepared with questions aiming to receive unbiased answers from the interviewees. However, Aasheim works in an advocacy group for wind power municipalities and producers, which may has affected his opinion. Also, Kipperberg and Nilsen may be influenced by their conducted research, as they are professors in social and environmental economics. Thus, a certain degree of biased opinions may have occurred.

The quantitative data is mainly collected from SSB, IRENA and NVE, which are sources with high credibility. The data presented is believed to be valid since all sources used are governmental owned or controlled, meaning the organizations should be politically neutral and unbiased. Additional information has been retrieved from Vindportalen which is funded by two trade association (NORWEA and Energi Norge) and the purpose of the website is to inform the public about wind power. This could lead to biasedness in published articles, reducing the validity of the information. But as stated, Vindportalen aims to inform stakeholders about current situations within the industry of wind power. Regjeringen is the Norwegian government's website. The government's main task it to ensure the safe and democratic governance of the country. Current tax plans and regulations might not be politically neutral as there is always a party in charge, but it is believed that the Norwegian parliament concludes with reliable information. Moreover, informative websites and research papers have been analysed to collect information.

Since the COVID-19 pandemic spread during the research, it is important to consider whether this will influence the data collected. This research mainly consists on investment costs, and production costs on renewable energy power plants, and it is highly unlikely that these would change outside of normal inflation. Since the estimated time to build a wind power plant is found to be approximately two years in Norway, the development period should be considered. There is a possibility that the development period will increase due to the pandemic, which may impact the reliability of the study and the results retrieved from the research.

4 EMPIRICAL ANALYSIS

The empirical analysis is divided into three sections. First, a global analysis is viewed upon, going through the development of renewable energy and a closer look to why the development has been at it is. Secondly, the development of Norway is analysed, also, relevant tax systems are included. Thirdly, a summary of the interviews is incorporated.

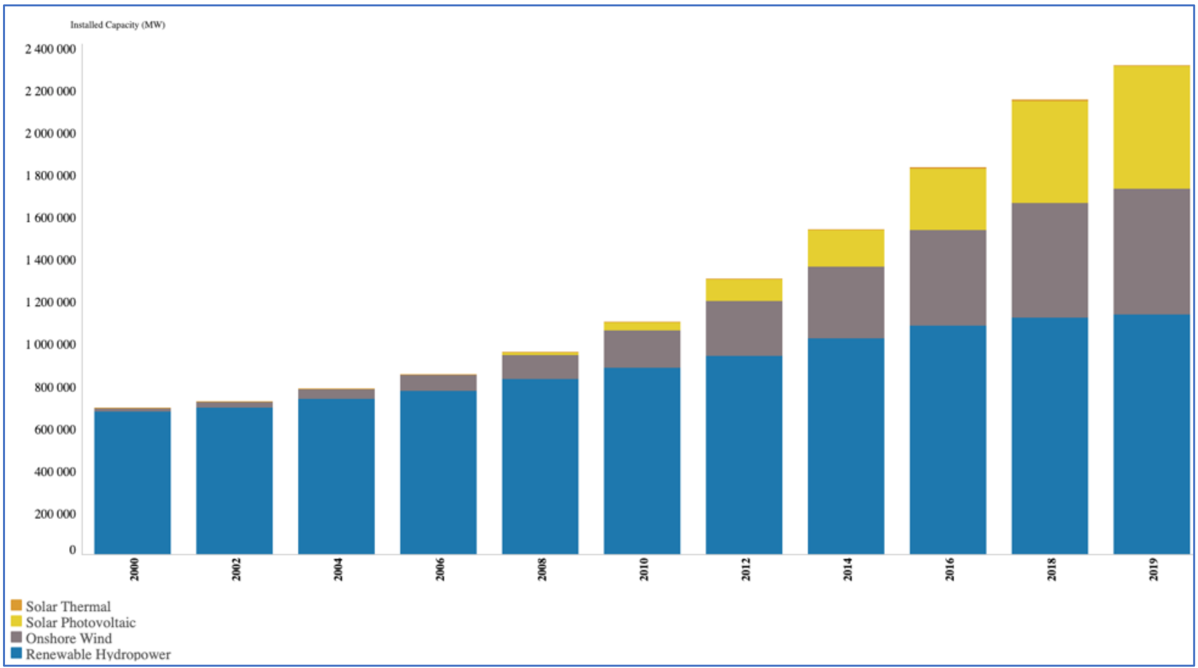
4.1 GLOBAL RENEWABLE ENERGY

Statistics from IRENA show that in the year 2000, the most dominating source of renewable energy worldwide was renewable hydropower. Table 1 shows the global trends that have happened in renewable energy sources between the period from the year 2000 to the year 2019. The total installed capacity was 753 411,37 MW. The installed capacity of hydropower was at 675 056,59 MW, which amounted to 89,6% of the total installed capacity. In comparison, onshore wind power had an installed capacity share of 2,2% and 16 859,90 MW the same year. Solar power had 0,1% and 808,47 MW (IRENA, n.d.-b).

The total installed capacity in 2019 was 2 534 125,97 MW. The installed capacity of hydropower decreased to a share of 44,7% but increased to 1 132 754,31 MW. Onshore wind power increased to a share of 23,4 % and had an installed capacity of 594 396,20 MW. Solar power has had tremendous growth, increasing to a share of 22,9% and an installed capacity of 580 159,00 MW (IRENA, n.d.-b).

Kahan (2019) expect that by 2050, energy usage will increase by 50%. Most of this will be in non-OECD countries, especially in Asia where the economy is expected to grow strongly. They anticipate that the industrial sector will increase with more than 30% in energy usage, transportation sector will increase by 40% and buildings sector such as residential and commercial structures will increase by 65%. They reason this vast growth of energy by increasing income, urbanization and access to electricity (Kahan, 2019). Additionally, the market power prices could be affected. Pettinger (2017) states that the price elasticity of energy is known to be inelastic in the short run, as it is difficult to find an alternative for the consumer. With the new technologies of solar energy, the consumer might invest in solar panels if the market prices for energy increases for a longer time. Thus, in the long run, it might come off as elastic (Pettinger, 2017).

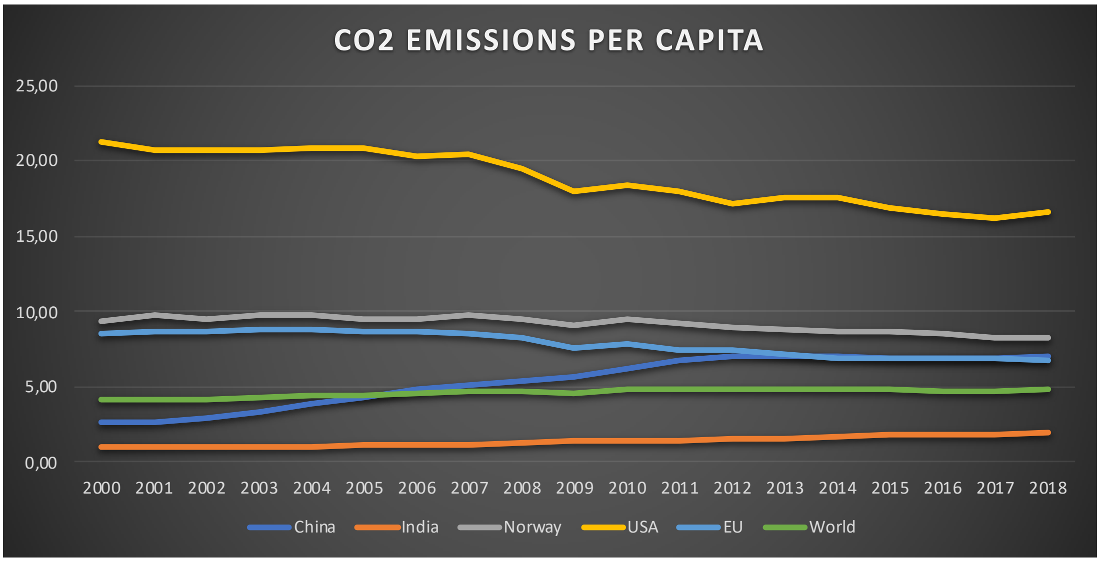
Table 1: Global - Trends in Renewable Energy (Workbook: IRENA RE Time Series, n.d.)



4.1.1 CO_2 per capita

Table 2 shows the development of CO_2 emissions per capita worldwide from year 2000-2018. At a global level, the CO_2 emissions per capita have had a slight increase along with India and China. Emissions in USA have decreased more, alongside small decreases in Norway and Europe (Øvrebø, 2020).

Table 2: CO_2 Emissions per capita (Øvrebø, 2020)



4.1.2 Development

This subsection will go through the three renewable energy sources mentioned in chapter 4.1.1, in addition to nuclear power.

As seen in table 1, hydropower remains the leading technology of renewable energy. The biggest contributors to new installed capacity in 2019 was China, Brazil and United States ("Hydropower Status Report," 2020). The report also states that hydropower has had an average growth of 2,1% from 2015-2019, while in 2019 the growth was 1,2%, which was excused by project delays in China (International Hydropower Association, 2020).

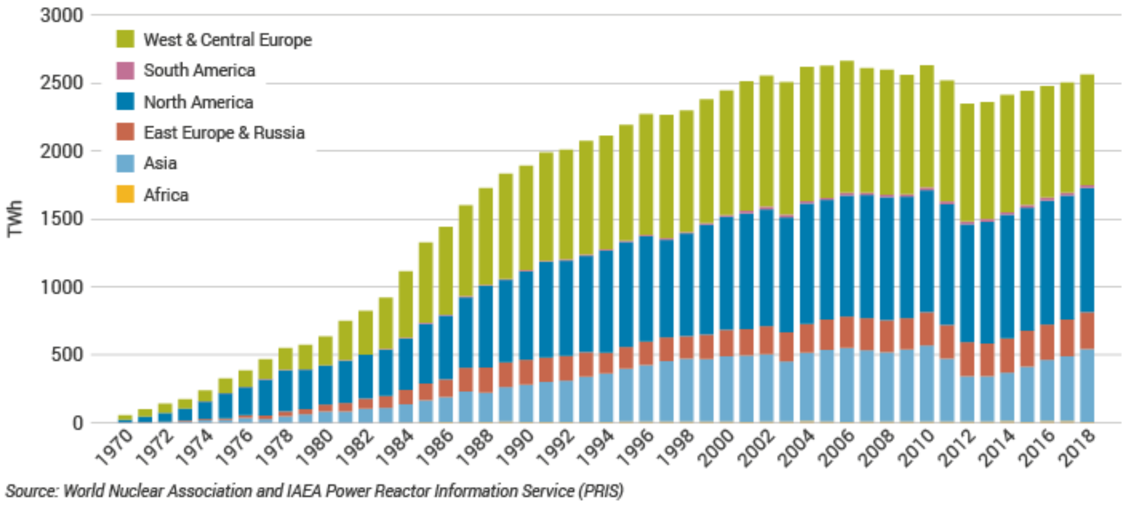
Onshore wind power has had a large growth since 2008, as shown in table 1. According to Lee & Zhao (2020), in 2019 a total of 54.2 GW of onshore wind power capacity was added. Also, in the market of wind power China is the leading nation, with a total installed capacity of 230 GW. In 2018, China went through a policy change to continue the path to "subsidy-free" onshore wind power. Studies by GWEC shows that of the new installations in 2019, 35% derived from market-based mechanisms. In China, as well as other countries, several auction systems have been implemented by the governments (Lee & Zhao, 2020, p. 37).

These auction systems exist for offshore wind power as well, which includes both bottom-fixed and floating wind turbines. According to Ueland et al. (2019), some of the countries in the EU that have auctions for offshore wind power is Germany, Netherland, UK and Denmark. The auctions imply that actors can bid on the degree of subsidies they require to develop an offshore wind power plant. This arrangement results in less risk in the development phase of an offshore wind power plant. In Germany and Netherland actors have submitted a "null bid" where they do not require any subsidies, except for assessment of the area and grid connection. Ueland et al. (2019) states that such zero bids are a clear evidence that developers expect that the projects will be sustainable with sole revenues from the power market. Ueland et al. (2019) claims that such zero bids are a clear evidence that developers expect that the projects will be sustainable with sole revenues from the power market. This is a clear indication that actors expect cost reductions through innovation for offshore wind power the next few years.

As seen in table 1, and confirmed by Veie et al. (2019), during the last five years solar power has been the technology with the quickest growth worldwide, which has caused a great reduction in costs. Most of the new installed capacity has been for facilities with larger rooftops because of the economies of scale that arises. The largest share of new solar power investments has been outside of Europe (Veie et al., 2019). Teknologirådet (2017) explains additional key drivers for growth in solar power as: reduced battery prices which make it cheaper to store, smart grids which increases the coordination possibility of stored and consumed energy, and digital platforms which simplifies the task for prosumers to sell produced energy (Teknologirådet, 2017).

The World Nuclear Association (2020) explains that nuclear power has high investment costs and a long development period. It is not considered as a renewable energy technology as it uses minerals during its production that produces nuclear waste but is CO_2 emission free. The nuclear waste is generated during the production process by fissioning uranium in the reactors. According to World Nuclear Association and IAEA Power Reactor Information Service (PRIS), nuclear electricity production had its initial growth between 1970 and 2000. During 2000 and 2018 the growth rate has been minimal, and even negative during a few years, as seen in table 3 (World Nuclear Association, 2020). The last couple of years thorium has been a topic of discussion to whether it can replace uranium as input in the production. Thorium is known for having a lower level for waste, compared to uranium, and brings higher safety margins (World Nuclear Association, 2017).

*Table 3: Nuclear electricity production (*Nuclear Power in the World Today*, 2020)*



4.2 NORWAY RENEWABLE ENERGY

4.2.1 Installed capacity year 2000-2020

Statistics from IRENA showed that in year 2000, the total installed capacity in Norway was 28 204,43 MW. The installed capacity of hydropower was at 26 766,00 MW, which amounted to a share of 94,9% of the total installed capacity. Onshore wind power was at 13,00 MW, representing a share of 0,00049%. Solar power was only at 6,00 MW and had a share of 0,0002% of the total installed capacity (IRENA, n.d.-b).

