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The Norwegian Hydropower

What Are the Drivers and Bottlenecks of the Small Hydropower Industry, and How Will These Further Affect the Development?

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This thesis was written as a part of the Master of Science in Economics and Business Administration at NHH. Please note that neither the institution nor the examiners are responsible − through the approval of this thesis − for the theories and methods used, or results and conclusions drawn in this work.

Preface

This thesis was written as a part of the major *Energy, Natural Resources and the Environment*, within the Norwegian School of Economics' Master's Program in Economics and Business Administration. The subject of the thesis is Norwegian hydropower development, and the reason I chose this topic is that I consider it an important part of the history of Norway, and it is a continuously relevant topic in the media and politics, as recently displayed during the election campaign leading to this fall's change in government.

Before landing on researching the drivers and bottlenecks of the hydropower development, I contemplated several different research questions, which lead to the current structure of this thesis with a general focus on hydropower development and the specific goal of determining the factors prohibiting and motivating this development.

I would like to thank the respondents from Småkraft, BKK, HelgelandsKraft, and Tafjord Kraftproduksjon, for being so welcoming and sharing, and not to mention quick to reply to follow-up questions. In addition, I would like to thank Robert Rønstad and the officials from NVE, for their quick and informative replies. Without the valuable information and knowledge of all of these people, I could not have completed this thesis. A special acknowledgment goes to my supervisor, Leif Kristoffer Sandal, for his advices and guidance throughout the entire process, and credit goes to the proofreaders for their hard work and excellent suggestions. The process of this Master's Thesis has certainly been very educational, and it has been exciting to experience the Norwegian hydropower industry up close.

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Executive Summary

The small hydropower industry in Norway is in a critical phase. The el-certificates system has proven to be a strong driver for new hydropower plants, as well as investments in existing plants, but with this system comes uncertainty regarding future revenue and profits. In addition to uncertainties connected to incentives, the price of electricity has fluctuated the past decade, fueling and dampening new investments with its movements. Strict acts and regulations concerning the utilization of rivers and lakes for electricity generation result in time-consuming processes, for both developers and governmental caseworkers, culminating in long waiting lines for possible hydropower projects. With only nine years left for developers to make the el-certificates system, actors in the industry expect a large increase in new electricity generation through new hydropower plants, which can affect both access to materials and the electricity price. In this thesis I have looked at the difficulties the hydropower industry have faced, are facing, and is likely to face in the future, through interviews with developers, and by looking at the industry in a historical perspective. Opinions surrounding the strength of the hydropower industry seem to differ, and there is great uncertainty concerning the future.

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Chapter 1: Introduction

In this chapter, I will describe the background and motivation for my choice of topic in my Master's Thesis, and I intend to talk about what made me decide on this specific topic. Further, I will present my research question, as well as the data I am basing my research on, and in the last part, I explain the structure of my thesis.

1.1 Background and Motivation

Water is a vital part of human existence. It covers about 70.9% of the earth's surface, while about 60% of the human body consist of water. The chemical compound, composed of two hydrogen molecules and one oxygen molecule, hence its chemical formula H_2O, also plays an important role in the photosynthesis, creating oxygen as a waste product. Aside from its organic and chemical properties, water is also a great source of power – especially in its moving form – that we are able to harness to generate electricity. Merriam-Webster defines hydroelectricity as "*the production of electricity by using machines that are powered by moving water*" (Merriam-Webster, 2013a). Another term for this is hydroelectric power, or the shortened *hydropower*, which I will refer to in my thesis.

With its mountainous topography and generally wet climate, Norway has long been utilizing one of its natural benefits – hydropower. Twenty percent of the country rise more than 900 meters above sea level, effectively rendering a large part of the country uninhabitable and unsuitable for income-related activities such as farming (Vogt, 1971). However, in these high mountains, lakes form because of local rainfall and melting snow, lakes that are ideal for storing and generating large amounts of power. With some intervening, we are able to store more of this untapped power by creating dams that, due to a somewhat predictable precipitation, rarely empties out. The water that does not gather in such reservoirs will continue to flow downwards in *watercourses*, defined as natural or artificial channels through which water flows (Merriam-Webster, 2013b), allowing for power generation further down the mountains as well.

There is an ever-increasing global focus on the environment, and organizations devoted to spread awareness of our fragile earth has blossomed since the late 1980s. The concern about the level of carbon dioxide in the atmosphere has led to international agreements, in the hopes of reducing the collective pollution. Most notable is the Kyoto Protocol of 1997, governed by the United Nations Framework Convention on Climate Change (UNFCCC), in which 191 parties commits to reducing their respective emissions (UNFCCC, 2013a). On September 27

2013, the Intergovernmental Panel on Climate Change (IPCC), one of the recipients of the 2007 Nobel Peace Prize, released a short and bold statement in connection with the publication of their 2013 report on climate change. This report stated that it is *extremely likely* that humans are the dominant cause for climate change and global warming (IPCC, 2013). Industrialized countries now have the watchful eyes of other countries, intergovernmental organizations, and concerned citizens carefully studying their environmental moves. Thus, many countries are looking towards renewable energy sources to reduce their emissions while maintaining a similar level of energy consumption. Governments are introducing incentives to encourage the use of renewable energy, like the el-certificates in Norway in 2012, which is a collective effort with Sweden to increase the clean power supply by financially rewarding developers of renewable energy sources.

With the increased focus on renewable energy, researchers, engineers, and economists are trying to figure out the best possible energy solutions for the future. It is important to remember that although the desired goal is an energy source that is *renewable*, and by extension unlimited, we are still talking about a *resource*, which means that some countries have a greater advantage when it comes to tapping into and utilizing these energy sources. The attention seems to be directed towards relatively new ways of harnessing renewable energy, like wind and solar power, while it appears to be less focus on more traditional solutions, like hydropower. A quick search on Google Trends[1] shows that although slowly decreasing in global popularity since 2008, "solar power" is still the most searched term out of the four I included, and "water power" just passed "wind power" in 2011. On average, "water power" is still the less searched term; see Illustration 1 in Appendix A.

1.2 Research Question

Norway is the sixth largest generator of hydropower in the world (Ministry of Petroleum and Energy, 2013a), and The Norwegian Water Resources and Energy Directorate (NVE) estimates that there are currently 214 TWh of annual hydropower generation potential in Norway, of which 40% – about 85.6 TWh – is untapped (NVE, 2013). This indicates that Norway not only has great experience and knowledge when it comes to hydropower, but also that there are still expansion possibilities in the hydropower industry.

[1] Google Trends uses global search terms, by giving them reference points relative to the number of searches on Google within the given period. It is not an exact science, as language and spelling will differ worldwide, but it gives us an indication of the trends.

So with this great hydropower potential, why is it that Norwegian companies choose to invest in other renewable energy projects abroad, like Statoil and Statkraft's ten billion-kroner investment in the Sheringham Shoal offshore wind farm off the east coast of England (Scira Offshore Energy, 2009)? Are there signs of fundamentally flawed mechanisms in the market for hydropower development that make large investments undesirable?

Former Prime Minister of Norway, Jens Stoltenberg, said in his annual New Year's speech in 2001, "We have now come to the point where further developments of large hydropower plants are over" (Office of the Prime Minister, 2001). As it is NVE and the Ministry of Petroleum and Energy who makes the final decision concerning close to all hydropower license applications (NVE, 2009a), the Prime Minister's statement indirectly introduced smaller hydropower plants as more viable options for the future of hydropower generation. This statement also forms the basis of my research, as I intend to focus on small-scale hydropower, i.e. power plants with an installed effect of 1.0 to 10 megawatts (MW). We usually refer to hydropower plants this size as small hydropower plants, or shortened, *small hydros*.

I want to look at the development of such small hydros, and try to determine whether there are any reasons why it seems that there is a lack of interest in hydropower in Norway. Is it possible to connect such possible reasons to endogenous and exogenous variables that are instrumental in hydropower generation, like electricity prices, financial incentives, new inventions, politics, and public opinion?

My research question is therefore as follows:

> *What are the drivers and bottlenecks of the small hydropower industry, and how will these further affect the development?*

1.3 Data and Information

I have based my thesis on three different kinds of data. First, I have collected data from Statistics Norway, as well as received data and information from officials at NVE and a hydropower project developer. Second, I have studied the history of the Norwegian hydropower from the late 19th century until now, and used this information to support the aforementioned data and subsequent research results. Third, and most important, I have conducted four interviews – two personal, one video conference, and one interview via e-mail – with companies that develop hydropower plants, whose opinions and thoughts I will compare and analyze to form conclusions and answer my research question.

1.4 Structure

In this section, I will describe how I have decided to structure my thesis to achieve the most natural and reasonable approach to this subject. The next chapter will serve three purposes. First, it will shortly describe how hydropower plants work, to equip the reader with a basic understanding of the term hydropower. Second, it will provide a thorough report of the most important events in modern hydropower history. The third part will center on the development of hydropower plants thus far, and I am going to present the application process that developers must go through, and look into how this has changed over the years.

In Chapter 3, I will elaborate on the choices I have made when it comes to collection of data and information, how I conducted my interviews and analysis, and how the methods I have used may affect my results and conclusion.

Further, in Chapter 4, I am describing the costs normally connected to a small hydropower plant, in part by reviewing an actual investment analysis, after which I will look at the electricity in Norway in Chapter 5. Here I will present relevant data and information on electricity prices, generation, distribution, and consumption, in addition to thoroughly describing the el-certificates system. Chapter 6 will contain a short presentation of each of the companies I have interviewed, to provide the reader with a quick overview of their general motives and focus.

I present the results of my interviews in Chapter 7, and in this chapter, I will analyze the information gathered concerning the interviewees' thoughts and opinions on the factors surrounding the previous, present, and future hydropower development. I discuss the collective results in Chapter 8, in which I compare these to the theory and secondary data previously described in this thesis, and this discussion will serve as a platform for my conclusions following in Chapter 9, together with possible topics for further research and studies. After the list of references, I have included an appendix consisting of information that the reader might find useful, like the interview guide I used in my thesis and additional graphs.

Chapter 2: An Introduction to Hydropower

This chapter will serve as the technological and historical background of my thesis, with a brief walkthrough of how hydropower plants work. As this thesis is within the field of economics, I will not go too deep into the technical specifications, but rather explain it in a manner that is sufficient for my further analyses. Thereafter I will present the reader with accounts of what I consider the most important – and relevant – events in modern Norwegian hydropower history. In the second half of this chapter, I will present data on the development, and a description of the license application process.