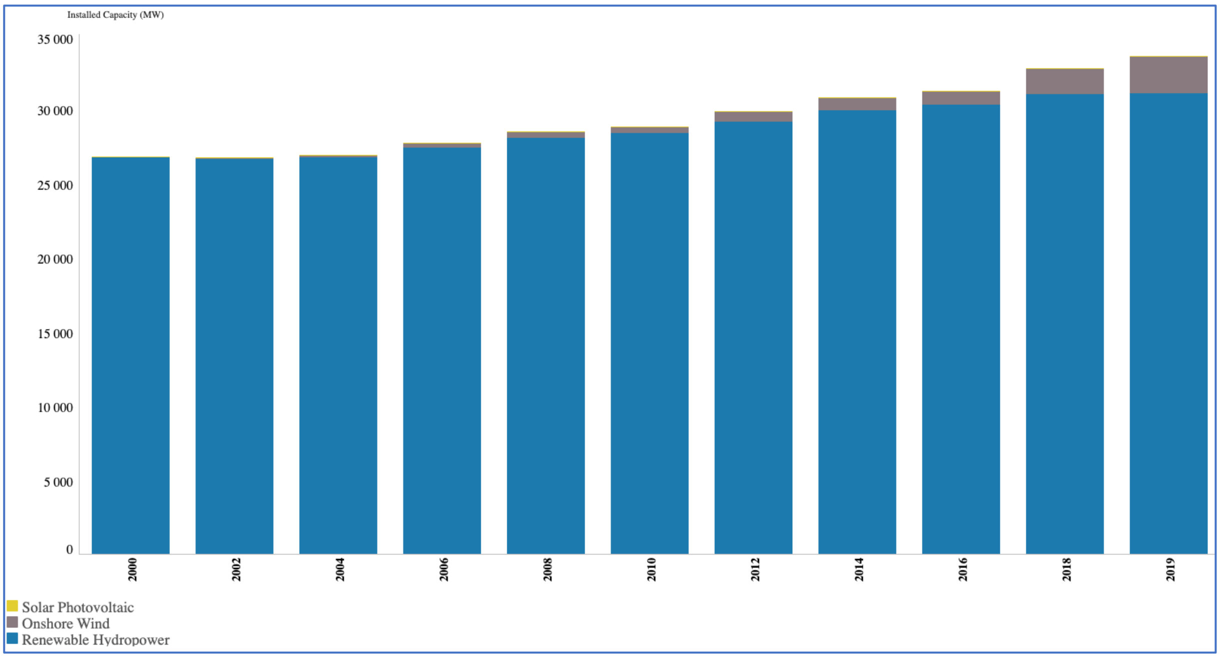
Now, statistics from NVE shows that there are 1 655 installed hydropower plants located all over Norway (NVE, 2020-d). IRENA states that hydropower is still the dominating source of renewable energy with an installed capacity of 32 684 MW, which is a share of 91,3% of the total installed capacity(IRENA, n.d.-b). Within the hydropower industry one must separate between large-scale and small-scale power plants, respectively larger than 10 MW and less than

10 MW of installed capacity. The expected full-load hours for both large-scale and small-scale hydropower plants are 3 300, according to NVE (NVE, 2020-b).

Statistics from NVE show that in 2020 there are 42 installed wind power plants in Norway which accumulates to an installed capacity of 2 582 MW. The total wind power is roughly 7,2% of the total installed capacity in Norway (NVE, 2020-d). The expected full-load hours for wind power are 3 701, while solar power has 900 (NVE, 2020-b). According to IRENA, in 2019 solar power had an installed capacity of 90,40 MW, amounting to a share of 0,3% of total installed capacity (IRENA, n.d.-b).

Table 4 shows the total development of renewable energy from 2000-2019. From the table, hydropower is clearly the dominating source, while wind power started its growth in 2006, having a solid growth the following years. In table 4, it is difficult to spot solar power as it still is immature in the context of the renewable energy industry in Norway. In table 8 the development of solar power is represented.

Table 4: Norway - Trends in Renewable Energy (Workbook: IRENA RE Time Series, n.d.)



4.2.2 Import/export of electricity

The following data is retrieved from SSB and represents the collected import and export of electricity in Norway from 2010-2019 (SSB, 2020.-a) As shown in table 5, Norway has a tradition of having a trade surplus of energy, except from two exceptional years. Table 5 shows that in 2010 there was a large trade deficit, and a smaller deficit in 2019. The power trading between Norway and foreign countries contributes to a better return on the power exported, and lower prices for the power imported, which brings more balances in prices for businesses and households (Sidelnikova et al., 2015, p. 45).

Table 5: Trade surplus (SSB, n.d., -a)

4.2.3 Levelized cost of electricity

The following data is collected from NVE (2019). The LCOE are divided into LCOE of investments and LCOE of operation and maintenance. As shown in table 6, the LCOE of the different technologies is dominated by high investment costs.

Table 6: Levelized cost of energy (NVE, 2020 -b)

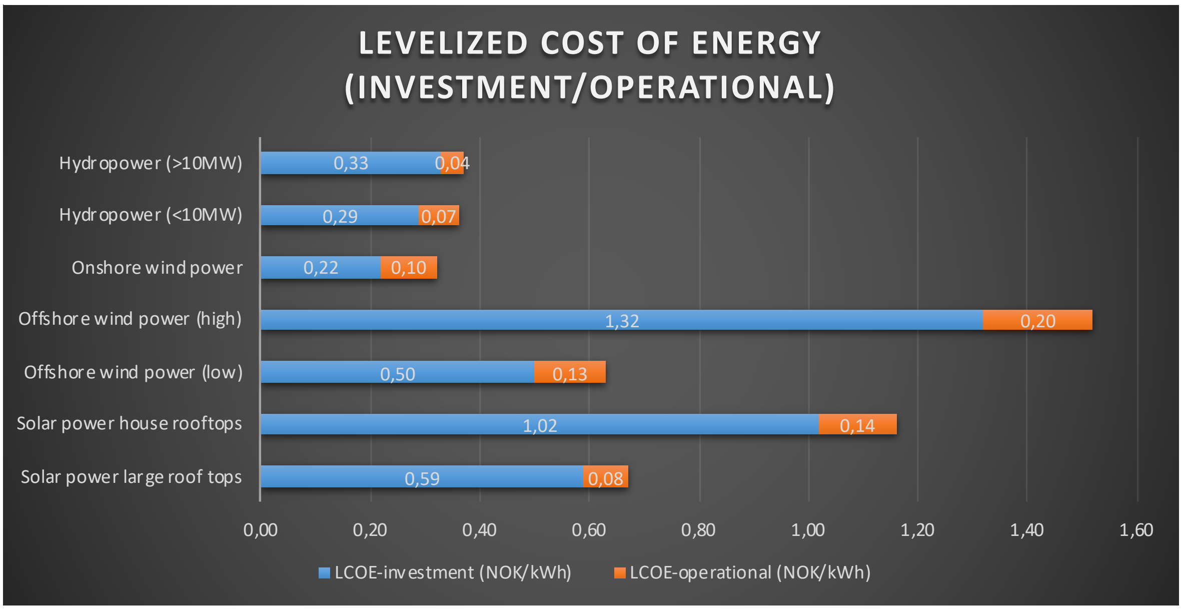
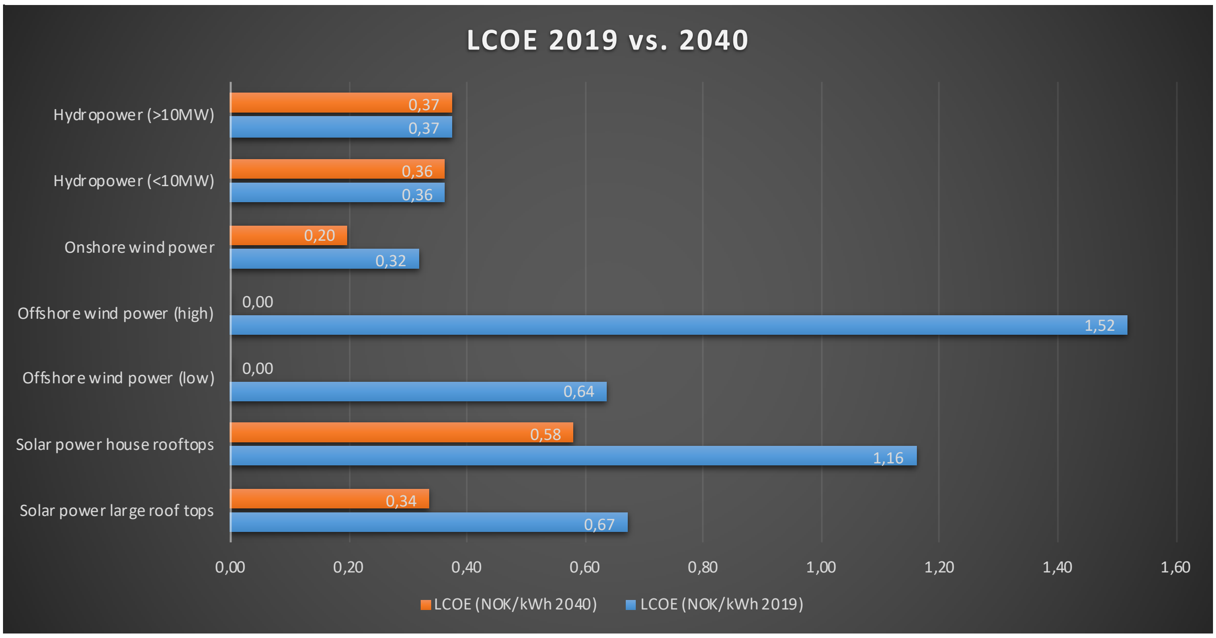


Table 7 shows NVE's expected LCOE of the different technologies in 2040. There was no available data on the future LCOE of offshore wind power.

Table 7: LCOE 2019 vs. 2040 (NVE, 2020 -b)



4.2.3.1 Wind power

The LCOE of wind power is divided into three technologies: onshore wind power, offshore wind power high and offshore wind power low. The technologies will be explained continuously.

The LCOE of onshore wind power is measured to 0,32 NOK/kWh. Table 6 shows that onshore wind power holds the lowest LCOE of all included technologies. LCOE of investments are 0,22 NOK/kWh. The investment costs are mainly related to the wind turbine itself, and as Vindportalen claims that it can amount to 65-75% of the total investment costs, which usually is 9-11 million NOK per MW of installed capacity. Additionally, infrastructure costs such as accessibility to the grid and road constructions to the park are critical investment costs (Vindportalen, n.d.-d).

Operational costs of wind power are mostly related to operation and maintenance, and amount to 0,10 NOK/kWh in LCOE, as seen in table 6. According to Vindportalen, usually the wind power producer will enter an operational contract with the wind power supplier to run the operations for at least two years, but normally last for five to fifteen years. When the contract expires the producer may choose to extend the contract or choose a different method to run the operation. However, large scale developers may have own organizations to run the operations and maintenance. The cost of maintenance is expected to increase as the wind turbines ages. Additionally, a cost that will vary from one location to another is the accessibility to the local power line. (Vindportalen, n.d.-d). In 2040, NVE expects that the LCOE of wind power will decrease to 0,20 NOK/kWh as shown in table 7.

NVE has divided offshore wind power’s LCOE into two categories, offshore wind power high and offshore wind power low. Through an email exchange with a representative at NVE, they explained the difference between the two as it was not mentioned at their page. The two represents the same “project”, but with a high level and low level of estimates of LCOE. The representative states that NVE expects the real LCOE of offshore wind power to be in between the two in the future (NOV, 2020-b). Table 6 shows that offshore wind power low has an LCOE measured to 0,63 NOK/kWh, while offshore wind power high is at 1,52 NOK/kWh. At the moment, offshore wind power is not profitable nor sustainable with the current technology. Østenby (2019) mentions that because of the difficult terrain on the Norwegian coastline offshore wind power is more expensive in Norway, compared to other European countries. Deep seas and complicated seabed conditions makes it less accessible to install bottom-fixed wind turbines. Hence, there are only a few places one potentially can build bottom-fixed wind turbines. The government have suggested two locations for building of offshore wind power: Sandskallen-Sørøya north and Utsira north. Sandskallen-Sørøya is accessible for both floating and bottom-fixed wind power installations, while Utsira is only accessible for floating wind power.

Østenby (2019) states that because of the deep sea, there is more potential in floating wind power for the Norwegian coastline. Floating wind power has less environmental impact compared to bottom-fixed. Additionally, the technology of floating wind power allows it to be more flexible than bottom-fixed, as it can be used at both deep and shallow seas and can also be transported to other locations. Nonetheless, as the technology of floating wind power still is immature it is more expensive than bottom-fixed wind technology. The technology of bottom-fixed wind power is more developed and continues to improve (Østenby, 2019). Veie et al. (2019) claims that there is an uncertainty in the future costs of offshore wind power, but as Østenby (2019) states, bottom-fixed technology is expected to decrease in costs due to more investments. Østenby (2019) mentions n example where bottom-fixed wind turbines a few years ago had an installed capacity of 4 MW, in 2018 they were 6,8 MW and nowadays wind turbines with 12 MW are being tested, while in 2025 they are expected to have 13-15 MW. Additionally, with an increased number of wind turbines being built the cost per kWh will be reduced because more turbines share the same costs, such as infrastructure, transportation, and investment costs. Danish offshore wind turbines are expected to have 4200 full-load hours (Ueland et al., 2019). NVE expects that offshore wind turbines will have between 4163 to 4356 full-load hours (NVE, 2020-b).