2.1 The Specifications of a Hydropower Plant

Hydropower is the art of utilizing the energy that is stored in water, which, like all things, contain two types of energy. We know the energy stored in motionless objects – like still water – as *potential energy*. In moving water, however, this energy transforms into *kinetic energy*, a power created by the force of the gravitational pull on the water. Thus, the higher the drop of a watercourse, and the wider it is, the more energy the water releases. As we will see, we have known how to somewhat capture this power for a long time, but it is with electricity generation it gets interesting.

2.1.1 The Two Types of Hydropower Plants

To harness the energy of moving water, developers can build hydropower plants that capture this energy directly from the watercourse, or they can dam a watercourse, creating a reservoir of potential energy that the operator can use to the control flow of water to the power plant. The latter involves a steadier electricity generation throughout the year, but also more interference in the environment, and power companies typically use this solution in larger hydropower projects. Small hydros often establish somewhat of a reservoir as well, but to a much lesser extent that what we talk about with large hydros, and more as a protective means rather than for storing water and control input. I will refer to these small hydro reservoirs as *pools* further in my thesis. In any case, the basics of hydropower is the controlled flow of water, centered towards a turbine, which creates a rotating movement that transfers to a connected generator. This process transforms the kinetic energy into *mechanical energy*, and the generator uses this new energy to produce electricity by rotating a copper thread in a circle of magnets (Spilsbury, 2012).

As water carries organisms, debris, and especially ice in the winter, it is important that developers filter the incoming water somehow, to shield and protect the turbine. This filtration starts with the *intake*, which is comprised of a grating and a hatch. In large hydros, we find these components somewhere in the conduit, i.e. the pipeline that transfers water from the reservoir to the turbine in the power station, usually placed close to the water source. In small hydros, we normally see the intake built into the pool construction. By doing so, small hydros can control for river sediments and debris – which will sink to the bottom of the pool or stop at the grating – and as icing in the winter, as well as the velocity of the incoming water. By protecting the hydropower plant from such externalities, one can reduce the wear and tear on the equipment, especially the turbine (NVE, 2010a).

2.1.2 The Effect of the Turbine and Resource Rent Tax

We consider the turbine one of the most important parts of a hydropower plant, and without it, we could not generate electricity. There are several different kinds of turbines to choose from, mostly depending on the water's drop height, but also on the amount of water input. The most common turbine in Norwegian hydropower is the *Francis* turbine, which is ideal for medium and large drop heights, from 30 to 600 meters. The *Pelton* turbine is more suitable if you have a higher drop height and relatively low water inflow, while some consider the *Kaplan* turbine best for watercourse hydropower, as this is more effective with lower drop heights and higher water inflow (Brødrene Dahl, 2013); see Illustration 2 in Appendix A. The effect of a power plant's installed turbines determines the classification of the power plant, and thereby the bureaucratic process the developers must go through during the planning stage. Within small-scale hydropower, we find the already mentioned small hydro, with a turbine effect of 1.0 to 10 MW. A power plant with an installed effect of 0.1 to 1.0 MW we consider a *mini hydropower plant*, and we denote a power plant with a lower effect than 0.1 MW a *micro hydropower plant*. The effect of the turbines also decides the tax level of a hydropower plant. As with most natural resources, the government subjects companies or private citizens operating a hydropower plant with a certain installed effect to a tax on *resource rent*, which is the government's way to secure an income from the exploitation of these resources. In Norway, the resource rent tax on hydropower is now 30% (Ministry of Finance, 2009), and in comparison, the resource rent tax on petroleum is 50% (Hannesson, 1998, p. 116). Today, the government enforces this tax on hydropower plants with an installed effect of 5.5 megavolt-ampere (MVA), which is just below 5.5 MW (Lie, 2012a). This means that small hydro with an installed effect of 5.5 MW or higher must pay an additional tax of 30% on the total amount of generated electricity, in addition to the regular corporate or private income tax, which are both currently 28%, making the marginal tax rate 58%. Both hydropower companies and environmentalists have strong opinions on this resource rent tax; developers want to increase the 5.5 MW level, while environmentalists are campaigning to subject all hydropower plants, no matter the size, to the tax (Lie, 2012a). The Conservative Party and the Progress Party, the two political parties who this fall formed Norway's new government, have both been in favor of increasing this maximum effect level. In their Political Platform, a document with their major political commitments presented on October 7 2013, the governing parties included their ambition of increasing the resource rent tax level to 10 MW, effectively exempting all small hydros from the resource rent tax (Office of the Prime Minister, 2013, p. 63). However, when the new government presented their revised state budget for 2014 on November 8 2013, it was clear that the exemption of small hydros from the resource rent tax would not happen just yet and instead the hydropower and petroleum industries must expect an increase in the resource rent tax to 31% and 51%, respectively. Combined with a proposed reduction from 28% to 27% in both corporate and private income tax, the marginal corporate income tax for the hydropower industry will still be 58% (Department of Finance, 2013).

2.1.3 Electricity Generation

We measure the electricity generated in a hydropower plant in kilowatts per hour, kWh, which is the amount of energy generated in an hour if the effect is 1.0 kW (SNL, 2010), and in most cases with small hydro, the easiest denotation is gigawatts per hour, GWh (1 000 000 kWh). The amount of electricity that a hydropower plant transports to the electricity suppliers depends on several factors in the mechanics of the plant. The effect of the turbines is of course very important, but one must also take other parts of the generation process into account. If there are locations in the system where some kinetic energy is lost, for example in the conduit, the turbine will not run optimally, reducing the total amount of GWh. Because of different generation due to warm summers and cold winters, we use the *annual average generation*[2] as a measure for hydropower plants, both individually and collectively.

The power grid, i.e. *a network of electrical wires and equipment that supplies electricity to large areas* (Merriam-Webster, 2013c), immediately transports the generated electricity via the network operator, who is in charge of the main power grids, to the local grid companies that distributes it to the consumers through the power suppliers (Statnett, 2013). In the Nordic

[2] One usually estimates electricity generation in hydropower for both summer and winter, and these two measures form the annual average generation.

and Baltic countries, the electricity price is market based, settled on the Nord Pool power exchange every day, which I will further explain in Chapter 5. The power grid is a natural monopoly, in that it is not cost-efficient for more than one company to operate it. Governmental-owned Statnett is the operator of the main power grid in Norway, while there are about 156 local grid companies (Ministry of Petroleum and Energy, 2012a), and due to their natural monopoly activities, the government imposes regulations concerning open access and equal treatment for all electricity generators, to ensure the maintained power balance. The Competition Authority and NVE monitor the relationships between the power producers, Statnett, the local grid companies, and the power suppliers, making sure the market actors follow the Competition Law of 2004 (Bergman et al, 2000, p. 126).

The grid companies and Statnett are depending on a source of income that they obtain through a *network tariff*, which both electricity consumers and generators must pay to gain access to the electricity in the power grid. This network tariff is comprised of two elements, a variable part and a fixed part. The variable tariff goes to covering costs of electricity transporting and the unavoidable loss of electricity during this transportation, which varies, and will therefore depend on electricity consumption and generation. The fixed part goes to maintenance and expansion of the power grid (NVE, 2013a). The grid companies set the network tariff under strict regulation under NVE, who sets a maximum tariff based on individual historical costs.

2.2 An Overview of Historical Hydropower Generation in Norway

To be able to look at the current and future development of hydropower in Norway, I believe it is important to understand how this market has evolved, and determine the historical problems and opportunities that have slowed down and fueled the hydropower market, respectively. Norway saw the blossoming of the "modern" hydropower a little more than a hundred years ago, and in this section, I will describe the most important events in hydropower history.

2.2.1 An Early Beginning

In Norway, people have been utilizing waterpower since the early Middle Ages, in its most primitive form. Back then, around the year 1200, mills and farms used this to create mechanical power. These watermills were quite simple, with an installed wooden water wheel that utilized flowing water to create movements in machinery that made farming easier. The popularity of such mills grew, and by the middle of the 18th century watermills had become an important part of the society, with water supplying mechanical power not only to farms and sawmills, but to important industries like ironworks and mines. During the 19th century, a water wheel made of steel replaced the simple, wooden wheel, resulting in a higher efficiency (SNL, 2013a). In Great Britain, the watermills played an important part as a supporting means of power during the Industrial Revolution, ca. 1750 to 1870, when coal, as fuel for the steam engine, was not always easy to come across. Senjens Nikkelverk, a nickel works on the island of Senja, in Northern Norway, built in 1882 is said to be one of the first hydropower plants in both Norway and Europe (Thue, 2006). The capacity of the plant was 6.5 kW, which today would classify as one-fifteenth of a micro hydro.

The late 19th century saw the introduction of electricity in Norway, and with the development of electric power transmission, owners of hydropower plants saw a possibility to harness the superfluous energy generated and transport this to factories and plants farther away. The first example of this in Norway was the wood processing factory Laugstol Brug in Skien. The operations manager of the factory, engineer Gunnar Knudsen, realized that they simply produced too much electricity, and started to sell the surplus of electricity to other Skien-based factories. Laugstol Brug based their dynamos and incandescent light bulbs on foreign inventions.

The generated energy was no longer just a mode of mechanical power to the factories in close vicinity to the water source, and the factories could make profits from selling the produced electricity. Thus, a heated political debate began, raising the questions: who were the real owners of the flowing rivers, who were allowed to invest in these hydropower plants, and how was the produced electricity going to be distributed?

2.2.2 An Electric Era

As the 20th century approached, a new industry blossomed: The power plants separated from the factories, leading to the founding of the *central power plants*. These plants generated electricity solely for selling it, modeled after Thomas A. Edison's Pearl Street Station in New York, opened in 1882. In Hammerfest, one of the first Norwegian central power plants opened in 1891. This was a hydropower plant, which transmitted electricity as much as 1.2 km away through alternating current (AC). One year later, Kristiania (now Oslo) saw its first central power plant, which ran on steam power through direct current (DC). The emergence of these quite differently powered plants sparked the debate between Norwegian engineers on what the "Norwegian Model" should be like. Engineers felt a modern solution was to focus on hydropower with alternating current dynamos, and this soon became a standard.