4.2.3.2 Hydropower

As shown in table 6, the LCOE of hydropower is 0,37 NOK/kWh for large-scale power plants, and 0,36 NOK/kWh for small-scale powerplants. However, LCOE of operational costs are lower in large-scale power plants (0,04), than for small-scale (0,07). The costs are mainly represented by high investment costs and low operational- and maintenance costs, as seen in table 5. Sidelnikova et al. (2015) claims that the costs of investment can vary in a large degree, not only because there are different types of power plants, but also because of differences in nature. Like onshore wind power, costs of road construction, transportation, and accessibility to grid varies from one location to another for investment costs of hydropower plants. They also state that the costs of operations vary with the age of the power plant, size and complexity (Sidelnikova et al., 2015). NVE expects that the LCOE of hydropower will have no change towards 2040, as shown in table 7.

4.2.3.3 Solar power

The LCOE of solar power is divided into two categories: solar power installed on large rooftops and smaller rooftops. Table 6 shows that solar power installed to large rooftops have the lowest LCOE of 0,67 NOK/kWh, while smaller rooftops have 1,16 NOK/kWh. Veie et al. (2019) claims that most of the growth has transpired over the last five years, as seen in table 8. Instalments of solar power to larger rooftops represents most of the new installed capacity, because of economies of scale. The growth in Norway came as a result of the global growth of solar power which has reduced the costs significantly (Veie et al., 2019).

Table 8: Solar power - Trends in Renewable Energy (Source (Workbook: IRENA RE Time Series, n.d.)

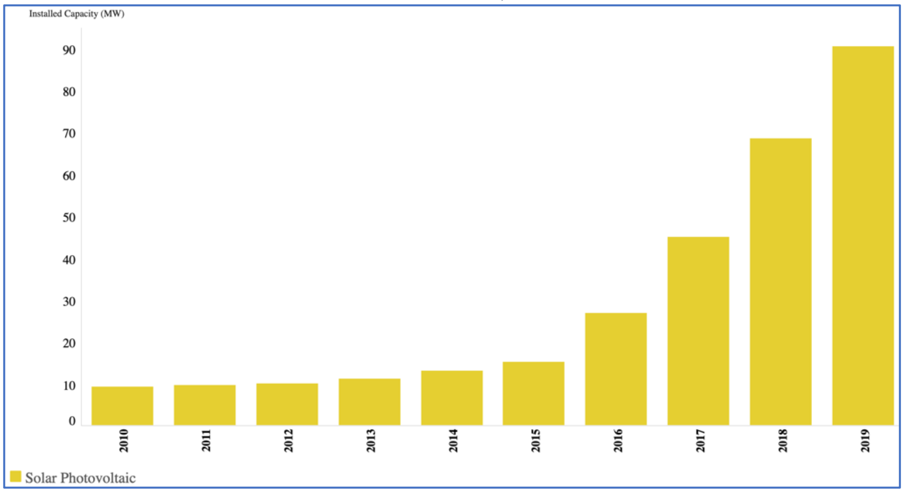


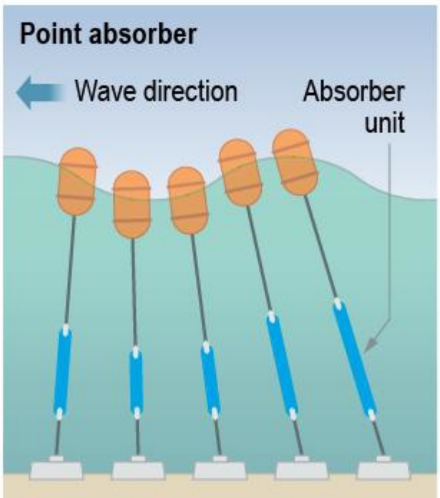
Table 7 shows that the LCOE is expected to decrease to 0,34 NOK/kWh for larger rooftops installations, and 0,58 NOK/kWh for house rooftops. Veie et al. (2019) states that Norway could experience a continuous growth in solar power towards 2040. For each self-produced kWh of solar power, the consumer will save the money one usually pays for grid tariffs and spot price. Which is what Veie et al. (2019) identifies as a clear competitive advantage that solar power has upon hydropower and wind power. Additionally, the construction industry, architects and designers in the future will be able to integrate solar power into their work. However, economical regulations and limitations to the grid will affect the investments of solar power towards 2040 (Veie et al., 2019).

4.2.3.4 Wave power

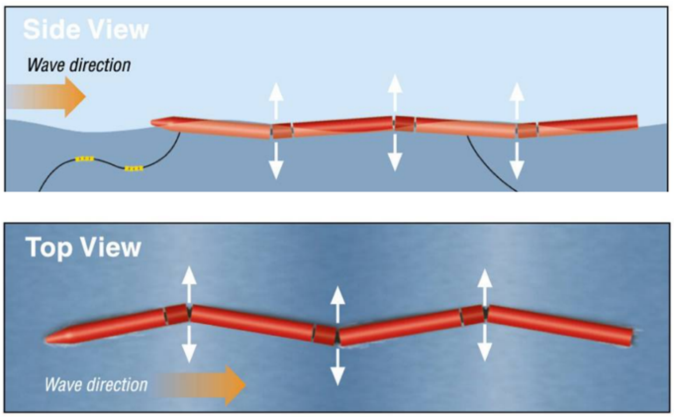
There are several options and possibilities for development of renewable energy sources at sea, in which wave power is a prominent option. Still at an early stage of the development, multiple actors have recognised the opportunities of wave power. Mjønerud (2019) explains that there are various advantages and disadvantages of wave power. Wave power has a tremendous potential due to the size of the ocean and the power of the movements, such as waves, tides and marine currents. Additionally, it is easy to predict the wave patterns for in the next couple of days. In comparison to solar power, wave power can provide a more solid power production. The power generation trough wave power is highest in the winter, which is when demand for energy is at its greatest. The challenges of wave power mainly concern the uncertainty of the early stage of development. Accordingly, it is challenging to receive financial support to develop the required technology at the early stage. The material is expensive as it would have to withstand powerful waves and saltwater. Moreover, since it is difficult to form the environment of the sea in a laboratory, the technology must be tested in the ocean, which may present challenges. On the other side, it is still uncertain to what extent the noise of the turbines affect living organisms in the ocean (Mjønerud, 2019).

As mentioned, there are several ways to generate energy from the movement in the ocean. Three of the most promising models are presented in the next sections. A publication by the European Commission states that wave energy has the potential to produce 3000-4500 full-load hours (SETIS, n.d.), despite that the technology is in an early phase of development.

*Picture 2: Point absorber (*Open Energy Information*, n.d.)*



Picture 1: Attenuator (Pizer, n.d., p. 2)

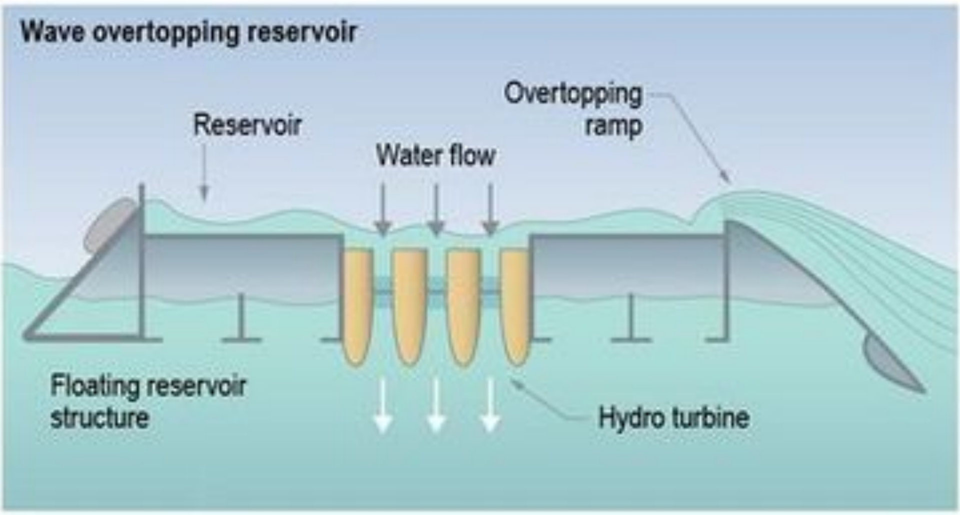


The first technology is the *point absorber* (picture 1). It works like a floating or buoy system that exploit the rise and fall of the ocean. The point absorber is anchored to the seabed and there is a turbine attached in between them. The hydraulic pumps will move along with the waves by generating energy in the turbine (Mjønerud, 2019).

The second technology is the *attenuator* (picture 2). The technology floats on top of the ocean and relies on the movement of the ocean. When a wave hits a segment of the attenuator it moves with the wave which makes pistons in each segment drive fluid into a motor that runs the generator, creating energy. There are two cables connected to the attenuator, to make sure the device does not disappear (Mjønerud, 2019).

The third technology is the *overtopping device* (picture 3). It relies on water that runs on top of the device, falling into a reservoir connected to a turbine. Since the reservoir is placed above the sea level, the water will run into a turbine that creates energy similar to regular hydropower turbines. When the water has ran through the turbine it will "fall" back into the ocean (Mjønerud, 2019).

Picture 3: Overtopping device (McGrath, n.d. (Source: Wave dragon)



4.2.3.5 Nuclear power

Currently, nuclear power does not exist in Norway. However, there may be a potential for development, which is why nuclear power is included in the analysis. Statistics from NVE shows that the costs of nuclear energy are primarily driven by the investment costs, comparatively to renewable energy costs. Nuclear power has an LCOE investment cost of 0,42 NOK per kWh. NVE (2020) states that the operational- and maintenance cost is at 0,13 NOK per kWh. Additionally, there is a 0.07 NOK/kWh in fuel fees. NVE (2020-b) does not expect any change in costs by 2040. Nuclear power has 7 800 full-load hours (NOV, 2020-b).

4.3 EXTERNALITIES

Vindportalen argues that it is difficult to estimate exactly how much labour that derives from building one wind power plant. However, they do mention a rule of thumb; one local full-time equivalent (FTE) per 15 MW installed capacity. Vindportalen expects that in the wind power projects at Fosen, installed capacity of 1000 MW, could generate 40 to 50 jobs, and approximately 600 jobs during construction (Vindportalen, n.d.-e). In an article from NRK Nordland, Professor Knut Holtan Sørensen reflected on why he expects that the locals within municipalities react differently on the development of wind power parks on their lands. For example, the wind power park built in Sortland by the Finnish energy company Fortum, the development did not face any significant amount of resistance from the inhabitants, in comparison to Frøya, where industrial machines were vandalized. According to Sørensen, the different reactions can be explained by the generated benefits in the municipalities. Sortland may benefit of increased jobs and might experience an increase in the municipality's revenue, while the situation may be divergent/different in other municipalities (Kristoffersen & Lambertsen, 2019).

4.3.1 Annual mortality rate for birds

One of the main quarrels always brought up with the implementation of wind power is how it affects avian life. For the death rate of birds an article by Faktisk.no has gathered information about the registered deaths of birds killed in Smøla. Between 2006 and April 2019 a total of 96 dead eagles have been found. Researchers have registered over five hundred dead birds by this wind power plant, which supports the Norwegian Environment Agency's recommendation to not build in this area (Skiphamn, 2019). The reasoning behind the resistance is because this is affecting endangered species. Vindportalen estimates that an average wind turbine will kill two to seven birds per year (Vindportalen, n.d.-f). Based on statistics from USA in 2009, Faktisk.no analysed how many birds were killed by the different energy sources (Molnes, 2019). The research conducted is a calculation on how many birds are killed per GWh by Wind-, fossil- and Nuclear- power. According to the analysis on number of bird deaths, wind power turbines kill 0.27 birds per GWh, nuclear power kills 0,42 per GWh, and fossil power kill 5,18 per GWh. To put this information into perspective, coal kills over ten times the amount as nuclear power and almost twenty times more than wind power (Molnes, 2019). The U.S. Fish & Wildlife Service states that the main culprit of bird deaths annually is cats as they killed around 2.4 billion birds. Building glass was a close second with roughly 599 million bird deaths. On the other hand, wind turbines killed an estimate of 234,012 birds in comparison with the others (U.S. Fish & Wildlife Service, 2018).

Norwegian Institute for Nature Research (NINA) have researched how to reduce the mortality rate for birds over the past ten years. According to May and Stokke, painting one of three rotors and the bottom part of the wind turbine black reduces the amount of collisions of birds (May & Stokke, 2019).

4.3.2 Environmental stewardship

Since renewable energy sources can cause environmental damages, Regjeringen states that it is important to balance the development of renewable energy power plants with environmental considerations. The development is regulated by a consequence evaluation program that is included in the process of concessions, as shown in figure 9. According to Regjeringen (2019-b), several potential consequences that could disrupt businesses and habitats. For instance, hydropower plants can affect fishing and outdoor activities, which then could affect tourism in the current area. A common measure to secure environmental values is to set a minimum limit for continuous water flow in the rivers. Moreover, hydropower can affect cultural heritages and landscape. As explained in section 4.3.1, birds are vulnerable for collisions with wind turbines, which Regjeringen claims to consider and aim to avoid. Wind power plants can affect landscape, outdoor activities, noises, reindeer breeding and biodiversity, which Regjeringen aims to avoid by controlling the locations and quantity of wind turbines. Additionally, Regjeringen accentuated the importance of planning the development of wind power plants at times where there are less contact with animal life (Regjeringen, 2019-b). However, Vindportalen claims that the environmental impacts that wind power plants cause are to a large degree reversible (Vindportalen, n.d.-b).