Central power plants were built in about twenty Norwegian cities up until 1900, with the focus being on supplying power to streetlights and public offices. Municipalities owned about half of these plants, while private companies accounted for the other half. Though the generation of electricity appeared to be expanding rapidly, it would take another 60 years for the majority of the Norwegian population to have electricity installed in their homes.

2.2.3 The Early Governmental Acts

Already in 1887 came the first act regulating the watercourses and in 1891, the government introduced the first act concerning electrical installations and plants, with an extension added in 1896. The common denominator for these acts was that they were considered to underestimate the value of Norwegian hydropower, especially because their focus was on hydropower as a driver for the more traditional mechanical power, with the turbines directly connected to the machinery. This means that the acts did not take into account the growing central power plants industry, which many criticized. One of the critics was Gunnar Knudsen, engineer and former operations manager at Laugstol Brug. Knudsen was in 1892 a member of the Norwegian Parliament, and he spoke out against what he believed was a grave error in valuation of the hydropower. At the same time, he warned the government about foreign investors, who had recently begun to show an interest in Norwegian watercourses. Knudsen feared this would lead to speculative investments and higher prices for the industries, and urged the government to buy rights to watercourses to prevent this. Another of Knudsen's justifications for governmental purchases of such rights was to prepare for the electrification of the railroads. The debate ended with some governmental investments, limited to the supply of electricity to railroads, as the government did not seem to consider foreign investors the threat as Knudsen would have them to be. After this, the debates surrounding the Norwegian hydropower subsided and it would take about another decade for them to become a prominent part of political debates again, with an outcome that would change the course of the Norwegian hydropower drastically.

2.2.4 The Modern Hydropower Politics

The beginning of the 20th century was a period of relatively large political changes in Norway. Most prominent was the dissolution of the Union between Norway and Sweden in 1905, leaving Norway as an independent country for the first time since 1319 (SNL, 2013b). Christian Michelsen, Prime Minister of Norway during the last year of the Union with Sweden, played an important role in the dissolution of the Union, and was elected Prime Minister when Norway became independent (SNL, 2013c). Michelsen was at the time the leader of the

Liberal Party, and thus began a period of fifteen years with mostly liberal Prime Ministers (SNL, 2013d), which would have a significant impact on the hydropower industry.

In 1906, the government realized that Member of Parliament and hydropower advocate Gunnar Knudsen might have been right in his warnings about foreign investors a decade earlier. It was Norwegian engineers educated abroad who early on saw the potential in Norwegian hydropower, and with the help of foreign investors, they started to buy watercourses to develop industries. Knud Bryn bought the rights to the waterfall Sarpsfossen with the help of German investors, and in 1899, his newly founded company Hafslund began production of calcium carbide (Hafslund, 2013). Engineer Sam Eyde also spearheaded several investments in Norwegian watercourses to ensure electricity supply for his planned chemical industries, with the help of a prominent Swedish banking clan, the Wallenberg family. Eyde founded, among other, Elkem and Norsk Hydro, in 1904 and 1905, respectively.

Although the foreign investments in Norwegian hydropower resulted in large industries, securing jobs, and fueled what is called the Second Industrial Revolution (SNL, 2013e), the government decided to revise the existing watercourses laws, fearing for the future of Norwegian hydropower ownership. The revisions in 1906 were made in such a hurry that the result became known as the *Panic Acts* – undoubtedly one of the more dramatic nicknames in Norwegian legislative history. The Panic Acts' most important clause was that foreign investors needed permission – license – from the King of Norway to buy rights to watercourse properties (Thue, 2003). Although the acts were somewhat rushed, the idea of licensing when it came to watercourses and hydropower stands as a cornerstone in Norwegian hydropower politics, and the acts represented the first step for the government as an active regulator, developer, and in some cases, generator of Norwegian hydropower.

2.2.5 Gunnar Knudsen and the Common Good

There was an increased focus on hydropower from the dissolution of the Union until the early 1920s. Due to the relatively stable economy in this period, the development of hydropower plants increased, and these supplied the electricity needed for the new chemical industries that represented the Second Industrial Revolution. Another major influence on the development of Norwegian hydropower in this period was the liberal Prime Minister elected in 1908 – none other than hydropower pioneer Gunnar Knudsen. Knudsen served two periods as Prime Minister in this period, from 1908 to 1910, and again from 1913 to 1920, making him the sixth longest-sitting Prime Minister in Norwegian history (NBL, 2009). Another influential politician in Knudsen's first period was Minister of Justice, Johan Castberg. Castberg engaged in, among others, the rights to watercourses, and was an avid Henry George follower. This ideology focused on property rights of natural resources and discouraged private owners and speculators. Henry George had argued that the values of the natural properties is an effect of the development in the Norwegian society, and therefore the hydropower should serve the *common good*. Knudsen supported this idea, and he believed this could best function if the hydropower profits were issued differently. This lead to a shift in the distribution of hydropower, from governmental to municipal, and two important acts, introduced in 1917, greatly represented this shift of power.

2.2.6 New Acts and Hydropower Municipalism

Like the Panic Acts of 1906, the two new acts characterized important steps towards the hydropower regulations we know today. The introduced acts were *the Industrial Licensing Act* – later replaced by *the Acquisition Act* – and *the Watercourse Regulation Act* (NVE, 2009b). These acts prioritized the public good above the major industries when it came acquisitions, development, and regulation of watercourses, and a key term was *reversion*. According to both the Industrial Licensing Act and the Watercourse Regulation Act, the watercourses and its adjoining power plants would automatically revert to the government after a licensing period of 60 years. A part of the value of these power plants – one third or less – would go to the municipalities. However, the Watercourse Regulation Act stipulated that so-called *power municipalities*, i.e. municipalities with vast power resources, would be exempted from this reversion rule if the generated power served the common good.

2.2.7 Electricity Optimism and the Economic Stagnation of the 1920s

Into the 1920s, the Norwegian economy was still relatively stable, and the government appointed in 1919 an Electricity Commission, headed by engineer in hydropower and professor at the Norwegian Institute of Technology (NTH) Olav Heggstad. Heggstad and his team of engineers started to work on a national-scale plan for further developing the electricity supply, which the Commission presented in 1922. Several Norwegian counties and municipalities proceeded to follow this plan, which led to large investments in hydropower over the next few years.

However, the period between the World Wars would soon prove to cause financial distress also in Norway, and the investments made as a part of the national electricity plan were put on hold – indefinitely. The demand for electricity dived, as large industries had to shut down production due to low exports. Several factories, such as Norsk Aluminium Company in Høyanger, had to sell shares to acquire capital to stay afloat. In many cases, foreign investors came to the rescue, and it became an increasing trend with partial foreign ownership in Norwegian industries in this period. Another consequence of the decline in electricity demand was that the hydropower plants built during the "power boom" a decade earlier were now generating at a loss, and the government came close to selling some of the hydropower plants in its portfolio.

2.2.8 Increased Demand in the 1930s and Post-War Growth

Despite the pessimism that grew in the Norwegian power industry during the late 1920s, the development of hydropower plants did not come to a complete stop. By the early 1930s, the demand for electricity began to rise again, mainly due to increased demand for aluminum and alloys. In the mid- to late 1930s the Nazi air force – the *Luftwaffe* – and its commander-in-chief Hermann Göring showed a particular interest in the Norwegian light metals. A couple of years later, this interest led to the second full-scale national plan for the Norwegian power industry, during the German Occupation of Norway, from 1940 to 1945. Ultimately, the new national plan ended when the Occupation did.

Although the Second World War caused a lot of destruction on Continental Europe, as well in certain parts of Norway, Norwegian hydropower plants and electricity supply were largely unaffected. On the contrary, the German Occupation's national power supply plan resulted in the development of several hydropower plants. The hydropower plants Tyin in Årdal (in production in 1944) (SNL, 2013f) and Mår in Tinn (development started in 1942) (SNL, 2013g) are examples of plants that the German forces worked on, and the latter is still generating electricity today.

After the war, the debate about whom the power generation should benefit reignited. Engineer and former principal of NTH, Fredrik Vogt, spoke against the Industrial Licensing Act, and wanted the government to open up for energy-intensive industries. In 1947, then-ruling Labor Party appointed Vogt director-general of the *Norwegian Water Resources and Energy Department* (NVE) which led to massive expansions in the hydropower generating industry. Mår hydropower plant was finished, and NVE started development on other large-scale hydropower plants, supplying factories like Norsk Hydro and Årdal Verk. After several years in a state of arrested development due to the war, NVE was officially back on track as the government's "hand" in hydropower production and supply.

In this period, the number of municipal hydropower projects was also increasing, but as the government, through NVE, was supplying most of the energy-intensive industry – as well as the wood processing industry – with cheap electricity, the private development of hydropower plants came to a halt. Due to the many new hydropower plants built up until the early 1960s, the government expanded the power grid, binding the country's power supply together. Especially important at the time was the connection between the east and west.

2.2.9 A Change in Popular Opinion and the Alta Watercourse Controversy

The expansion of the hydropower industry from the late 1940s led to several large hydropower plants. Some of these involved major environmental interference, and in the mid-1960s protests and demonstrations rose against such large hydropower constructions, which many perceived as destructive. Initially, youth and students from the affected areas led the demonstrations, but the rest of the communities soon joined in the fight against developers. The demonstrations reached a peak in 1968, when NVE presented its plans for the watercourse running through Alta and Kautokeino in Northern Norway, simply referred to as the Alta River.

The initial plans for a hydropower plant in the Alta River caused a massive uproar in the Norwegian society, and they engaged municipalities, environmental organizations, private citizens, and especially the physically affected indigenous Sami people. The plans included damming the lake Virdnejávri to serve as a reservoir for the plant, which originally meant submerging the village of Máze, predominantly inhabited by Sami people (SNL, 2013h). In 1973, NVE altered the design of the reservoir to accommodate the newly approved governmental protection of Máze. In 1978, the Norwegian Parliament approved the Alta hydropower plant and its installations, and the same year protestors formed the organization *People's Action Against the Alta/Kautokeino Watercourse Development*. In the summer of 1979, the organization started one of the biggest cases of civil disobedience in Norwegian history, demanding that NVE stop the construction of the hydropower plant. Despite successfully delaying construction through hunger strikes, large demonstrations, and claims of destruction of heritage sites, the Supreme Court ruled the construction of the Alta hydropower plant legal in 1982, which led to the dissolution of the People's Action shortly after (SNL, 2009). Because of the massive attention that surrounded the construction, as well as the cultural impact the protests had on both Norwegians and the Sami people, the Alta power plant is today listed as one of Norway's cultural heritage plants, a list compiled by NVE, Energi Norge, Statkraft, Norsk Hydro, and the Directorate for Cultural Heritage (SNL, 2013i).

2.2.10 The Era of Protection

On April 6 1973, while the protests against the Alta power plant were in full swing, the Norwegian Parliament approved the first *Protection Plan for Watercourses*, after decades of discussion and planning (Ministry of Petroleum and Energy, 1994). The first plan included a permanent protection of 95 watercourses, and the goal of the plan was to secure values connected to natural sciences, cultural heritage, scenery and outdoor recreation. The Parliament approved Protection Plan number two, three, and four in 1980, 1986, and 1993, respectively. In addition, the Parliament added two supplements, the first in 2005, and the second in 2009, after which it considered the Protection Plan completed. As of now, the protection list includes 388 watercourses, representing an estimated 49.5 TWh of production (Ministry of Petroleum and Energy, 2013b). These 49.5 TWh are included in the estimates of potential annual hydropower generation mentioned in Chapter 1.2, which means that about 23% of the total 214 TWh are in fact inaccessible by law. Thus, a remaining 36.1 TWh of annual Norwegian hydropower generation is still untapped and "available". In the 2005 supplement, the Parliament also decided to exempt hydropower plants with an installed effect of 1.0 MW or less from the protection plans, meaning that NVE *can* approve mini hydropower projects' license applications, despite being located in a protected watercourse.

2.2.11 Collaborations

Until the 1960s, it was often single investors, municipalities, or government-controlled companies like NVE who planned and built hydropower plants. As larger hydropower plants became more sought after, joint ventures between companies emerged as a trend that would continue into the 21st century. An early example of this was the hydropower company Sira-Kvina, formed in 1963 as a collaboration between Lyse Produksjon, Statkraft, Skagerak Kraft, and Agder Energi Produksjon (SNL, 2013j). Statkraft is fully governmental-owned, while the other three companies have both governmental and municipal shareholders. The collaboration involved a massive project in the Sira and Kvina watercourses, which would eventually serve seven hydropower plants. Construction of the first of six steps was completed in 1968, and the entire project was finished in 1989 (Sira-Kvina Kraftselskap, 2013).

2.2.12 Liberalization of the Electricity Market – The Energy Act

In 1990, the government presented the Energy Act, which involved major changes in the Norwegian power market. According to Thue (2006), the figureheads of the Energy Act were Prime Minister Jan P. Syse, Minister of Petroleum and Energy Eivind Reiten, as well as the Centre for Applied Research at the Norwegian School of Economics. The act opened for competition in generation and supply, as well as trading with electricity, and for the consumers one of the biggest changes involved the right to choose which company they wanted to serve as their electricity supplier, effectively liberalizing the power market. In 1992, as a part of this liberalization, the government separated then-Statkraft into two entities, Statkraft and Statnett, responsible for electricity generation and the power grid, respectively. This is comparable to the liberalization of the gas market in the United Kingdom, where British Gas, controlling the gas pipeline – also a natural monopoly, had to separate its services into several companies to comply with the requirement of *third party access*. This means that a company controlling a natural monopoly must allow any company access to the monopolized resource, whether it is a gas pipeline or power grid, for a reasonable tariff (Hannesson, 1998).

Opponents of the act raised concerns about the effectiveness of the market powers in a liberal electricity market. Lawyer Ingolf Vislie spoke in late 1990 about the possible effect the existing percentage tax would have on power companies in a decentralized market (Vislie, 1990, cited in Thue, 2003, p. 173). According to Vislie, if the power companies do not have the possibility to adjust the electricity prices, as a free market solution entails, they cannot ensure that their income is sufficient to pay their taxes, which the Norwegian tax authorities mainly based on the value of the power plant. The Ministry of Finance agreed with Vislie, but it would still take six years for the introduction of a different tax system for power companies, based on revenue (Ministry of Local Government and Regional Development, 1997). Even though the debate grew quite heated in certain circles, the act appeared to go almost unnoticed in the public. Thue (2006) accredits some of this public indifference to the generally low electricity prices in the first half of the 1990s, due to increased temperature, and heavy precipitation, which led to a decrease in demand for electricity, and full reservoirs, respectively.

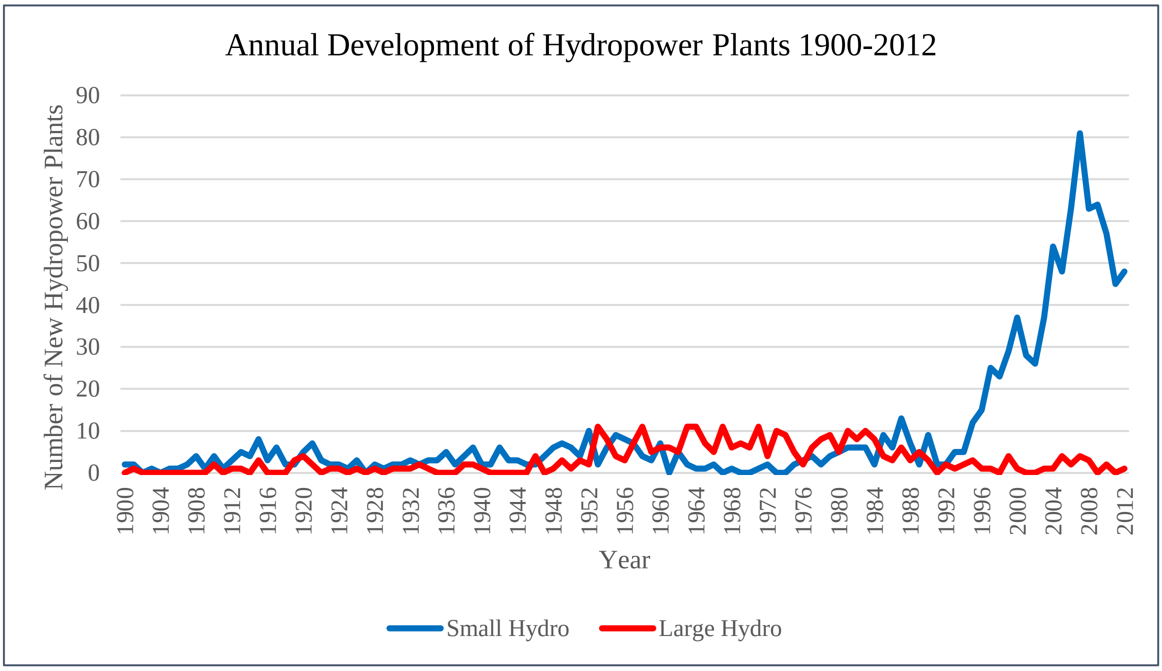
The Parliament adopted the Energy Act on January 1 1991. The following years saw a stagnation in the development of hydropower plants, according to Thue (2006). Though he does not go into details surrounding this decline, it is possible that the current financial crisis in the Nordic countries (Ministry of Finance, 2011), perhaps combined with the current tax issues, held some responsibility. The completion of the *Svartisen* hydropower plant in 1993 (SNL, 2013k) stood solitary as one of the few large hydropower plants completed in the 1990s (Thue, 2006).

2.3 Data Analysis of the Hydropower Development

In this part, I will present the first part of the data I have collected from Statistics Norway, shortened SSB. Founded in 1876, Statistics Norway has long been in charge of the official statistics in Norway, governed by the Ministry of Finance (SSB, 2013a). Statistics Norway gathers information and data on different subjects, like society, industries, and economics, and has a vast statistical database. In this thesis, I will look at data sets collected from Statistics Norway, and perform simple analyses to further use as support for my research and findings. Concerning the development of hydropower I have collected two data sets, one based on the accumulative number of hydropower plants from 1970 to 2012, and one describing the amount of new hydropower plants on an annual basis from 1900 to 2012.

2.3.1 New Hydropower Plants 1900-2012

The data I consider relevant in this chapter is the number of new hydropower plants from year to year. First, I will present the data on the number of new hydropower plants from 1900 to 2012, as registered by NVE[3], provided by Haakon Skau Seming, Senior Engineer at NVE. Graph 1 below illustrates the data:



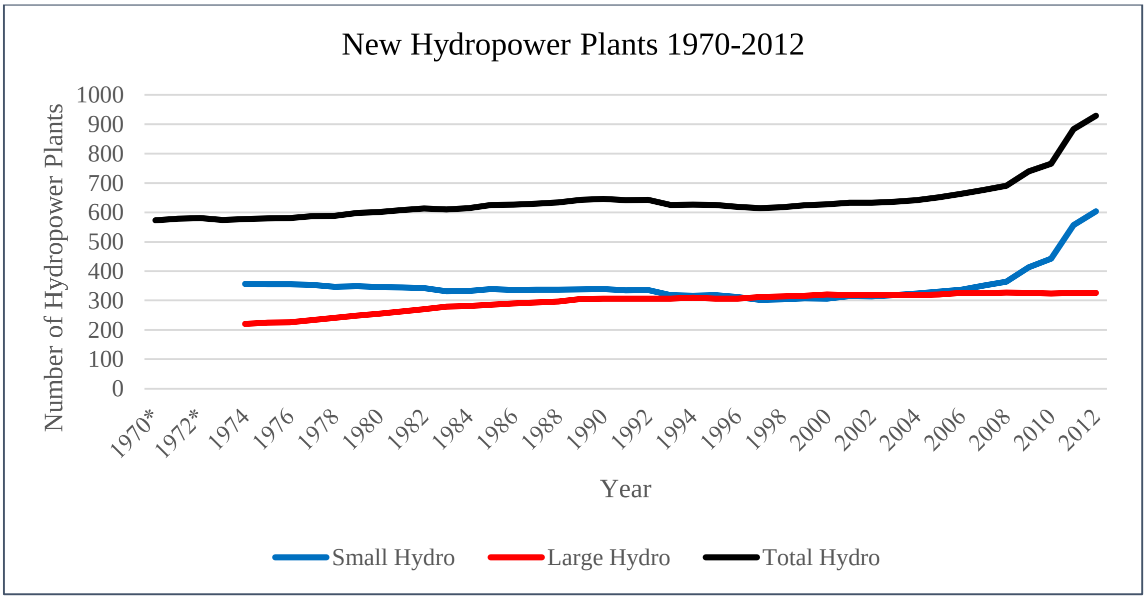
Graph 1. Source: NVE via. Seming, H. S. (2013). Small Hydro ≤ 10 MW, Large Hydro > 10 MW.