Jakobsen et al. (2019) states that visuality and noise is objective measurements, but how they affect people are subjectively related. Wind power plants brings visual exposure and noise for close surroundings, and neighbours of a power plant can be affected by this. Visuality, noise, shadow flickering and obstruction lights for air traffic are effects that eventually can bring a negative impact on both real estate prices and public health. Jakobsen et al. (2019) admits that the studies on how public health is affected by wind power plants are too shallow but states that the life quality of certain individuals *can* be reduced. Shadow flickering and light flashes can trigger some individuals to seizure. However, Jakobsen et al. (2019) referred to a study by Knopper et al. 2014, where they concluded that the frequency of the shadow flickers from wind turbines was slower than what usually triggers seizures, hence, were not a risk for individuals with such conditions. Noise and visual disturbances are factors that are included in the mentioned consequence evaluation program in the concession process. NVE proposes that a regulation concerning a minimum distance between wind power plants and settlements should be introduced, which could provide predictable frameworks for authorities, neighbours and developers. Jakobsen et al. (2019) states that NVE suggests a minimum distance of four times the height of the wind turbine. Information retrieved from Jakobsen et al. (2019) is related to Regjeringen's (2019) information, which explains that citizens are concerned that their outdoor activities such as hiking, will be directly affected by the environmental consequences of the wind power (Jakobsen et al., 2019).

4.4 PUBLIC POLICIES IN RENEWABLE ENERGY

Vindportalen states that in some markets there is a need for governmental control of the activity and the supply. Some examples of these markets are alcohol, telecom, and the production of energy. The government can give businesses the green light to conduct business through a concession – a tool in which the government utilizes to regulate and control that the activity in the country for the publics' best interests. Concessions are not entirely locked down to businesses as the government can also grant individuals, sports organizations, and a county these restrictions (Vindportalen, n.d.-c).

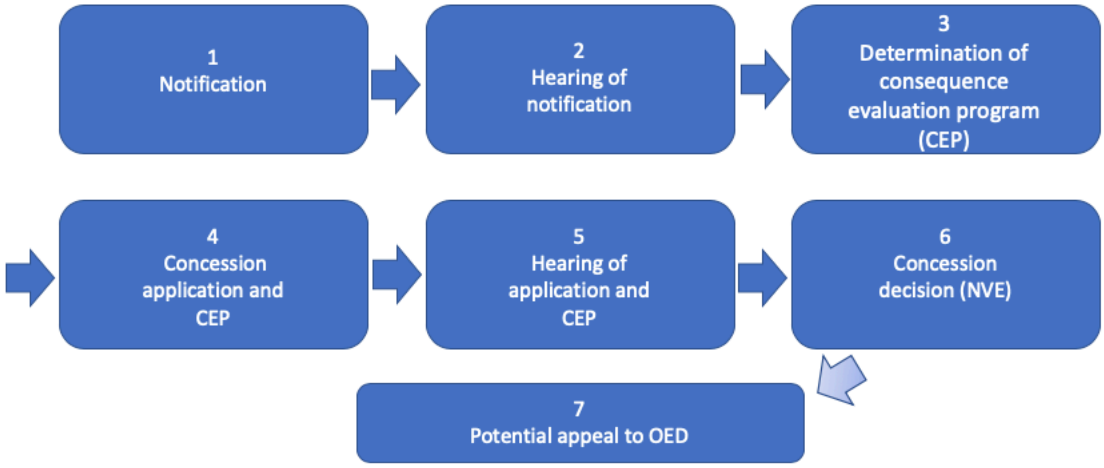
4.4.1 Green certificates

According to NVE (2020), green certificates where introduced in 2012 in a collaboration with Sweden to reach the goal of increasing renewable energy production with 28,4 TWh towards 2020. Green certificates are a subsidy to make investments within renewable energy more profitable. The power plant approved for green certificates will receive one green certificate per produced MWh of renewable energy. The customers cover the costs of the green certificates as it is added to the purchasing power price. This provides extra income for the producer, making them more profitable. The green certificates have a duration of 15 years and will only apply for approved power plants put into operation within the end of 2021. Sweden has however extended the arrangement until 2030 (NVE, 2020-c).

4.4.2 Concessions in Norway

According to the Norwegian Energy Law (Energiloven), a concession is necessary to build or conduct an energy facility that upholds an installed capacity of 1 MW or more. The Planning and Building Act gives municipalities power to grant small-scale power plants with an installed capacity of less than 1 MW (Veileder for Kommunal Behandling Av Mindre Vindkraftanleg, 2015). The concessions are granted by NVE, which can be described as a centralized authority. The duration of one application for concession usually takes several years, depending on the complexity of the application. For wind power, a concession will last for 25 years, which means that the wind power developer has 25 years to install and operate a wind power plant. Figure 9 illustrates the process of a concession application (Vindportalen, n.d.-c).

*Figure 9: Milestones in the concession progress(*Vindportalen*, n.d. -c)*



4.4.3 Taxes on wind power and hydropower

According to NOU (2019), wind power does not have special taxes or license-based income plans such as hydropower. A committee have assessed to which extent different tax conditions could affect the companies' choices of investments in hydropower or wind power projects. The government believes that investments in hydropower, wind power or other industries will not be mutually exclusive, since companies that wish to maximize profits will have an incentive to invest in profitable projects. There might be restrictions on investment capital in a company, such as qualified labour or limited capacity in the power grid. Currently there is a high rate of development in the wind power industry which could lead to postponed hydropower investments, but the government believes such constraints does not necessarily lead to a lower priority for hydropower projects with a high return. Currently, the tax system is divided into three different categories: wind power, hydropower plants under 10 MW of installed capacity, and hydropower plants over 10 MW of installed capacity (NOU 2019: 16, p. 147-148).

Table 9: Tax systems for hydropower and wind power (NOU 2019: 16, n.d., p. 148)

WIND POWER	HYDROPOWER < 10 MW	HYDROPOWER > 10 MW
Corporate tax (linear depreciation over five years)	Corporate tax (depreciation over 40/67 years)	Corporate tax (depreciation over 40/67 years)
Property tax (technical value)	Property tax (tax value)	Property tax (profitability)
		Resource rent tax
		Taxation of natural resources
		Concession agreement (power supply)
		Concession tax

Corporate tax is a tax that companies pay on their profits; the current tax rate is 22% in Norway. The corporate tax has been reduced over the last years to compete with neighbouring Nordic countries, which all have similar tax levels. Another reason Norwegian corporate tax is a little higher than other Nordic countries is a result of stricter depreciation laws (NHO, n.d.). Currently the difference is that Hydropower has a depreciation over 40/67 years while wind power is over five (NOU 2019: 16, p. 148).

Property tax is calculated differently in all three power plants given that the municipality has implemented it. Wind power's tax is based on 2-7 thousandth of the industrial tariffs of the wind farm. The rule of thumb for wind farms is 70-100% of total investments costs as an industrial rate (Vindportalen, n.d.-d).

Property tax on hydropower is based on the assets' value, which corresponds to the market value. For hydropower <10 MW the property tax is calculated based on the tax-depreciated value of the investments. Lastly, hydropower >10 MW property tax is calculated as a present value over an indefinite period of estimated future income with an exception of operation costs, resource rent tax, and template estimated replacement costs (Energifakta Norge, 2019).

A resource rent tax is designed for hydropower plants profits, as its production is a limited resource. This tax is only on Hydropower plants that have generators greater than 10 MW. The resource rent tax is meant to give back to the community through extraordinary surplus, and the tax rate is 37% (Energifakta Norge, 2019).

Taxation of natural resources in Norway is designed as a production fee of 0,013 NOK/kWh. This tax is divided by 0,011 NOK/kWh to the municipalities and 0,002 NOK/kWh to the county (Energifakta Norge, 2019).

Concession agreement (power supply) is a contract that requires hydropower >10 MW to supply the municipalities affected by the development with up to 10 percent of generated power. The purpose of the concession agreement is to secure the development of municipalities power supply at a reasonable price. Municipalities and power developers have the liberty to agree on the price of the concession agreement. If there is not an agreement between the parties, the price should be based on full cost. This price is calculated based on the average cost of a representative selection of power plants. This price is called the OED price, and it was set in 2018 at a value of 0,112 NOK/kWh (Energifakta Norge, 2019).

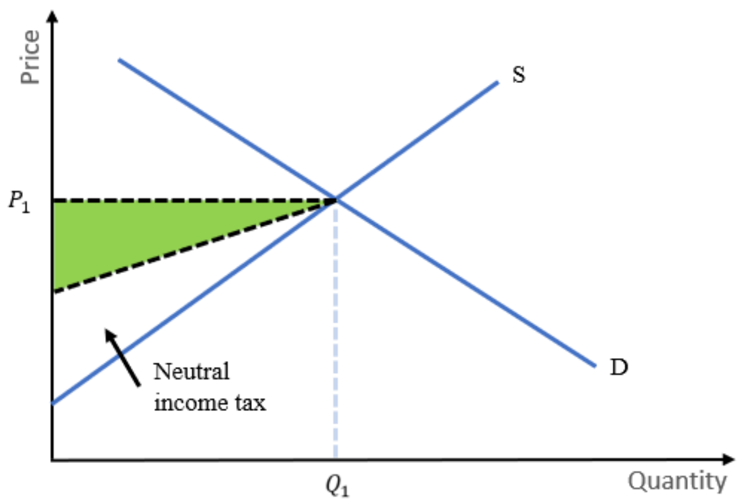
Concession tax is mandatory for hydropower >10 MW as it pays the state and municipalities affected by the development. The tax rate is based on a theoretical calculation of how much the power plant can produce, not the actual production, and is measured natural horsepower (NHP). For newer concessions, municipalities receive 24 NOK/NHP, while the government receive 8 NOK/NHP. For older concessions however, the tax rates varies to a larger degree (Energifakta Norge, 2019).

4.4.3.1 Shift in the supply by taxation (profit-based taxes versus gross taxes)

According to NOU (2019) the government designs taxes and fees that can be dependent or independent on the profitability of the business. This can create a significant impact on future incentives within investments. That is why the optimal tax design as seen in table 10, will affect producer surplus, and not cause a deadweight loss in the market. Further, additional information about tax designs will be presented.

NOU (2019) presents different taxes and explains which way they can affect a business. A proportional tax on a company that chooses to maximize the value of the business will not change the company's market position. Operating decisions and investments made by companies will still be profitable after tax through this tax system. The other option would be a gross tax that can capture the revenues, depending on the design of the tax, but it will not depend on the profitability of the business. A value tax is a design of gross tax, as it is affected by quantity and prices, but is independent of profitability and costs. Another example is a quantum tax, which is completely independent of costs, prices, and profitability. Quantum tax implies that companies that have tax on profitable resources might become unprofitable, regardless of the company's profitability. Companies imposed these types of taxes will evaluate operating decisions and investments different compared to companies without the tax. The level of the tax is one of the major factors to the size of socio- economic loss (NOU 2019: 16, p. 87).

Figure 10: Neutral income tax (NOU 2019: 16, n.d., p. 87)



4.5 SUMMARY FROM INTERVIEWS

Three interviews are conducted as a basis for the qualitative analysis. The questions where individualised for each interviewee as they origin from different backgrounds and professions. It is beneficial to categorize the collected qualitative data into sections, since the content of the data is connected, while providing different perspectives. This segment will contain the interviewee's perspectives on the different subjects that were brought up in the interviews.

4.5.1 Regulations

There has been a public discussion of how wind power developers have been taxed less compared to hydropower developers, and whether this is a fair regulation. The interviewees were questioned about the tax-level imposed on wind power producers to reveal their reflections on this. They were also questioned whether they believe it is a fair regulation. Whether this is fair towards hydropower developers, was not an assigned question to the interviewees, however, it was something that all three of them wanted to air their opinions on naturally.

Additionally, wind power has had massive subsidies that spurred the growth of installations in Norway the past ten years, giving it a comparative advantage towards hydropower developers. The initial thought of the question was to bring light to why the subsidies were needed and if wind power plants can be sustainable after they get removed.

Interviewee 1: Andreas Aasheim

- *What kind of taxing would you recommend that wind power developers are imposed?*

Aasheim started by explaining that as for the moment, wind power developers are imposed to property tax and corporate tax. Moreover, Aasheim states that they are prepared to pay a natural resource tax like hydropower development. Norwea has prepared a new tax model for wind power development, but it is still up for discussion.

- *What consequences would an extension of the electricity certificate for have for future investments have in Norway?*

Aasheim does not think it would make a difference since the electricity certificates does not have a value anymore as it is possible to develop wind power plants without support. He claims that the positive with the certificates is it generated a goal on how much the government wanted to develop. He also claims grid owners and NVE must adapt to the increasing production so that the power grids can withstand the higher level of energy transportation. Finally, he states that the world will need a lot of power in the future, and the certificates worked as a guideline since there is no technology that can solve this efficiency in power alone.

Interviewee 2: Øivind Anti Nilsen

- *Do you still insist that a natural resource tax is the optimal solution for wind power developers?*

In the debate between Aasheim and Nilsen, Nilsen mentions that the municipalities where wind power plants are located does not benefit enough from providing their land for these huge power plants. Nilsen explained that a new tax model prepared by the government was introduced as a suggestion in 2019, where tax revenues would fall to central authorities instead of the municipalities. The suggestion met major resistance and therefore, was instantly rejected. The municipalities were hopeful to receive a similar compensation, such as the compensation for hydropower production. He states that if central authorities still want to produce more renewable energy, then a certain amount of wind power plants have to be installed. Nilsen claims, that to manage the development of wind power without high level of conflicts, then a new centralized taxation has to be introduced. Nilsen mentions that for the moment, wind power developers ask authorities within a municipality if they can pay a certain annual amount to develop power plants on their land. Negotiation power creates differences between municipalities as there will be differences on what they will receive as compensation.

Interviewee 3: Gorm Kipperberg

- *How should the wind power plants be taxed?*

Kipperberg begins saying that he is not expert within this subject, but his main issue with the matter is that it should not be uneven compared to others within this segment. He suggests that wind power should be at the same level as hydropower, so that it does not give an unfair incentive to invest in wind power compared to others. He believes that wind power should also be charged with a resource interest rate, as the projects gain access to a public good, which is the Norwegian nature. Kipperberg wants everything with a negative impact on nature to pay a pollution tax, as the sole purpose of this tax is to correct a market failure to eliminate a deadweight loss. He ends by stating that wind power on land has received direct subsidies and green certificates, which he opposes because the projects have not been either business or socioeconomic profitable.