[3] Based on the reporting system that NVE imposes on developers (NVE, 2009a)

I have sorted the data according to the sizes most appropriate for my thesis, *Small* and *Large*. From the graph, we can see that the number of new hydropower plants have varied somewhat over the years. Especially the period from 1950 to 1990 we can characterize as a period of volatility, with few clear trends. After mid-1990, however, *Large Hydro* seems to permanently decline, while *Small Hydro* has quite a dramatic increase, and subsequent decrease after 2007. It is worth mentioning that power plants with an installed effect of less than 1.0 MW represent close to half of the total *Small Hydro* data collected. On average, developers built 9.58 small hydropower plants annually in Norway from 1900 to 2012. Some sources incorporate a *medium hydro* variable, but the definitions of this variable vary so for the sake of simplicity and clarity, I have chosen to denote all hydropower plants with an installed effect of more than 10 MW *large* in my thesis, as this is the practice at NVE, according to Selfors (2013).

Included in the data set sent by Mr. Seming is the category “Pumps”. This category represents a technology that usually transfers water between a hydropower plant’s two reservoirs, using pumps, to control and regulate intake to the power plant, either on a seasonal or daily basis (Fornybar.no, 2013). Because pumps function as an addition to an existing power plant and not as a new plant, and because the number is quite insignificant, I have chosen to omit this category from my analysis.

To further look at the hydropower development, I will use cumulative data accessible from Statistics Norway, which run from 1970 to 2012[4]. The data gives us the following graph:



Graph 2. Source: SSB (2013b). Small Hydro ≤ 10 MW, Large Hydro > 10 MW
* Source: SSB (1978), restricted information.

The annual-based data I have collected consist of the accumulated number of hydropower stations each year, according to their sizes, and we can interpret this as the *net development*. What this this tells us is that when the development is negative, as with small hydro from 1992 to 1993 where the number of small hydros decreased from 336 to 318, is that the net sum of opened and closed plants this year was negative 18. Adding the number of new power plants from Graph 1 in 1992 and 1993, which were two and five, respectively, more than 18 plants have likely shut down. The *large hydro* appears to have had a steady growth from 1974 until the mid-1990s, after which it somewhat flattened out. It is apparent from the data and graph that small hydros have had the most turbulent development, from a slow decrease into the 1990s; to an interesting, steep upwards slope in the 2000s. To compare these two hydropower developments further, I decided to perform some relevant calculations.

2.3.2 The Compound Annual Growth Rate (GAGR)

Since the 1974 to 2012 data from Statistics Norway are annual and compounded, I chose to calculate the *Compound Annual Growth Rate* (CAGR). This gives us the annual *theoretical*

[4] The data from 1974 – 2011 was collected from SSB, while the data for 2012 is found at (NVE, 2013b).

growth of each hydropower size for selected periods, if the development had been constant over these periods (NASDAQ, 2009).

I have calculated the CAGR for nine-year periods[5], as well as over the entire period from 1974 to 2012. I have used the standard CAGR formula,

$$\text{CAGR} = \left(\frac{End\ Value}{Beginning\ Value}\right)^{\left(\frac{1}{No.\ of\ Periods}\right)} - 1$$

Listed in the table below are the results from my calculations.

Hydropower Plants Development			
CAGR			
	Small Hydro	**Large Hydro**	**Total Hydro**
1974 - 1982	-0,54 %	2,64 %	0,76 %
1983 - 1992	0,17 %	1,07 %	0,59 %
1993 - 2002	-0,14 %	0,43 %	0,14 %
2003 - 2012	7,37 %	0,28 %	4,30 %
1974 - 2012	**1,39 %**	**1,04 %**	**1,26 %**

Table 1. Source: SSB (2013b)
Small Hydro ≤ 10 MW, Large Hydro > 10 MW

The results show that despite its rather volatile development, with periods of both negative and positive growth, small hydro has had the highest theoretical annual growth from 1974 to 2012, with an estimated 1.39% annually. This is mainly due to its very high increase in the 2000s, where the growth was 7.37% per year. Large hydros, on the other hand, have not experienced a theoretical negative growth in the selected periods, but the growth per year is quite low and shows a decreasing trend towards 2012.

The *Total Hydro* line in Graph 1 and column in Table 1 represents the development of all hydropower plants, irrelevant of size. Both the interpretation of the graph and the CAGR of these data tells us that there has been an overall modest development of hydropower plants in this period. It is worth noticing the very modest development of 0.14% annually during the 1990s, which supports the statements of Thue (2006). However, the CAGR estimations of the 2000s are higher than ever, due to the recent increase in new small hydros.

[5] With the first period (1974 – 1982) covering eight years so that it would fit the data.

2.3.3 The Relative Change

Although the CAGR method is very useful when comparing different data over time, it could also be important to look at the actual relative change in the different hydropower plant sizes from year to year, by calculating $\frac{New\ Value - Old\ Value}{Old\ Value}$, as this could tell us something about trends. Because the data is cumulative, we are in fact talking about a form of *net relative change*, in accordance with the explanation given to Graph 2, but I will simply refer to this as the relative change. The results of these calculations tell the following story:

We can see from Table A in Appendix B that the relative change for small hydros has mostly been concentrated around 0%, i.e. very little year-to-year change, especially during a period from mid-1980s to mid-2000s. Before and after this period, the changes in small hydro development seem to be more volatile, showing little sign of trends. Large hydros had a higher, positive relative change until the late 1980s, when this dropped to revolve around 0.00%, which is comparable to the results I have found earlier in this chapter. The interpretation is as follows; a relative *decrease* indicates a more modest development of hydropower plants compared to the year before, but still a positive development if the relative change is higher than 0.00%. For example, in 2010, there were 442 small hydros, up from 413 in 2009, which represents a 7.0% relative increase. By 2011, the net increase in small hydros was 115, resulting in 557 small hydros, and a relative increase by 26%. In 2012, the net number of small hydros "only" increased by 46 (an 8.2% relative increase), i.e. a positive development, however represented by a drastic decrease in the relative change. A stable growth would translate into a smooth transition from one year to another, like the relative change in small hydro during the period from 2003 to 2012, and large hydro's period running from 1977 to 1983, but besides these two, there seem to be few periods with stable year-to-year developments. The relative change in total hydropower development appears to be more tranquil – and positive – than the separate developments, perhaps indicating that an increase in one hydro size weighs out a decrease in the other, reflecting a possible substitution trend in the hydropower industry.

2.4 The Hydropower Plants' Application Process

The governing body of Norwegian hydropower development is the Norwegian Water Resources and Energy Directorate (NVE), subjected to the Ministry of Petroleum and Energy. Its mission is to supervise the planning, development, and operation of hydropower plants, and make sure the different stages follow the governmental acts, specifically the Water Resources Act of 2000, the Planning and Building Act of 1985, and the Energy Act of 1990

(NVE, 2012a). Through the Planning and Building Act, NVE is subjected not only to the Norwegian government, but also to European Union Directives (NVE, 2009c).

After settling agreements with potential landowners and other property-related business, project developers contact NVE with their proposals. There are three outcomes of developers' first contact with NVE, depending on, amongst others, project size and interference in nature. First, if the proposed hydropower plant is very small – or the project involves an upgrade rather than a new development – and does not entail significant interference in nature, NVE can exempt it from the licensing process. The second, and most common outcome, is that NVE refers the developer to an official license application. NVE processes all license applications for hydropower plants with an effect of 10 MW or less, and this process involves public hearings and inspections, and ultimately a decision. The third outcome is that NVE forms a recommendation to the Ministry of Petroleum and Energy. This happens if the planned hydropower plant has a larger effect than 10 MW, or if the application falls under the Industrial Licensing Act of 1917 or the Act Relating to Regulations of Watercourses of 1917, as is often common with large hydropower plants with reservoirs (NVE, 2010b).

NVE also has the authority to revise license terms, in order to secure that existing hydropower plants' standards follows the regulations. By November 2013, the list of revision candidates includes 432 hydropower plants. The main goal of these revisions is to improve the environmental impact of older plants, and although NVE can impose measures that the hydropower plant owner must take, it is only the *terms* of the license, not the license itself, that are being revised (NVE, 2012c). One of the most common measures to achieve environmental improvements is by introducing *minimum flow requirements*. The goal of these is to secure that a hydropower plant, both reservoir or watercourse-based, does not dry out the watercourse and maintains the water quality, thus ensuring a flow of water that may be vital for the wildlife, or the scenery. NVE decides the minimum flow, in accord with the Water Resources Act, for each license application, and the given flow requirement will effectively reduce the total amount of water that the plant can use for electricity generation.

2.4.1 A Walkthrough of a Standard Application Process

Because most small hydro projects fall under the license regulations, this is what I will focus on further in my thesis. When developers submit a license application, one of NVE's priorities when further processing the application is to determine the controversy of the hydropower plant, according to Arnulf Røkke, Head of Project Development at Småkraft. This includes the public hearings, mentioned above, which are used to establish the "public voice" in the matter. If locals, politicians, or environmentalists raise concerns, the license applicant can address these concerns, and answer questions that the public may have. After this, NVE will make the decision whether the license should be granted or not, and if granted, the public may protest the decision. NVE is left with two options, either they have a noncontroversial application and approves the license, or the potential protests prevent an approval. In the latter case, the project developer can appeal, and NVE will send its decision to the Ministry of Petroleum and Energy. Here, caseworkers will review and process the appeal, and the Ministry subsequently makes its own decision, which is irreversible.