- *When the subsidies disappear from wind power in 2021, the price may increase. What consequences could this bring to the consumer?*

Kipperberg believes that removal of the green certificates could contribute to slowing down the investment rate or the development of wind power. He also believes this will have a positive impact as there will not be as many negative. Wind power is 3-4% of the Norwegian electric portfolio, meaning the price increase would be marginal. Kipperberg ends by mentioning his research on the preferences of the Norwegian population proving that a tax which will reduce the profitability of wind power will have a positive net effect on Norway.

4.5.2 Local consequences

There has been a certain amount of negativity towards wind power and how it affects nature during the last few years. Attempting to figure out if there a reason behind the sudden change in people's opinion on the development of wind power, and what might have affected it. Another important factor is trying to unravel what consequences the implementation of new wind power plants has on municipalities, and at what level does the negatives start to become positive.

Interviewee 3: Gorm Kipperberg

- *From a socioeconomic perspective, can the externalities be worth it in the long run?*

Kipperberg starts by saying he cannot give a general answer to this question. He believes under certain assumptions of technological improvement of the turbines, reducing the unit costs, and in certain price trajectories scenarios, it could be justified in a socioeconomic perspective to have wind power in Norway despite the negative environmental effects. However, to what extent should wind turbines be installed depends on several parameters. Up until now Kipperberg believes wind power on land does not have a socioeconomic benefit, and there have not been any good arguments for granting development of the power plants. As of now wind power might have become profitable in a business perspective, and the green certificates are not necessary anymore, it will still be required to measure the business up towards all the negative effects to perform a socioeconomic analysis. Finally, Kipperberg states that Norway needs a comprehensive plan to strategically choose what projects should be approved, as some geographical locations might have less environmental costs.

4.5.3 Wind power

Wind power plants have had an extreme growth during the last decade in Norway. Finding which challenges wind power producers and developers have met during the process is vital to understand the current situation. Accordingly, it is vital to determine whether wind power cause disadvantages that may outweigh the advantages, and if the process of development is necessary. Further, the questions are asked by the purpose of discovering whether there are other alternatives to wind power that Norway has not explored.

Interviewee 1: Andreas Aasheim

- *Do you believe the development of wind power can take over hydropower, or to what extent?*

Aasheim claims that currently there is being build a lot more wind power compared to hydropower, and that will be the case in the foreseeable future. Moreover, he does not believe wind power will take over hydropower, and that is not the aim.

- *What kind of value creation do you think wind power developers bring to the municipalities?*

Aasheim argues wind power value comes in two phases, development and operation. He states that there is data which supports his claims on what value investments bring. The data shows that approximately every third kroner invested in wind power affects Norwegian actors, including local and regional actors throughout the entire life cycle. He also states that during the operation phase it creates value though business tax, employees, local goods and services, hotel accommodations, and more.

- *What challenges has wind power developers encountered during development?*

Aasheim claims the biggest challenges during the last months has been getting components and necessary personnel to the power plants. However, he believes this is a transient phase, because overall the development has gone relatively well. Some of the challenges includes environmental issues and legal protests by citizens.

- *In other words, there has not been any issues with municipalities or the governments?*

In 2008 the framework changed by removing the double licensing process, and it consisted of the concession and planning. Aasheim asserts that the process was too difficult to coordinate both municipality processes at the same time. Over the last year Aasheim claims that the planning work has suddenly become a small challenge, because not all municipalities agreed upon the change in 2008. He believes if municipalities agree to distribute land, they should uphold their part, because if they do not the government will step in and grant the land.

- *How will municipalities differentiate themselves in order to attract new labour though the wind power plants?*

Aasheim states it depends on the municipality's population and location. Smaller municipalities will have more challenges to get labour, since it requires people to move. He continues to explain that infrastructure will be necessary, to attract a new potential labour force, but also states that this is outside of his expertise.

- *We have spoken with an economist that explained that he believes from a socio and business-economist perspective, that building huge power plants in some places, rather than several small plants is more profitable. What is your perspective on the matter?*

He started by saying that this is something that they feel they have already done, where some power plants have an installed capacity of 400 MW. Aasheim understands the dilemma but claims it will require a significant increase in the network infrastructure to move the power from the power plants, if Norway only decides to build few large-scale power plants. Thus, a spread of power production across Norway, will reduce the strain on the grids Additionally, he believes that to maximize wind power production, it will be necessary to develop wind power plants in locations where wind is strongest. This reduces the risk of not having development in areas with subpar wind conditions. This reduces the risk of not having wind turbines where production would be subpar.

- *What is your perspective on offshore wind power?*

Aasheim begins by stating his support of offshore wind power, and that Norwea is working on both onshore and offshore wind. He believes that onshore wind power will feed the Norwegian power grids in the future. On the other side, offshore wind will be an export of technology, including floating structures, concrete foundations, maritime operations/installations, and export of electrons from fixed foundation facilities.

Interviewee 2: Øivind Anti Nilsen

- *Do you believe wind power has the potential for value creation?*

Clearly it is possible to make money proclaims Nilsen, as there is a high demand for power. He states the issue is the transmission capacity, but if it continues to expand it will create value. Power generation is as good as any other income, if it is profitable. Additionally, when asked if he believes wind power plants will affect tourism, he delves deeper into value creation. Nilsen states the development and operational phase will generate value creation but is sceptical to how much it will affect local actors and municipalities. The reasoning behind this scepticism, is that development might generate jobs within different industries, but the phase has a duration of around one year, and the international suppliers of the turbines are specialists, who will be doing maintenance. Finally, Nilsen states he had investigated research papers about if wind power plants influenced unemployment, and reveals it was significant.

- *What consequences or opportunities do you see if Norway chooses to withdraw from wind power?*

He does not believe there would be any consequences in the short term, because currently Norway produces enough power to self-sustain. Nilsen argues that it will be important to focus on the future as one day the oil companies will reduce, and Norway will require a backup, energy is a prime example. He finished off by stating it is important to play it safe during the shift to renewable energy as Norway would be worse off in international negotiations if we are not willing to do anything.

Interviewee 3: Gorm Kipperberg

- *What advantages and disadvantages do you see with increased investment within wind power in Norway?*

The advantage is that power is a valuable product, and energy is a demanded product. Kipperberg continues with that if wind power development helps increase the overall power generation in Norway, it will increase the degree of self-sufficiency, which is an advantage. He describes this as one of the hidden utility values of a good, it could be compared to an option's value if we need more power. He also states that this is outside of the profitability perspective. He then goes on to distinguish the difference between electricity and energy. Energy consumption in Norway includes all fuel that is used, for example, electricity, gas, fossil fuels etc., meaning that Norway is not self-sufficient and not 100% renewable. While looking at electricity, Norway is a net exporter in an average year, and the portfolio consists of 94% hydropower, and 6% wind power and district heating. Moreover, Kipperberg states that since Norway is partially integrated within the European market, and is self-supplied with renewable electricity, it is important to contribute to the extent that it generates utility, political profitability or a greater optimization perspective. He ends by stating that increase wind power in Norway will stimulate local job markets and will increase the total renewable production capacity in Europe.

Kipperberg researches on the disadvantages of wind power. He starts of by listing the environmental impacts, which include visual effects, habitat disruption and ecosystem fragmentation (described as dividing natural landscapes with industrial developments). These elements could affect endangered animals or plant species, and this is one of the major environmental challenges worldwide. Kipperberg delves deeper into the visual effects by mentioning it could negatively affect other industries, for example tourism. Moreover, research shows that people not only get financial welfare from market goods and services, but also from public goods and services and nature goods and services.

4.5.4 Hydropower

The content of this section is pursuing to uncover what effects the externalities of hydropower plants have on the environment, and whether the government is treating them the same way as the externalities of wind power. Another important question is if hydropower has an opportunity to create value in the future considering the current governmental emphasis is on wind power.

Interviewee 2: Øivind Anti Nilsen

- *What development do you think we will see for hydropower production if more actors start investing in wind power or established actors continue to expand?*

Nilsen states that hydro power facilities constantly get upgraded with new tunnels and turbines. He proclaims that there has been a newly opened hydro power facility in Rogaland, however he does not believe that Norway will put up any new dams because the energy capacity is relatively constant.

Interviewee 3: Gorm Kipperberg

- *What externalities does the development of hydropower plants bring?*
- *We have also heard that it is more profitable to have smaller power plants because of taxation.*

According to Kipperberg, engineers from NTNU have stated that Norway can upgrade the exciting hydropower plants, especially the turbines to increase the production with the same amount of water. The way Kipperberg understands the situation is that there is a possibility for a significant increase in electricity production by upgrading existing hydropower plants with relatively moderate environmental consequences compared to wind power installation. However, Kipperberg states that by building more structures, roads, high voltage pylons or anything that would affect nature, this would result in ecosystem fragmentation, visual effects or habitat disruption

- *What thoughts do you have on the future value of hydropower?*

Kipperberg states that hydropower will provide high value in the future, because large plants produce an incredible amount of energy. He proclaims that it would take thousands of wind turbines just to break a small portion of what hydro power produces. However, Kipperberg is very sceptical about small-scale hydropower, because they are spread around Norway, produce minimal power and leave a wound in nature. In an environmental and socioeconomic perspective, the solution would be to build large scale plants, that damage the nature in chosen locations, compared to multiple small plants where the environmental damage is spread out.

4.5.5 Nuclear power

After the nuclear disaster in Japan, Germany started shutting down nuclear power plants. The purpose of this section is to see if there is a possibility for nuclear power to achieve the same growth as wind power, since it is a carbon free alternative. Further, the questions are assembled to see if there are any major challenges or issues with the process. In addition, the questions aim to collect perspectives on Norway's situation on Thorium, and whether it can be beneficial source of energy in the future.

Interviewee 1: Andreas Aasheim

- *In an interview with EnerWe, you stated that you do not believe that nuclear power will play a major role in Europe and the United States. Why do you have this opinion?*

Aasheim starts by claiming nuclear power will be too expensive but expresses that the costs will not even be necessary in this equation if no one is able to build it. He also claims that not a single nuclear power plant has been put into operation since 2005. Aasheim brings up two nuclear power plants in development, Olkiluoto 3 in Finland and Flamanville in France. Both power plants have been in development for over 10 years. Additionally, he states that Hinkley point C in England has the most expensive power generation in Europe.

Moreover, Aasheim motioned Thorium does not have enough technology and forth generation nuclear power, that no one in Europe believes in. He believes nuclear power will play a major part in Asia, based on Chinese technology. The citizens of Europe would show resistance if it were ever to be developed in their countries. Finally, he states that the power plants in development will be completed, but once they reach their lifespan there will not be built new nuclear power plants.

Interviewee 3: Gorm Kipperberg

- *Do you believe nuclear power could be an opportunity for Norway, considering the amount of Thorium?*

Kipperberg does not understand why nuclear power is not on the global political table as a source for carbon free energy, and he does not even think Thorium is required to answer this question. From a technical, environmental and socioeconomic perspective, it is a mystery. He believes that the world must trust that people in different countries vote in such a way that reflects their political preference. There are socioeconomic professors that believe nuclear power is not profitable and require major investments and assessing whether it is profitable all costs need to be considered. Kipperberg states that he would need to see unit costs of nuclear power production per kWh compared to other sources, also including environmental costs and investment costs into the equation. If the numbers check out, then nuclear power should be considered as a part of the global CO_2 politics and towards a fossil free society.

4.5.6 Tourism

There has been an ongoing debate on whether wind power plants will create or diminish tourism. The reasoning behind these questions is to see if wind power plants can create a new market within the segment or will damage an existing one. Nature is one of Norway's main attractions, thus, it is vital to assess what influences implementations of wind turbines will have on tourism.

Interviewee 1: Andreas Aasheim

- *Do you think an expansion of wind turbines will affect the normal tourism in the municipalities? (Interviewee 1 and 2 were asked the same question)*

Aasheim claims that there will be a positive shift in tourism with an expansion of wind turbines. He proclaims there is multiple datasets that indicates the increase in tourism, including the usage of area will increase, hotel bookings and new areas will have new potential. Aasheim clearly states there is a difference between the Norwegian national tourist and tourism in general, then their point of view of traveling to a wind power plant will differentiate.

Interviewee 2: Øivind Anti Nilsen

Nilsen has a hard time believing that wind power plants will generate any form of tourism. He continues by stating that international travellers will not come to Norway to visit wind power plants. Even though there have been mayors that have claimed tourism has increased with seminars and optimism, Nilsen believes this will only be in the beginning phase of the development and it will fade just as fast as it came.

Interviewee 3: Gorm Kipperberg

- *Wind power manufacturers have argued that there are wind turbine tourists, what are your opinions on the matter?*

Kipperberg states while it is theoretically possible, there is not enough research that can document this. There are arguments that new roads to the wind power plants will make nature more accessible, and that this could potentially be commercialized to create activity. It is also theoretically possible to create spectacular wind power plants, that will generate curiosity among tourists. However, Kipperberg believes that the national tourists will not contribute to an increase in GDP, unless beach vacations are traded for wind power plant visits. Moreover, Norway is known internationally for its untouched nature, and multiple tourism organizations are worried that the negative outweigh the positive effects.

4.5.7 Others

The purpose of this section is to present collected perspectives unrelated to the topics above. Accordingly, the questions are assembled to collect information on Norway's situation on import and export, and whether the expansion of wind power contributes more in Europe that it does in Norway. Further, the questions aim to achieve an overview on whether wind power is the best option for future investments, and if innovation can make this possible. Finally, it is questioned whether the Norwegian currency could be affected by the shift to renewable energy from the petroleum sector, or if the correlation stems from something else.

Interviewee 1: Andreas Aasheim

- *How important has innovation been in the process?*

He claims innovation has played a vital part in the development of wind turbines, because during the last 10 years the price of wind power has gone down from €60-70 per KWh to well below 0.3 NOK. Aasheim states that wind power developers relied on subsidies but currently they have one of the cheapest power productions. He continues to explain that the innovation within the wind turbines increased efficiency by over 10%, and they generate more power over the same time period. Additionally, Aasheim mentions that innovation has contributed for how to place the turbines for max wind efficiency.