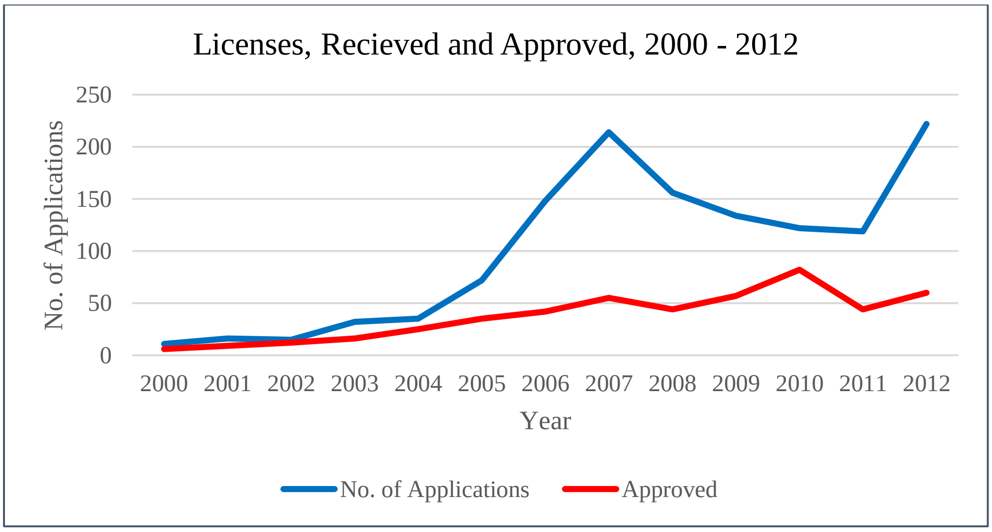
It is worth mentioning that not all license applications are entitled to a public hearing; NVE determines whether this is necessary in the early stages of the process, to filter out "bad" projects. NVE has listed several issues that can act as deal breakers if found too severe, and among these we find projects that violate environmental acts and regulations, that clearly interfere with public interests, and projects based on incomplete applications (NVE, 2012b). Also listed is a relevant question of a project's investment costs and expected revenue. NVE calculates its own realistic *upper-limit revenue*, and if the projected revenue exceeds this, NVE will contact the applicant and inform that they will reject the application if the applicant cannot reduce the investment costs. I will get back to a hydropower plant's investment costs and revenue in Chapter 4.

2.4.2 An Increase in License Applications and Change in Routines

The Norwegian government founded the Norwegian Water Resources and Energy *Department* (NVE) in 1921 and for several decades, it functioned as a governmental generator of hydropower. In 1986, its role as a hydropower developer ended when then-NVE demerged into NVE and Statkraft, and changed its name to Norwegian Water Resources and Energy *Company*. NVE was now solely an advisory body, and to emphasize this, the government changed the name once more in 1998, to the Norwegian Water Resources and Energy *Directorate* (Thue, 2006).

The procedures of the license application process have not changed significantly over the years, as the same fundamental acts and regulations are still in effect. However, NVE has attempted to speed up the process by introducing different kinds of prioritizations, with the most prominent being the Master Plan, *Samlet Plan*, approved by the Norwegian Parliament in 1986. This plan involved watercourses and hydropower projects being classified according to a *potential conflict* scale and costs, where projects placed low on the conflict scale were placed in Category I, and more controversial projects were placed in Category II. Category I projects could apply for a license right away, while Category II projects were put on hold. The Parliament decided, in 2005, to exempt small hydro projects from the Master Plan scheme (NVE, 2013c). NVE introduced a new prioritization scheme in 2012, to deal with the increasing amount of applications, and they pledged to have all applications handed in before January 1 2013 reviewed and processed before 2017, to make the el-certificates system. This new scheme involves prioritizing applications according to their locations, and processing license applications within specific areas at the same time in so-called "packs". By doing so, NVE reduces the pressure in its individual regional offices by evenly spreading out the ongoing application reviews, as well as deprioritizes areas with limited access to the power grid (NVE, 2012b).

In the 2013 Political Platform, the new government introduced its aspiration to improve and shorten the license application process by transferring some of NVE's jurisdiction to the municipalities, especially concerning licenses to small hydros (Office of the Prime Minister, 2013, p. 62). Graph 3 on the next page shows the number of license applications NVE has received each year, as well as the number of approved applications.



Graph 3. Source: NVE, via Kannick, H. (2013)

From NVE's data on licenses, we see that the number of applications started increasing significantly around 2004, before dropping, and then increasing again. We also see that despite the increased number of applications, the number of approved applications has had a steady growth, with certain drops, which at certain points leads to a low percentage of approved applications. In 2007 and 2012, for example, NVE approved only 25.7% and 27.2% of the applications, respectively. The gap is quite significant in some periods, which leads to queues at NVE.

Chapter 3: Methodology

In this chapter, I intend to explain the methodology I have used in my thesis, and precisely why I chose the specific methods and tools. I have mainly based my thesis on qualitative data, with some quantitative support, and I shall clarify my reasons for doing so, and discuss other options, as well as possible errors that may arise in research like this. Furthermore, I will talk about my interviews – how I conducted these, and what possible errors such a source of information could entail.

3.1 Empirical Study and Research

When trying to determine the underlying cause or motivation for a certain situation, or simply trying to describe a large system or population, it is usually necessary to observe, investigate, and conduct experiments to achieve the important knowledge and information. Commonly known as *empirical study*, it is the cornerstone of researches and analyses, and naturally plays an important role in my thesis. We can utilize empirical research to either *describe, explain,* or *predict* situations, depending on what we wish to accomplish, and these three purposes may often intertwine (Jacobsen, 2000). The results of an empirical study will of course differ depending on your initial outlook, but according to Jacobsen (2000), we must be aware of two critical factors when conducting empirical researches. First, the study in question must be *valid*, i.e. what we are observing is in fact what we wish to observe, and second, the study must be *reliable*, which means that we should conduct it in a credible fashion with as few measurement errors as possible. If these two measurements are less than satisfactory, we cannot generalize the findings of the empirical research, and thus the study is not very relevant. Holme and Solvang (1998) stress the importance of a well-formulated and creative research question in an empirical study. Formulating – and limiting – a research question can often be the most challenging part of a study, and that the researcher must “attack” the research question with a critical mind, as it will largely control how you conduct your further studies (Holme and Solvang, 1998, p. 40).

The focus of my thesis is mainly descriptive, as my goal is to investigate the factors driving and slowing down hydropower development in Norway. However, as my research question suggests, I am also hoping to be able to use the information I gather to say something about the future development; therefore my thesis will include a predictive part as well.

3.1.1 Case Studies

In my research question, I have expressed my desire to thoroughly look into and determine various factors in the Norwegian hydropower industry and figure out how these affect the development. Thus, I found it reasonable to apply a case study method, defined by Yin (2009, p. 17) as way to illuminate and understand contemporary decisions, individuals, processes, and events. Through descriptive and qualitative case studies, a researcher is able to study a phenomenon in a "real life" context (Simons, 2009, p. 20). When designing a case study, one must consider the amount of cases that are relevant to analyze and investigate. Yin (2009) distinguishes between *single-case* studies and *multiple-case* studies, and describes a multiple-case study as one where the study focuses on several units, and in each unit the case differ somewhat, resulting in several cases in total. According to Jacobsen (2000, p. 77), the aforementioned units can be single individuals, groups, organizations, or societies. The units a researcher examines in a case study must be restricted in space and time, meaning that the case study should focus on a limited number of industries, schools, companies, etc., and target a specific event or decision (Jacobsen, 2000, pp. 77-78). One can also use case studies to explore and understand the mechanisms of change (Simons, 2009, p. 23). Simons (2009) suggest using qualitative methods to provide a case study with relevant and detailed information, as these allow for an in-depth study of the experience and complexity of actions and policies in their "natural habitat".

As I was designing the case study for my thesis, I found that the definitions of a multiple-case study above seemed quite appropriate for my subject, as my focus, or case, would be on hydropower development and its corresponding decision-making, thus restricting the case in time. By interviewing companies, or units, in close contact with this development, with their own business models and agendas, the main case may split into several similar cases, which I then can analyze and compare.

3.2 Different Methodological Approaches and Their Consequences

When conducting an empirical study, there are several paths one can take in securing the relevant information, and all of these may corrupt the study. According to Jacobsen (2000), four categories of approaches are relevant in empirical studies, and these are *deductive* or *inductive*; *qualitative* or *quantitative; individualistic* or *holistic*; and *close* or *distant* approaches.

First, one must decide whether to address the study *deductively* or *inductive*ly. The former consists of the researcher creating her own expectations about the study, based on earlier empirical finds, and collect information to support these expectations. While being a useful tool for comparing earlier beliefs and theories, Jacobsen (2000) states that such an approach may “cloud” the researcher’s judgment in the gathering of information. When you are looking for a specific relationship, it is easy to only search for the information relevant for this relationship, and disregard other important factors, thus limiting the input of vital information. On the opposite side we find the inductive approach, in which the researcher address the study with an “open mind”, collecting all relevant data and information and uses this to create theories. The latter includes its own risks of interpretational errors. In my case, I went for a mix of these two, while considering the possible errors, as I will discuss later.

The researcher must choose whether to go for a qualitative or quantitative approach. The former includes collecting data and information through personal interviews and observations of the relevant subjects, while the latter involves collecting data – usually numbers – that the researcher can interpret through statistical tools to say something about a large number of individuals. The choice of a qualitative or a quantitative approach connects to what you wish to achieve with your empirical study. A researcher can use a quantitative approach to gain a *total perspective* of the area of interest, and through a qualitative approach, a researcher can acquire transferable knowledge about a certain group and the impact of certain situations (Holme and Solvang, 1998).

The individualistic and holistic approaches connect to how we understand and interpret certain circumstances, as explained by Jacobsen (2000). As individualistic approach focuses on the single individuals in large societies or organizations, and their actions and motivations to understand and draw conclusions about the collective opinions of a society, the holistic view centers on the ever-changing actions and motivations of individuals, for example at work or at home with their family.

The goal of an empirical study is to produce results or theories that are transferable to other similar situations or societies, which other researchers may easily replicate or further develop. This is of course difficult if the original researcher influences the subject in any way that could distort the results. Jacobsen (2000) points out the researcher’s personal values as one of the most important reasons for “contaminated” results. Through a more distant approach, one may mitigate the possibility of non-transferable results, although critics of this approach argue that a closeness is necessary to understand fully the subjected individual.