- *Should Norway prioritize investments in wind power in the future?*

Aasheim claims climate and electrification is something that everyone agrees needs to happen, and that Norway would need an additional 80 TWh of renewable power to be close to being 100% renewable. Additionally, he states that at a point in time the petroleum industry will not be able to supply 200-250 thousand jobs, and a shift in the Norway labour market will happen. Aasheim believes by increasing the power production there will be a new generated job sector that will include battery factories, data centers, ammonia production, ferroalloys and process industries.

Interviewee 2: Øivind Anti Nilsen

- *If there is a larger development of wind farms with visual pollution in Norway, we can imagine that this energy will be exported. At the same time, we continue to import brown* *energy from European grid, which includes pollution taxes. How will this affect the utility of the Norwegian people?*

He deliberates the reason Norway buys energy is because there is low production in Norway. Or the fact that foreign energy is cheaper. Nilsen continues by stating that it is only fair because Norway gets to connect to an international network, and their production is not 100% renewable. Additionally, because Norway has connected to the international network, the opportunity to sell surplus arises. Nilsen describes a scenario if Norway was to close their boarders for export of power, Norway would always have to produce and stop the production if there was a surplus. He believes as an economist that he sees the advantages of being able to smooth out the tops and bottoms of Norway's production. Finally, Nilsen claims during the electrification of Norway there will be two options, either buy electricity internationally or produce more internationally, because the increase in power needs to be covered.

- *Historically, we have seen that the oil price and Norwegian kroner exchange rate has had a negative correlation. If we had chosen to continue wind power production in the long term, do you think the oil price would not have had an equally significant impact on the exchange rate?*

The reason behind this correlation is that Norway has foreign investments, and the fact that the petroleum has a high income. Nilsen believes these correlations will disappear once the production of petroleum sector makes up a smaller percentage of the GDP. Nilsen states there is no law that says petroleum production and the NOK exchange are linked, and that the reason there is a correlation is because petroleum is such a big part of Norway's total income. Once the oil becomes less significant in Norwegian GDP, the correlation between oil prices and currency exchange rate will dissipate.

- *Lastly, is there anything you are interested in finding out that could be interesting for us to conduct research on?*

Nilsen states that the hydropower municipalities are compensated better than wind power municipalities, this needs to change. He continues by saying that the public resistance has grown every year. He hopes that central authorities will go to action and change their regulations. Nilsen mentions that he cares for the next generations and want them to have something that they can sell. However, if the next generations do not want to continue with wind power production, then to a certain degree the wind power plants are possible to reverse along with the environmental impacts.

Interviewee 3: Gorm Kipperberg

- *If there is a larger development of wind farms with visual pollution in Norway, we can imagine that this energy will be exported. At the same time, we continue to import brown energy from European grid, which includes pollution taxes. How will this affect the utility of the Norwegian people?*

Kipperberg argues that Norway does export renewable energy while still importing power generated from coal, nuclear, and other renewable energy sources. He believes this is a form of misdirection from the energy developers, which should be regulated by laws and regulations concerning how they should be allowed to market. He states that one argument for the development of wind power is that it will reduce the carbon emission levels in Europe. The emission levels are regulated resulting in emission costs will be included in the price. He continues saying that even with the electrification of Norway it still will not reduce Europe's emissions because of the regulations and quotas. Kipperberg believes it would be a better choice to create stricter regulations on emissions rather than developing more renewable energy, since it would force the developers and consumers to change their behaviour.

5 DISCUSSION

5.1 HISTORIC AND FUTURE ENERGY PRODUCTION

The production of energy will continue to increase in the future since it is a highly demanded product. The Paris Agreement will incentivise future generated production to be a renewable energy resources with no CO_2 emissions. As illustrated in table 1, the installed capacity of renewable energy has increased with 1 780 714,6 MW from 2000-2019, which is a growth of 236% from year 2000. Essentially, the accumulated growth is related to the global growth in population. There has been an increase in the amount of jobs, technology has evolved, and several industries are being electrified, among them transportation. Additionally, certain energy sources have been replaced by renewable energy, which naturally increases the installed capacity. As mentioned in chapter 4.1, the growth of energy consumption is expected to continue, in other words the demand for energy is increasing. Most of the growth is expected to be from non-OECD countries, and particularly in Asia. The largest increase in energy is expected to derive from the buildings and transportation sector.

Although there has been a vast increase in renewable energy production, table 2 shows that there has not been a significant change to the CO_2 emissions per capita globally. As shown table 2, over the last 18 years the world has increased the average CO_2 emissions per capita from 4,1 to 4,8 metric tons, while Europe had a reduction from 8,6 to 6,7. In Norway the CO_2 emissions per capita have been reduced from 9,4 to 8,3 metric tons, and the USA had a reduction from 21.3 to 16,6. There is a trend in western countries reducing their overall CO_2 emissions per capita while Asia is showing the opposite such as China who had an increase from 2,6 to 7. Even though China proves to be the country with the highest activity of renewable energy installations, they are as seen in table 2, the country with the largest increase in CO_2 emissions per capita.

Additionally, it is important to mention that Europe does not produce 100% renewable energy, which is why countries like Norway can export renewable energy to those in need while importing energy that might be produced from resources as coal, fossil fuels or nuclear. The consumer might be unaware of what energy they are using, which is something that could cause negative reactions. Kipperberg states in chapter 4.5.7, that energy developers should inform the consumers about what type of energy they are supplying and not mislead by only stating what they produce. Historically, Norway's energy production has been in a trade surplus with a few exception years as seen in table 5. The implementation of wind power will increase the surplus of energy, and as Aasheim states in chapter 4.5.1, Norway has adapted by making sure the grid and powerlines can reach other countries in Europe. It is expected that the demand for energy will continue to grow, and developers needs to follow. Generally, in the European network power grid there is carbon tax included in the purchasing prices, and for renewable energy there is a premium. The demand for energy is increasing as the world is becoming more electrified, and more countries are willing to pay a premium for guaranteed supply of renewable energy.

Currently, countries affiliated with the Paris Agreement are trying to implement more renewable energy sources to reach the common goal, to reduce CO_2 emissions. Several governments have implemented subsidies to increase the production of renewable energy. Without subsidies wind power would not be profitable from either a business economic or a socioeconomic perspective, due to the negative externalities power plants bring. Subsidies have given developers time and resources to innovate their technologies to where they are sustainable without further subsidies.

5.2 ONSHORE DEVELOPMENT AND COSTS

In 2019, hydropower grew by 1,2% where the largest growth of new installed capacity of hydropower was seen in China, Brazil and the United States. Even though the growth rate was at 1.2% in 2019, hydropower is still growing steadily around the world. Table 4 shows that hydropower has followed the same trend in Norway, where there has been a constant growth. Onshore wind power grew globally by 54.2 GW in 2019 alone. Several countries have implemented new market-based mechanisms such as auctions, tenders and green certificates in order to make the wind power industry independent of subsidies, i.e. sustainable. The growth of solar power continues, mainly due to large reductions in costs. Additionally, a great incentive to further investments of solar power is the flexibility of it, where it can be installed to large rooftops. As mentioned in chapter 4.2.3.3, solar power can disrupt energy market prices as the consumer can produce their own energy while avoiding variables that are implemented in the market prices such as grid tariffs. Yet, most of the investments in solar power has been outside of Europe, where sunny weather is more frequent, especially compared to Norway. Thus, Norway might not be able to obtain the same level of production within solar power compared to for example onshore wind power.

Nuclear power has not had any significant growth during the last 20 years. It seems that Nuclear power plants are being shut down only to be replaced by newer models since 2012, with the greatest growth in Asia as seen in table 3. Nuclear power has had a strange past through meltdowns and nuclear waste. One of the main issues Aasheim brings up is that even if we look past previous problems, it is not possible to build nuclear power in Europe. The reasoning behind his claim is that Europe has two big projects in development, Olkiluoto 3 and Flamanville, which have been in development for over ten years. Additionally, Hinkley point c has the highest power generation costs in Europe. While these factors need to be taken into consideration Kipperberg finds it confusing from an environmental and socioeconomic perspective why nuclear power is not on the global political table. Both Kipperberg and Aasheim agree that the costs need to be taken into consideration to be able to consider Nuclear power, but they differentiate on the future potential of its role in Europe. The prognosis of the LCOE of nuclear power show that it is not expected to have any changes towards 2040, which gives an indication that future investments look bleak.

From the data presented in table 6, the LCOE of renewable energy sources are mostly represented by investment costs. Onshore wind power retains the lowest investment costs of 0,22 NOK/kWh but do also have the second highest operational costs at 0,10 NOK/kWh, only beaten by nuclear power at 0,13 NOK/kWh, which also has 0,07 NOK/kWh in fuel fees. Large-scale hydro power plants have the lowest operational costs with 0,04 NOK/kWh, followed by small-scale hydropower plants at 0,07 NOK/kWh and solar power installed to large rooftops 0,08 NOK/kWh. Due to low operational costs, accessible technology and large amount of resources hydropower has been the dominant source of renewable energy production. However, as presented in table 7, the LCOE of onshore wind power is expected to decrease by nearly 38%

towards 2040, while hydropower is expected to be stagnant. Onshore wind power is expected to have huge investments in innovation, which is the reason behind the foreseeable cost reductions.

5.3 VALUE CREATION

The value creation of wind power is one of the arguments that wind power developers most commonly use to persuade municipalities to let them develop. Factors like tax incomes, local jobs, use of restaurants and hotels, have been mentioned as benefits for the municipalities if they would allow wind power production to develop. Nilsen questioned the reality of these factors of value creation as he is unsure about the certainty of them.

A source to value creation that power plants bring is the concessions agreements of power supply the developers has to award the municipality. The concession agreement has a fixed price stated in the law. All the leftover energy will then go to the county, which means that the whole area around the power plant will be supplied with more electricity, for a lower pricing.

Nilsen acknowledges in chapter 4.5.3, that a few jobs may be generated for maintenance and operations. Vindportalen's rule of thumb is one local FTE per 15 MW of installed capacity, despite that the exact number of FTE can vary from one wind power plant to another. Vindportalen estimated around 40 to 50 jobs for operations and maintenance for a big wind power plant such as the one at Fosen (1000 MW of installed capacity). With only 25 000 inhabitants it might be difficult to fill 40 to 50 jobs with a qualified workforce. Additionally, Aasheim mentions that smaller municipalities may not have the required infrastructure to welcome a family with two kids, such as school places, job for the other partner and housing.

In chapter 4.5.6, the interviewees discussed how wind power plants can generate tourism. Wind power developers claims wind power plants generate tourism, while environmental and socio economists beg to differ. The evidence wind power developers rely on is the fact that tourism does not reduce in the affected areas. While conducting an interview with Aasheim he provided information about how new roads will be built to increase accessibility for new areas and that it has increased hotel bookings. Aasheim claims that it is necessary to differentiate between the typical Norwegian tourist and tourism in general but believes that the total number of visitors will increase. However, Nilsen and Kipperberg believe these effects will only be a phase in the initial development of power plants but fade away once wind power plants are normalized. They believe an increase in tourism is possible in theory but claim there is not enough research to document these claims. They both also state that Norway is known internationally for its untouched nature, and it might damage the existing tourism more than wind power plants potentially can generate. It is possible to build attractive wind power plants to increase tourism, which has been seen within hydropower. The Øvre Forsland hydropower plant has been designed to complement the surrounding natural environment (DiStasio, 2016). Helgeland Kraft, the developer of Øvre Forsland hydropower plant, won the Architizers 2016 A+ award, which has the highest prestige within spectacular architecture and was nominated to multiple more (Helgeland Kraft, n.d.).

5.4 EXTERNALITIES

A frequently discussed matter are the externalities that occur when large power plants are built and how the municipalities are compensated. The utility of the inhabitants will most likely be affected to a certain degree. For instance, large wind turbines can be more visible for the inhabitants than a hydropower plant installed in a river or waterfalls around a mountain. These types of externalities are called externalities in utility, where their utilities are affected by an economic actor's activities. As mentioned in chapter 4.3, many Norwegians have a negative opinion on the development of wind power plants because of the externalities in utility. However, one of the advantages with wind power plants that both Vindportalen and Nilsen mentions, is that the environmental impacts are to a degree reversible. The environmental impact hydro power has in rivers and waterfalls are significantly larger, as the infrastructure is built into the mountains. On the other hand, wind turbines create a surface impact but once they are removed there will be less impact in nature.

The main externalities of renewable energy power plants from an environmental and socio- economists perspective that cause a dead weight loss is visual effects, habitat disruption and ecosystem fragmentation. Each of these factors have a negative impact on humans and the environment. Visual effects will prove to be difficult as most people do not want wind turbines in their "back yards" by possibly blocking out the sun creating shadow flickers, or producing sound causing disturbances. Visual effects could also damage other industries such as tourism. Habitat disruption has been a problem all over the world, as power plants require massive amounts of property to develop. This leads to the destruction of untouched nature, causing a lot of problems for species that live in these areas. Lastly large power plants will cause an ecosystem fragmentation, which will divide up nature and create a massive problem for species that live there. These issues need to be weighted up against the benefits of renewable energy production which is a reduction in emissions and the expected growth of the worlds required electricity. Kipperberg believes centralizing wind power will be more social economical beneficial, as the externalities will be concentrated in large and few areas compared to smaller power plants spread around Norway. Aasheim agrees with Kipperberg and states that is mainly what wind power developers are trying to do, but it is also required to spread windmills out as it would cause lower production to only have them in one area, and a massive expansion of the grid and power lines would be necessary for this.

5.5 PUBLIC POLICIES AND TAXES

Currently municipalities want more power over concessions in Norway, as NVE and the government has the final say in whether power plants should be built. Once a concession is granted for wind power developers it lasts for 25 years. With the innovation that is happening within this technology it could result in taller and stronger wind turbines, than what the municipality originally agreed upon.

For now, municipalities have from the Planning and Building Act only authority to approve development of power plants where the installed capacity is 1 MW or less. For power plants with more than 1 MW of installed capacity NVE has the authority to grant concessions, i.e. a centralized authority. However, due to the discussions regarding further development of wind power it seems like municipalities would like a more decentralized authority structure, as they are the ones affected by the externalities such as loud noises, shadow flickering, habitat disruption and decreasing real estate prices. As mentioned in chapter 4.3.2, the Consequence Evaluation Program is there to reduce the chance of people to get affected by these externalities. The high level of protests nowadays may force a change in what is required for concessions if wind power investments is going to continue, as for example a longer distance between power plants and inhabitants, or a set height limit on the wind turbines.

Currently, the tax system in Norway differentiates between wind power and large-scale hydropower, which in return means municipalities receive less in return when wind power is developed. Nilsen expressed his opinion in chapter 4.5.1, on this matter where he was against any further development of wind power plants before new regulation and taxes that favours the municipalities are implemented. Large-scale hydropower plants are imposed corporate-, property-, concession, and resource rent tax, including concession agreements. Wind power on the other hand is only imposed corporate- and property tax. Additionally, wind power developers depreciate wind turbines over five years compared to hydropower developers that depreciate their power plants over 40 to 67 years. The depreciation difference will reduce the corporate tax that wind power developers are imposed over the first five years. The taxation differences prove that hydropower is giving back to society to a higher degree compared to wind power. Sørensen believes there is a valid reason to why the locals react differently when development starts in their own municipality – the compensation is not consistent.

There is continuous discussion of how a tax imposed on wind power developers would affect their production capabilities. As mentioned, wind power has a competitive advantage over hydropower because there are fewer taxes associated. Wind power developers has just recently managed to become sustainable, which gives reason to believe that new taxes would result in a leftward shift in the supply curve. The government has a goal to reduce the deadweight loss as much as possible by imposing neutral income taxes that can balance the total socio-economic surplus as seen in figure 10. It is also important to state that wind power will need additional taxes to provide municipalities with the loss of land and natural resources that are used. Once these taxes are imposed on wind power developers, it will mainly affect the producer surplus, thus, leading to a reduction in profits. It is believed that reduced profits will also reduce the incentives of investors.

5.6 OFFSHORE POTENTIAL

The Norwegian coastline has a considerable potential for renewable energy production from the wind and the movement in the ocean. The past decade several countries have experimented with bottom-fixed wind power. Countries such as Denmark, Netherland, Germany and the UK have invested in bottom-fixed wind power, but in comparison to Norway, they have an advantage of encompassing a shallow coastline which is more accessible. As stated in chapter 4.1.2, the mentioned countries have the past years implemented an auction system for offshore wind power, which has operated as an incentive for developers to innovate. Due to a high degree of incremental innovation, offshore wind turbines are now larger and have longer blades, making them more productive compared to onshore wind turbines. Increased productivity means that one can use either the same amount of wind turbines to generate more energy, or a lower quantity to generate the same amount of energy. The null bids that developers have offered is a clear indication that bottom-fixed wind power now is sustainable without subsidies in the countries mentioned above. An important advantage of offshore wind power is that it is less visible for inhabitants which eliminates certain externalities that individuals may experience with onshore wind power.

Yet offshore wind power is not sustainable in Norway due to the difficult offshore terrain. The problem with the Norwegian coastline is that the steep shore slope is very close to land, which makes it less accessible to develop bottom-fixed wind turbines. The steep shore slope makes the development costly since one would have to use technology that reaches the seafloor, which in comparison to other European countries, are significantly deeper. Moreover, the LCOE presented in table 6 shows that there is a great uncertainty in the costs of offshore wind power, which mainly can be explained by lack of testing. Floating wind turbine technology is still too immature, and therefore, it may be a while before one can see a high degree of offshore wind power investments in Norway. As mentioned in chapter 4.2.3.1, currently, there are only a couple of locations that have been approved for testing in Norway. The Norwegian offshore wind turbines are expected to have between 4163 to 4356 full-load hours.

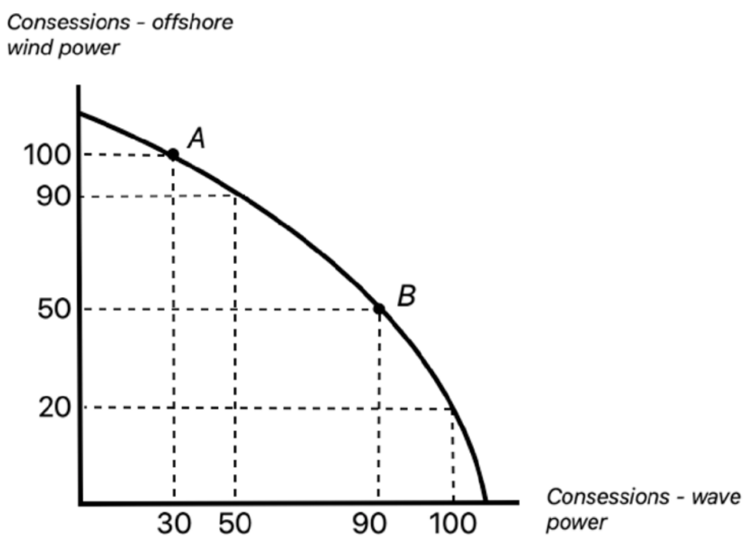
The uncertainty of offshore wind power in Norway can create opportunities for other technologies. The ocean is constantly moving, which is why wave power could be a great opportunity for Norwegian offshore power production. Wave power is expected to be a more flexible and less visible offshore technology, compared to offshore wind turbines. The status quo of wave power technology is that it is too immature. However, the operational costs are expected to be low once the technology is ready. Since wave power production can be generated by different technologies it could be a competitive advantage in countries that are in the same situation as Norway. Additionally, waves are not generated only by wind, which means that wave power could produce when offshore wind power cannot. As mentioned, wave power could potentially bring 3500-4000 full-load-hours. With three different main models of wave power one cannot generalise them with a specific number for full-load hours that can justify each model. Which model that will generate most full-load hours is something that this research lacks data on.

Even though certain externalities can be eliminated with offshore power production, it does not imply that there are no externalities. Offshore wind power and wave power can be a source to inter-firm externalities by affecting the quality of the waves coming into shore after hitting the power plants. An inconsistent wave pattern may affect beaches that are normally known for excellent surfing conditions, which could lead to less surfers and tourism to the exact beach. However, these technologies could be used together with for example aquaculture and oil platforms in order to reduce their CO_2 emissions, which is an example of beneficial externalities.

5.6.1 Production possibility frontier

If the technology of offshore wind power and wave power become sustainable in Norway, a question of opportunity cost may appear. The coastline is a limited resource only available for a specific amount of power plants from the two technologies. NVE's task is to decide what kind of allocation is optimal for Norway. Even though this is not a problem that may concern NVE at the moment, it could be an issue in the future. An example of this dilemma is displayed in figure 11, where NVE only has a certain amount of concessions to allocate. If they grant 100 concessions to offshore wind power, there would only be 30 left for wave power. Thus, an opportunity cost will occur if technologies within wave power suddenly has a breakthrough. This could cause NVE to find themselves in a situation where they would want to allocate 20 more concessions to wave power, which would reduce wind power by 10.

Figure 11: Concessions offshore opportunities



6 CONCLUSION

The objective of this research is to identify key factors that can affect future investments within renewable energy in Norway, with the support of two supplementary questions. The first supplementary question aims to reveal if global trends within renewable energy affects the Norwegian market. While the second supplementary question aims to find whether externalities can delay the development of wind power in Norway.

According to the analysis, the Norwegian renewable energy market is influenced by the global trends. The growth of the renewable energy sources in Norway is lagging a couple of years, compared to the overall growth. The analysis points to the fact that investments in certain renewable energy sources becomes attractive in Norway once the technology has been developed in the global market. The industry of wind power has been in a massive growth the past ten years, well-aided by subsidies, which are now being phased out. For onshore wind power this has provided time for the technology to become sustainable. In Norway, it would be ideal to introduce a similar auction system as multiple countries have implemented, hoping it would slowly erase the implemented subsidies. Additionally, LCOE of onshore wind power shows that costs will decrease, which is why an auction system would be optimal, and by that reducing the deadweight loss caused to society. Several countries are now subsiding offshore wind power aiming to achieve the same result, while other countries have already managed it. In Norway, offshore wind power is still underdeveloped and would require subsidies for implementation, which is also the case for wave power. Moreover, following the trends of other nationalities could be difficult as the Norwegian coastline has a more complicated terrain.

Solar power has had a substantial growth in Norway the past five years. However, the analysis shows that the global growth started in 2011, which shows that the Norwegian market is reliant on development of technologies abroad. Nonetheless, most of the new investments within solar power has been outside of Europe, where the weather conditions are significantly better. Therefore, as the Norwegian climate is characterized by low temperatures, solar power investments are not attractive in larger scales. However, if market power prices increase over a longer period, then consumers might want to invest in solar power to produce their own power.

There seems to be a new trend where the instalments of new hydropower plants are decreasing. In 2019, the global growth of new installed hydropower plants had a slight decrease compared to previous years. In Norway, the best areas for hydropower production are already in use. Therefore, a development of hydropower plants at less optimal areas will result in lower income for the producer, since the LCOE of hydropower is expected to be stagnant towards 2040. Thus, the Norwegian and global trend of reduced growth within hydropower is comparable.

Although nuclear power has a great potential, the issue lays in development time and investment costs, which is proved by the current projects in Europe. There is a large amount of thorium in Norway, however, it will require a significant amount of R&D investments before thorium reactors are ready for commercialization. Due to the historical events of nuclear meltdowns, most countries are against development of nuclear power production. Additionally, maintaining the nuclear waste is costly. Therefore, nuclear power is not expected to flourish in Norway in the next 20 years.

Some Norwegian citizens are protesting by aiming to shut down further development of wind power plants due to the externalities that affect them. Firstly, the main issue that is brought up is how wind power plants destroys the untouched nature and what consequences this could bring in the long run. Developers are affecting a smaller area by utilizing larger wind turbines that generate the same amount of energy. Additionally, the infrastructure of wind power plants has less of an impact compared to hydropower, as it is reversible if future generations choose to remove it. Secondly, the visual effects are brought up, which mainly involve citizens that live close to the power plants. Visual effects can be reduced if the locations are properly managed by NVE and the municipalities by avoiding building in populated areas. Thirdly, the annual mortality rate for birds is brought up. By comparing wind turbines to other energy sources, turbines are causing less bird deaths. Lastly, it is important that the inhabitants are heard by the government, which implies that the Consequence Evaluation Program may need adjustments. There are reasons to believe that municipalities want a decentralized authority system as they feel unfairly treated. They want to have a bigger influence in which projects that will be approved, especially when the negative impacts are significant. The government should reduce the duration of a concession or set requirements for finished instalment within ten years. In addition, there should be a requirement on the maximum size wind turbines can have in concession approved areas. Nonetheless, Norwegian citizens may have to accept that the development will continue in Norway to contribute to the common goal of becoming climate neutral. The underlying mental attributions must change by focusing on the positive environmental effects instead of the negative.

Throughout the thesis, several factors which could affect renewable energy investments have been analysed and discussed. Subsidies in form of green certificates and tax cuts have been identified to affect investment decisions as seen in the growth of renewable energy, both globally and in Norway. Subsidies provides less risk to the investments and gives an immature technology time to develop, which can be seen in the wind and solar power market. The green certificates will be phased out at the end of 2021 in Norway. Thus, investors will not be able to take advantage of the green certificates. Additionally, policymakers will need to introduce new taxes for wind power developers due to the protests and environmental impact that instalments bring. The removal of the green certificates and the introduction of new taxes will affect future investments as it becomes less profitable. However, since the LCOE of wind power is predicted to decrease by nearly 38%, it will balance the removed incentives to a certain degree, resulting in a slight decrease in investments. Furthermore, as the best areas for hydropower production are already in use, the profits of potential new power plants will be lower as the LCOE is expected to be constant. Thus, there will be a decrease in new instalments of hydropower plants, and continuous improvements to existing power plants. The governments want to continue the expansion of renewable energy production, so it is expected that there will still be subsidies.

6.1 FURTHER RESEARCH

To conduct further research on which key factors that can affect investments nuclear and wind power requires more attention. The limiting factor in this thesis has been a lack of time and resources, as many of the factors require foreign information which is not easy to acquire. Thus, there is additional work to be done, concerning nuclear, wave and offshore wind power.

It would be interesting to delve deeper into nuclear power as it has immense potential even though it has negative connotations. This could be conducted through poll in multiple countries to get a view on people's opinions to see if it is compatible with the governments that reject it. Additionally, nuclear power is extremely costly and has a long development phase. Analysing the costs in different countries to unravel why it is more expensive in Europe and the U.S. compared Asia. With the amounts of thorium in the world, it is logical to investigate how thorium reactors can be commercialized. Currently, there are different sources conducting research by testing thorium reactors, but this is not commonly known. By addressing that issue, it could change opinions on nuclear powers future.

The future of wave power seems exciting due to the potential that it has with less visual externalities compared to offshore wind power. Additionally, it is worth to look into how its potential can be maximized together with aquaculture and oil platforms. However, a further research on how the investment costs can be reduced is recommended. Lastly, the offshore wind power projects at Utsira north and Sandskallen-Sørøya north will provide important answers for the future of the industry in Norway.

7 REFERENCES

Bessant, J., & Tidd, J. (2013). *Managing Innovation* (5th edition). Chichester: John Wiley & sons, Inc.

Corporate Finance Institute (n.d.). Levelized Cost of Electricity (LCOE). Retrieved June 4, 2020 from https://corporatefinanceinstitute.com/resources/knowledge/finance/levelized-cost-of-energy-lcoe/

Creswell, J. (2014) *Research design* (4th edition). Thousand Oakes: SAGE Publications, Inc.