3.3 Choice of Industry and Subjects of Interest

As soon as I had figured out the topic of my thesis, I started working on a research question that could best reflect and answer the questions I had. Because of the importance of hydropower in Norway, both in the past and present, I limited my thesis to the *Norwegian hydropower*, which also shortened down the list of possible research questions. Initially, I was interested in comparing the Norwegian development of hydropower to that of other renewable resources, like wind and solar power, and look at the implementation of new instruments and methods. However, as the reader will see later in this thesis, the shares of wind and solar power in the Norwegian power industry are still quite insignificant, and the focus on new inventions varies greatly across the different actors in the hydropower industry. Previous empirical studies have looked at some of the important factors of the hydropower development, like the introduction of the el-certificates, and used data and information from the Swedish el-certificates market to predict or explain how this would work in Norway, see for example Aune, Bye, and Hansen (2005). I therefore decided to study the hydropower development as a whole, and by doing so, identify the most common drivers and bottlenecks, according to actors in this industry.

Because of the large number of hydropower plants, as well as the diversity of their owners, I found it reasonable to limit most part of my thesis to small hydropower plants – with an installed effect of 1.0 MW to 10 MW – for two reasons. First, the development of large-scale hydropower plants is arguably naturally impaired because of their sizes and restricted appropriate locations, and second, mini hydropower plants – with an installed effect less than 1.0 MW – are often developed, owned, and operated by private persons, with whom it could be difficult to establish contact. That said, I am looking at the total hydropower development as a part of my supporting theory and analysis, as trends and focus change a lot over decades.

In Norway today, there are several large companies focusing on small hydropower development and operation, and they have very different forms of ownership. The government and municipalities own shares in many power companies through subsidiaries. To acquire the information I needed to answer my research question, I decided to contact several small hydropower-developing companies, irrelevant of their ownership status, as this is difficult to match. In addition to contacting representatives with positions as developers in these companies, I have been in contact with other sources close to the development, which I will discuss further in Chapter 3.4.2.

According to the definitions in Jacobsen (2000), my thesis includes information from mostly *respondents*. These are in direct contact with a situation or subject, and in some way represent the actual group of study. *Informants,* on the other hand, are close to the relevant situation and has great knowledge about it, but do not represent the group. In my thesis, I have interviewed five respondents, of which four are included in my analysis. In addition, I have received valuable information from representatives from NVE, whom I consider highly relevant when it comes to Norwegian hydropower development. I could naturally have interviewed informants, such as private citizens or environmentalist, as these certainly play a part in the social aspects of the Norwegian hydropower. Unfortunately, due to the restricted size and time working in this thesis, the social and environmental aspects are limited to the current respondents' perspectives.

3.4 Collecting the Data

I have based my thesis on individual and personal interviews with respondents from the hydropower industry, as well as one interview and comments via e-mail. To support both the theoretical and analytical part of my thesis, I have collected secondary data and information from governmental sources in the form of quantitative data, as well as the relevant acts and regulations. The intention with this subchapter is to provide information about how to collect data and information accurately, and I will describe how I did this in order to answer my research question.

3.4.1 Primary Data

A qualitative approach involves a certain relationship with the respondent (Holme and Solvang, 1998). A researcher can collect qualitative data and information through interviews, observations, social experiments, and questionnaires, and we call the data a researcher collect directly – and for the first time – for *primary data* (Jacobsen, 2000, p. 124). When an empirical study involves a restricted number of respondents, as mine did, an interview is a good mean of collecting individual perceptions and interpretations concerning relevant phenomena (Jacobsen, 2000, p. 131). It is possible to conduct an interview in person, over the phone, or electronically via either a video conference or e-mail (Sekaran and Bougie, 2013, p. 118), and they all have their strengths and weaknesses. In face-to-face interviews, the researcher can easily clarify misunderstandings and doubt, but these interviews can involve travel costs and are somewhat time-consuming. Telephone and e-mail interviews, as well as video conferences, lack personal proximity and the researcher or respondent can terminate the interview without warning, but they are relatively cheap and very flexible (Sekaran and

Bougie, 2013). As the intention of my thesis in to identify essential, and underlying, situations in hydropower development, I conducted three personal interviews, with respondents from Småkraft, and Tafjord Kraftproduksjon, as well as Robert Rønstad, Project Manager for Small Hydro at the municipality of Norddal, who joined in at the meeting I had with Tafjord Kraftproduksjon. Due to the long travel distance to HelgelandsKraft's headquarters, the respondent and I decided to conduct the interview via video conference, and because of a busy schedule, the respondent from BKK offered his information and help through e-mail. For my multiple-case study, I will compare the cases of Småkraft, Tafjord Kraftproduksjon, HelgelandsKraft, and BKK. My interview and subsequent e-mail communication with Robert Rønstad will form the primary basis of my chapter on hydropower investments, as he provided me with valuable information concerning this subject. In addition, I have included some of the respondents' knowledge and opinions in other chapters of my thesis, as this felt natural.

3.4.2 Secondary Data

In addition to the primary data I collected through interviews, I have also used secondary data to support my findings. Secondary data refers to information collected by other researchers, often through former empirical studies, and may involve books, governmental publications, census data etc. (Sekaran and Bougie, 2013, p. 116). The secondary data in my thesis consist, as mentioned earlier, mostly of qualitative data collected from governmental institutions like NVE and Statistics Norway, as well as governmental acts, and historical accounts of the hydropower industry in Norway. The qualitative data I collected are comprised of annual and quarterly data on electricity prices, electricity generation, as well as accounts of the number of hydropower plants in Norway. In some of the qualitative data, I have taken certain liberties. Most importantly, the data on prices and el-certificates values are not corrected for growth in inflation according to the consumer price index. However, because the secondary data are simply supplementing the primary data in my thesis, I have decided to disregard this, and interpret the data as I collected it, to give the reader a simple overview of the price development. As a preparation for the interviews, I used secondary data in the form of financial statements and press releases concerning the companies I was interviewing.

3.5 The Interview Process

In this part, I will discuss some theoretical factors that I believe play important roles before, during, and after an interview. In addition, I shall comment on how these different factors affected my interviews and thereby my information gathering.

3.5.1 The Structure of an Interview

When conducting an interview, the researcher chooses the structure and order of the interview beforehand. According to Jacobsen (2000), the structure of an interview is either open, closed, or something in between, and Kvale and Brinkmann (2009, p. 130) use the same definitions, using the terms *unstructured*, *structured*, and *semi-structured*, respectively. With little to no questions or order to follow, the interview is as a regular conversation, and we consider it an unstructured interview. On the other side, a researcher could have formulated questions with set answers for the respondent, referred to as a *structured* structure. A semi-structured interview is a mix of these two, where the researcher brings a set of prepared questions or topics, though mainly as an "anchor". As I had a somewhat clear picture of what I needed to know to answer my research question, I chose to follow the semi-structured interview form. Incidentally, one considers this optimal for collecting information (Jacobsen, 2000, p. 133).

Before conducting a semi-structured interview, a researcher usually works on the *pre-structure*, defined by Jacobsen (2000, p. 132) as the process of determining the theme and topics of an interview. The pre-structuring puts the important topics in focus, and it prepares the researcher for the demanding information gathering ahead (Holme and Solvang, 1998). The best way to do this is by creating an *interview guide* (Jacobsen, 2000), which consists of subjects the researcher wish to bring up during the interview. I therefore created an interview guide based on the information I felt was needed to best answer my questions, see Appendix C. A part of the work that went into the pre-structure and interview guide consisted of studying hydropower plants, to avoid spending too much time during the interviews on what is essentially basic information. I constructed my interview guide to follow a simple pattern, with questions relating to the different topics were somewhat separated, to make the connections logical and simple to follow for the respondent. I focused on keeping the questions short and concise to avoid both confusion and leading questions, which could influence and affect the respondent's true motives or thoughts (Sekaran and Bougie, 2013). The main subject of the interviews was the obviously relevant subject of drivers and bottlenecks in the hydropower development, but I also decided to bring up subjects more indirectly related to this, so that I could, in addition to collect and compare statements across cases, make up my own mind concerning the development. By doing so, I was able to compare the responders' answers to a total impression of the interviews, which in my opinion worked quite well. By studying the companies in advance, I could modify my interview guide to suit my responders. Because I have based my thesis on a topic that is not necessarily common knowledge, I did not have the opportunity to test my questions on a well-informed subject in advance. However, I did consult friends and family to ensure that the wording of my questions was not leading or misleading, which could lead to bias, according to Sekaran and Bougie (2013).

The time and location of an interview is often based on what is practical for the researcher and the respondent. Jacobsen (2000) identifies two locations, one that is *natural* for the respondent, and one that is *artificial*. A natural location is one that the respondent is familiar with, like in his home or at his office, while an artificial location is neutral and relatively unknown for both the researcher and the respondent. The location of an interview can affect the information collection process as the respondent may act differently in the two locations, and we know this as this as the *context effect* (Jacobsen, 2000, p. 134). I followed my respondents' requests, and conducted the personal interviews in conference rooms at their workplace, which is quite natural for the respondent. This is also where I believe they feel the most comfortable when it comes to interviews concerning their work.

During the interview, my goal was to assume an attentive, listening position, and by doing so gather information from the respondent (Jacobsen, 2000, p. 138). This includes both a mental and a physical component, and how the researcher conducts himself during the interview may easily affect the respondent and ultimately the information collected. Further, for an open stream of information to occur, it is vital with a certain trust or bond between the researcher and the respondent. I previously mentioned closeness in Chapter 3.2, and there are ways to establish a professional trust. I started by formally introducing myself, explained my research, and asked the respondent if he had any preliminary questions or comments (Jacobsen, 2000, pp. 136-137). It is all about being respectful, polite, and professional, and this was something I focused on to ensure an informative interview.

According to Kvale and Brinkmann (2009), documentation of an interview can include audio and video recording, notes, and memory. A tape recorder allows the researcher to concentrate on the topics, as well as the dynamics of the interview, and the recording is available for further studying. The researcher should take notes as well for two reasons. First, it is a great way to show what you found important at the time of the interview (Jacobsen, 2000, p. 135). Second, you will be able to reference certain parts during the interview, to show attentiveness and interest for the topic as well as for the respondent. A tape recorder can cause uneasiness, so it is important to ask for permission to record the interview. The presence of a tape recorder introduced no protests in neither of my interviews, so I recorded the interviews while also taking notes, which was very helpful in my analysis.