DiStasio, C. (September 14, 2016). Norway's most stunning hydropower plant is now a tourist destination. Retrieved from https://inhabitat.com/norways-most-stunning-hydropower-plant-is-now-a-tourist-destination/

Energifakta Norge (January 03, 2019). Skattelegging av Kraftsektoren. Retrieved from https://energifaktanorge.no/regulering-av-energisektoren/skattlegging-av-kraftsektoren/

Fagerberg, J. (2015). Innovation - a New Guide. https://doi.org/10.1425/82941

Faktisk.no (n.d.). Om oss. Retrieved May 31, 2020 from https://www.faktisk.no/om-oss

FN-sambandet (February 02, 2020). Parisavtalen. Retrieved from https://www.fn.no/om-fn/avtaler/Miljoe-og-klima/Parisavtalen

Gates, B. (December 29, 2018). What I learned at work this year. GatesNotes. Retrieved from https://www.gatesnotes.com/About-Bill-Gates/Year-in-Review-2018

Gårseth-Nesbakk, L. (September 23, 2019). Avskrivning. *Store Norske Leksikon.* Retrieved from https://snl.no/avskrivning

Halvorsen, K. (2003). *Å forske på samfunnet – en innføring i samfunnsvitenskapelig metode* (4th edition). Cappelen Akademisk Forlag.

Hansen, T. (April 28, 2015). Sentralisering. *Store Norske Leksikon.* Retrieved from https://snl.no/sentralisering

Hansen, T. (January 28, 2019). Desentralisering. *Store Norske Leksikon*. Retrieved from https://snl.no/desentralisering

Hayes, A. (April 3, 2020). Inefficient Market. Retrieved from https://www.investopedia.com/terms/i/inefficientmarket.asp

Helgeland Kraft (n.d.). Øvre Forsland kraftverk. Retrieved June 7, 2020 from https://www.helgelandkraft.no/Vannkraft/om-oss/vare-anlegg/ovre-forsland-kraftverk/

International Hydropower Association (2020). Hydropower Status Report.

Innolytics (n.d.). What is Radical Innovation? Retrieved June 4, 2020 from https://innolytics-innovation.com/radical-innovation/

International Hydropower Association (n.d.). A brief history of hydropower. Retrieved May 27, 2020 from https://www.hydropower.org/a-brief-history-of-hydropower

IRENA (n.d.-a). About IRENA. Retrieved June 9, 2020 from https://www.irena.org/aboutirena

IRENA. (n.d.-b). Technologies. Retrieved May 27, 2020 from https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Technologies?fbclid=IwAR1m9hGDhEUCxHC09m-CLfBdA7RV_VIUV1lkpgWXSBcLitpxF8UCbotcKmk

Jakobsen, S. B., Bølling, J. K., & Bjerkestrand, E. (2019). Nasjonal ramme for vindkraft.

Jensen, A. B. (March 4, 2019). Møt den norske kjernekraft-gründeren som er nominert til europeisk innovasjonspris. Retrieved from https://www.tu.no/artikler/norsk-kjernekraft-grunder-pa-forbes-liste-pa-tide-at-norge-far-oynene-opp/459527

Jick, T. D. (1979). Mixing Qualitative and Quantitative Methods: Triangulation in Action. Administrative Science Quarterly, 24(4), 602–611. https://doi.org/10.2307/2392366

Kahan, A. (September 24, 2019). EIA projects nearly 50% increase in world energy usage by 2050, led by growth in Asia. *U.S. Energy Information Administration. Retrieved from.* https://www.eia.gov/todayinenergy/detail.php?id=41433

Kristoffersen, K.J. & Lambertsen, O-F. (June 12, 2019). Nesten alle nye vindkraftanlegg er eid av utenlandske selskaper. Retrieved from https://www.nrk.no/nordland/nesten-alle-nye-vindkraftanlegg-er-eid-av-utenlandske-selskaper-1.14584535

Lee, J., & Zhao, F. (March 25, 2020). *GWEC Global Wind Report 2019.*

May, R. og Stokke, B.G. (February 12, 2019). Svartmaler vindkraft for naturen. Retrieved from https://www.midtnorskdebatt.no/meninger/kronikker/2019/02/12/Svartmaler-vindkraft-for-naturen-18448000.ece

Mjønerud, I. (November 18, 2019). Bølgeenergi – Alt om fornybar energi. Retrieved from https://strøm.no/bølgeenergi

Molnes, G. (June 23, 2019). Fakta før valget: Syv spørsmål og svar om vindmøller · Faktisk. Retrieved from https://www.faktisk.no/artikler/Y5p/fakta-for-valget-syv-sporsmal-og-svar-om-vindmoller

Moran, E. F., Lopez, M. C., Moore, N., Müller, N., & Hyndman, D. W. (2018). Sustainable hydropower in the 21st century. *Proceedings of the National Academy of Sciences*, 115(47), https://doi.org/10.1073/pnas.1809426115

National Renewable Energy Laboratory (n.d.). Point Absorber. [Picture]. Retrieved from https://openei.org/wiki/Definition:Point_Absorber

Naturvernforbundet (June 12, 2020). Vindkraft. Retrieved May 14. 2020 from https://naturvernforbundet.no/vindkraft/

NHO (n.d.). Selskapsskatt. Retrieved May 3, 2020 from https://www.nho.no/tema/skatter-og-avgifter/artikler/selskapsskatt/

Norges Vassdrags- og Energidirektorat (June 12, 2020-a). Om NVE. Retrived June 4, 2020 from https://www.nve.no/om-nve/?ref=mainmenu

Norges Vassdrags- og Energidirektorat (June 03, 2020-b). Kostnader i energisektoren. Retrived June 6, 2020 from https://www.nve.no/energiforsyning/energiforsyningsdata/kostnader-i-energisektoren

Norges Vassdrags- og Energidirektorat (June 15, 2020-c). Elsertifikater. Retrived May 5, 2020 from https://www.nve.no/energiforsyning/elsertifikater/

Norges Vassdrags- og Energidirektorat (April 30, 2020-d). Kraftproduksjon. Retrived May 10, 2020 from https://www.nve.no/energiforsyning/kraftproduksjon/?ref=mainmenu

NOU - Norges offentlige utredninger. (2019). Skattlegging av vannkraftverk.

Saunders, M., Lewis, P. & Thornill, A. (2009). *Research methods for business students* (5th edition). Essex: Pearson Education Ltd.

SETIS - Strategic Energy Technologies Information System (n.d.). Ocean Energy. Retrieved April 15, 2020 from https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Ocean_Energy.pdf

Olje- Og Energidepartementet. Kommunal- Og Moderniseringsdepartementet Offentlige (2015). Veileder for kommunal behandling av mindre vindkraftanleg.

Pettinger, T. (July 18, 2017). Price Elasticity of Demand - Short and Long Run. *Economics Help.* Retrieved from https://www.economicshelp.org/blog/435/concepts/price-elasticity-of-demand-short-and-long-run/

Pindyck, R. S., & Rubinfeld, D. L. (2012). Microeconoomics | (Eighth). New Jersey: *Pearson Education, Inc.*

Pizer, D. (n.d). *The developent of the Pelamis: past present and future*. Post presented by Ocean Power Deliver LTD.

Regjeringen (March 20, 2019-a). Norsk vannkrafthistorie på 5 minutter. Retrieved from https://www.regjeringen.no/no/tema/energi/fornybar-energi/norsk-vannkrafthistorie-pa-fem-minutter/id2346106/

Regjeringen (July 25, 2019-b). Fornybar energi og miljøforvaltningen. Retrieved April 15, 2020 from https://www.regjeringen.no/no/tema/klima-og-miljo/naturmangfold/innsiktsartikler-naturmangfold/fornybar-energiproduksjon-i-norge/id2076808/

Richardson, L. (May 03,2018). History of Solar Energy: Timeline & Invention of Solar Panels. Retrieved from https://news.energysage.com/the-history-and-invention-of-solarpanel-technology/

Riley, G. (n.d.). Price Volatility in the Coffee Market | Economics | tutor2u. Retrieved June 3, 2020 from https://www.tutor2u.net/economics/reference/price-volatility-in-the-coffee-market

Rutherford, E. (1905). *Radio-Activity* (2nd edition). Cambridge: Cambridge University Press.

Sea Motion Energy (n.d.). Produksjon av fornybar energi basert på bølgekraft. Retrieved April 20, 2020 from https://www.seamotionenergy.no/

Sidelnikova, M., Weir, D. E., Groth, L. H., Nybakke, K., Stensby, K. E., Langseth, B., . . . Qureishy, T. H. (2015). Kostnader i energisektoren.

Skiphamn, S.S. (September 30, 2019). 100 havørner funnet drept av vindturbiner på Smøla. Retrieved from https://www.faktisk.no/faktasjekker/wRV/100-havorner-funnet-drept-av-vindturbiner-pa-smola

Snyder, C., & Nicholson, W. (2007). *Microeconomic theory*. (10th edition). Mason: Thomson Higher Education.

Solberg, L. R. (n.d.). Elsertifikatordningen gir økt produksjon av fornybar strøm. Retrieved May 27, 2020 from https://www.energinorge.no/politiskesaker/elsertifikatordningen/

Statistisk Sentralbyrå (n.d.-a). Elektrisitetsbalanse. Retrieved May 6, 2020 from https://www.ssb.no/statbank/table/12824/tableViewLayout1/

Statistisk Sentralbyrå (n.d.-b). SSBs virksomhet. Retrieved May 27, 2020 from https://www.ssb.no/omssb/om-oss

Statkraft. (2019). Global energy trends to 2035. https://doi.org/10.1787/weo-2013-5-en

Teknologirådet (May 11, 2017). The solar revolution and what it can mean for Norway. Retrieved from https://teknologiradet.no/en/the-solar-revolution-and-what-it-can-mean-for-norway/

Tidd, J., Bessant, J., & Keith, P. (2005). *Managing Innovation.* (3rd edition). Chichester: John Wiley & Sons, Inc.

Tuovila, A. (September 24, 2019) Deadweight Loss Definition. *Investopedioa*. Retrieved from https://www.investopedia.com/terms/d/deadweightloss.asp

Tuovila, A. (January 31, 2020). Depreciation Definition. *Investopedioa.* Retrieved from. https://www.investopedia.com/terms/d/depreciation.asp

U.S. Department of Energy (n.d.). The History of Nuclear Energy. Retrieved May 27, 2020 from https://www.energy.gov/sites/prod/files/The History of Nuclear Energy_0.pdf

U.S. Energy Information Administration (March 24, 2020). History of Wind Power. Retrieved from https://www.eia.gov/energyexplained/wind/history-of-wind-power.php

U.S. Energy Information Administration (n.d). What Is Price Volatility. Retrieved May 25, 2020 from https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2003/10_23/Volatility 10-22-03.htm

U.S. Fish & Wildlife Service (September 14, 2018). Threaths to Birds. Retrieved June 1, 2020 from https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php

Ueland, I., Weir, D., & Østenby, M. (2019). Auksjonsprisene på havvind i EU faller.

Veie, C. A., Sidelnikova, M., Skau, S., Koestler, J., Aksnes, N. Y., & Hole, J. (2019). Analyse og framskriving av kraftproduksjon i norden til 2040. (Issue 43).

Vindportalen (n.d.-a). Brukstid og Kapasitetsfaktor. Vindportalen. Retrieved April 3, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/Vindkraft/Vindfysikk/Vindenergi/Brukstid-og-kapasitetsfaktor

Vindportalen (n.d-b). Fordeler og ulemper. Retrieved April 3, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/Vindkraft/Myter-og-fakta-om-vindkraft/Fordeler-og-ulemper

Vindportalen (n.d-c). Konsensjonsprosessen. Retrieved April 4, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/Lover-og-forskrifter/Konsensjonsprosessen

Vindportalen (n.d-d). Kostnader og investering. Retrieved April 11, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/OEkonomi/Kostnader-og-investering

Vindportalen (n.d-e). Lokale ringvirkninger. Retrieved April 5, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/OEkonomi/Lokale-ringvirkninger

Vindportalen (n.d-f). Vindkraft og fugl. Retrieved June 1, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/Miljoe/Vindkraft-og-fugl

Vindportalen (n.d-g). Vindkraft i Norge. Retrieved February 20, 2020 from https://www.vindportalen.no/Vindportalen-informasjonssiden-om-vindkraft/Vindkraft/Vindkraft-i-Norge/Historie

Wave Dragon (n.d.) Overtopping device [Picture] Retieved from https://science.howstuffworks.com/environmental/earth/oceanography/wave-energy2.htm?fbclid=IwAR2FrcvVPxi1k3VbxMB8TpS4M0cEgsnQICj8w1zYu9fCkBkTvfaKNDamNb4

Workbook: IRENA RE Time Series. (n.d.). Retrieved June 7, 2020 from https://public.tableau.com/views/IRENARETimeSeries/Charts?:embed=y&:showVizHome=no&publish=yes&:toolbar=no

World Nuclear Association (February, 2017). Thorium. Retrieved from https://www.world-nuclear.org/information-library/current-and-future-generation/thorium.aspx

World Nuclear Association (March, 2020). Nuclear Electricity Production [Table]. Retrieved from https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx

Østenby, A. M. (2019). Dybde og kompliserte bunnforhold gjør havvind i Norge dyrere enn i Europa.

Øvrebø, O. A. (n.d.). Opp 43 prosent: Enda en rekord for norsk vindkraft. *Energi og Klima*. Retrieved April 5, 2020 from https://energiogklima.no/nyhet/datakilder/status-for-vindkraft-i-norge/

Øvrebø, O. A. (May 02, 2020). Klimagassutslipp per innbygger i Norge og verden. *Energi og Klima*. Retrieved May 20, 2020 from https://energiogklima.no/klimavakten/utslipp-per-innbygger/