Jacobsen (2000) states that although there are no rules when it comes to the duration of an interview, there are certain time aspects a researcher should focus on. An interview that lasts longer than 90 to 120 minutes will usually be quite tiresome for both the researcher and the respondent, and they may lose focus, while a 30 minutes interview may be too short to gather all information necessary, especially when conducting a semi-structured interview (Jacobsen, 2000, p. 135). An optimal interview should last from 60 to 90 minutes, so I used this length as a template, and I informed my respondents about the desired length ahead for the interview to make sure that the interview did not feel rushed due to lack of time. The shortest interview I conducted lasted 40 minutes, while the longest lasted 77 minutes. When agreeing on a length of an interview beforehand with a respondent, a researcher limits the topics to the given time. Of course, a semi-structured interview where the respondent enjoys talking about the subject can run longer than anticipated, and therefore it is often up to the researcher to end the interview, and doing so in a respectful way (Jacobsen, 2000). At the end of my interviews, I expressed that I believed I had the information I needed in order to research the topic further, and asked the respondent if they had anything else they would like to add, or any questions concerning my thesis, which I happily answered.

3.6 Analysis

My focus during the interviews was to harness valuable information from the respondent, and later be able to analyze, verify, and report findings connected to this information (Kvale and Brinkmann, 2009, p. 177). The post-interview stages are important in empirical case studies, as we wish to compare the information gathered to other interviews or forms of collected data. Therefore, it is important to document the interview carefully, as mentioned in Chapter 3.5. After an interview, the researcher possesses large amounts of raw data that he has to form into *transcribed* data (Jacobsen, 2000, p. 175). Using a tape recorder makes the raw data as complete as possible, but transcribing an interview from a tape can be a tiresome job when the interviews last 60 to 90 minutes (Kvale and Brinkmann, 2009, p. 180).

Further, Jacobsen (2000, p. 178) argues that the researcher should transcribe the notes and tape from an interview as soon as possible after the interview is finished, and supplement the tape recording with the notes for the reason given earlier. I decided to follow this routine, and I transcribed my interviews the same day as my interviews, or the day after, to make sure that the information I got was fresh in my memory. Although my thesis is in English, I decided to conduct my interviews in Norwegian, so in the process of transcribing, I also translated the information I got. The next thing I did, after having translated and transcribed the interviews, was to *categorize* the data, defined by Jacobsen (2000, p. 185) as a way of collecting the information we have from an interview into groups, depending on their topic or theme. This way, I could easily use the information to compare and analyze cases across several different units. After finishing the categorizing, it is often helpful to review the chosen categories and determine whether we have placed a piece of information in a wrong category (Jacobsen, 2000, p. 197). I then used the secondary data I have collected to support the findings and possibly find anomalies, to further strengthen my analysis.

3.7 Ethical Aspects

Ethical issues may easily arise when collecting primary data through interviews, where the researcher must take a respondent's emotions and feelings into consideration. The level of ethical concern naturally depends on the topic of an interview, nevertheless, there are important decisions a researcher must make throughout the entire interview process (Kvale and Brinkmann, 2009, p. 63). As for my thesis, the subject of hydropower is quite non-dramatic, but there are certainly aspects that can cause the respondent to become uncomfortable. When I worked with my interview guide, I realized for example that questions concerning a company's willingness to invest in new inventions could easily sound judging. Therefore, I made sure to structure the interview guide to accommodate for such questions, to mitigate the possible discomfort these may cause.

Further, in some cases the researcher can benefit from purposely withholding information from the respondent, as the subject may be offending and can cause biased answers (Jacobsen, 2000, p. 134). Whether this is ethically right, is for the researcher to determine. As I did not have an "ulterior motive" for my interviews, I clearly stated to my respondents the intentions of my thesis early on, as a means of establishing trust. I also sent most of my topics to the respondents in advance, further to establish trust and to give them a chance to prepare themselves, as some of the questions I had required some background information. The respondent may also withhold information, for either personal reasons or reasons connected to his employer. For example, one of the respondents informed me about a conflict with locals in the construction phase of a plant, but the company in question considers it a personal and irregular case, and the respondent therefore asked me to exclude this from my analysis, which I have done. This could of course cause errors in the results, as the next subchapter focuses on.

3.8 Validity and Reliability

As mentioned in Chapter 3.1, in an empirical study I want to collect information that I can generalize and transfer to other, similar situations or cases (Jacobsen, 2000, p. 369). The terms validity and reliability are measures used to say something about the collected information in an empirical study. Related questions are "how well does the information fit the study?", "did we observe what we were supposed to?", and "was the information gathered correctly?" In the post-interview and analytical phase, it is important for the researcher to ask these questions, and to look carefully at the collected data, sources, and respondents (Jacobsen, 2000). The strength of the collected data and information relates to an empirical study's *internal validity* (Jacobsen, 2000, p. 206). Whether the findings of an empirical study is generalizable and transferable depends on the findings *external validity* (Jacobsen, 2000, pp. 213-214). A way to determine the external validity of your results this is by reviewing other empirical studies, and see whether the findings of your study is comparable, thus somewhat transferable, to the findings of others, defined as *replication logic* by Yin (2009, pp. 43-44).

As for my thesis, I have interviewed five respondents from the hydropower industry, and based on this I believe it is difficult to generalize my findings to apply to all companies in this industry. However, the respondents I have interviewed come from companies of different sizes, backgrounds, and business strategies. The respondents themselves were all male, but they varied in age, professional background, and education. I therefore believe I have been able to capture some of the differences in opinion and thought across the hydropower industry and that the internal validity of my findings is strong. By supplementing my findings with quantitative data, I believe I can further strengthen my findings.

The reliability of the research depends on several factors throughout the planning, collecting, and transcribing of information, and may cause different results in otherwise identical studies (Kvale and Brinkmann, 2009, p. 245). Similar to the aforementioned context effect, the respondent may also experience what Jacobsen (2000, p. 217) calls *interviewer effect*, which happens as the respondent reacts to the researcher's gender, outfit, manners, or background. With this in mind, it is of course possible that the answers given during my interviews would have been slightly different had I been of the opposite sex, or in a different age group, but this is difficult to change. Therefore, to strengthen the general reliability of my findings, I chose to focus on my interview guide and interview behavior. As my respondents all were native Norwegians, I decided to conduct my interviews in Norwegian, to assure that what the respondents gave of information was not limited to their knowledge of the English language.

I have therefore spent much time transcribing the interviews from Norwegian to English, which was time-consuming, but of course necessary to avoid errors during transcription, as mentioned in Jacobsen (2000, p. 220). I am, however, very secure in my English proficiency, so I do not expect this to influence the reliability of my study.

3.9 Weaknesses

In this subchapter, I will talk about the difficulties and weaknesses that may arise in a research like mine, and how it is imperative to overcome such difficulties to produce the best results possible.

First, when conducting an empirical research, there is always the potential risk of measurement and interpretation errors as listed earlier in this chapter. The researcher may inadvertently "create" the results during the study, due to what Jacobsen (2000, p. 18) calls the *research effect*, and he highlights an experiment conducted in a workplace, where the participants knew that researchers were observing them, and therefore acted accordingly when subjected to various stimuli. We know this as the *Hawthorne effect*[6], and this may easily affect any empirical study where a researcher intrudes in a subject's personal or professional life. The Hawthorne effect will to some degree always be present, but by focusing on this and thoroughly designing the study, one is able to mitigate the effect, and produce the most valid and reliable results possible.

Second, in addition to validity and reliability, some other factors will affect the outcome of an empirical study. Sekaran and Bougie (2013, p. 22) describe the damage that could follow a subjective interpretation of research results. When a researcher does not utilize her objective analytical skills when processing the collected data, the result is misleading conclusions largely based on the researcher's own thoughts, opinions, and values. If the researcher is able to stay objective throughout the study, the results produced will be more scientific, and naturally more transferable. Although it is difficult to be your own judge when it comes to objectivity and subjectivity, I do believe I have completed this study with as much objectivity as possible. It also helps that the subject of hydropower does not exactly blur any lines concerning ethical or morality issues, from which, of course, it could be harder to distance oneself. The researcher can also make certain errors during the analysis and interpretation of

[6] Elton Mayo was the researcher of the experiment, conducted in the U.S. in the 1920-30s, where he studied how the physical work environment affected the employees (Jacobsen, 2000, p. 19).

the collected information, that could lead to distorted results, and according to Jacobsen (2000, p. 378), one of these errors is reading too much into the collected information or data. This easily connects to the objectivity factor, and a researcher must be careful in his interpretations to avoid this. To make sure that results are based on the actual information it is important with a critical mindset during the interpretation, and one way to demonstrate this is by including direct quotes in the analysis (Jacobsen, 2000, p. 200). Because I translated the interviews from Norwegian to English, I had the respondents validate their respective quotes, to increase the strength of my analysis.

The third weakness that may affect the results of my empirical study relates to the study samples. As mentioned, the number of respondents in my thesis is not necessarily enough to generalize across the industry. However, when we talk about generalizing in a multiple-case study, we do not apply the same definitions that the general empirical studies are based on, see for example Sekaran and Bougie (2013, p. 22). I wish to collect is the respondent's experiences and thoughts on the subject of Norwegian hydropower, and use this information to see if I can determine differences and similarities between the case-companies. As the reader will see in Chapter 6, some of the companies I have interviewed connects through their parent companies, such as BKK, Statkraft, and ultimately the government. They are major players in the Norwegian hydropower industry, and it is difficult to circumvent these when doing research on small hydropower. However, my impression from the interviews is that the respondents spoke very clearly on behalf of themselves and company that employs them, and never mentioned the parent companies. I therefore chose not to go into the specifics of ownership, as I do not expect this to be an issue in my thesis. The respondents seem very competent when it comes to the subject of hydropower, therefore I consider their opinions and remarks valid and well thought through, and most likely somewhat comparable to those of people in the same positions in other power companies or hydropower investment companies.

3.10 Summary

I have described how I collected the information needed for answering the question I posed in this thesis, and I explained that I have based my thesis on a multiple-case study. I intend to compare the different cases mainly using primary data collected through interviews with respondents from the case companies, supported by additional primary and secondary data. Moreover, I have discussed the pitfalls I find relevant for my empirical study, and clarified how I intend to avoid these to procure the most accurate data and information, and subsequently construct the most appropriate analysis, and results.

Chapter 4: Investments in Hydropower

As we saw in Chapter 2, the development of hydropower in Norway has changed quite a lot over the years, and a shift in focus has occurred. Less interference in nature has been a desired target, shifting hydropower companies from large hydro installations to small hydros. So, what does this mean for the investments that power companies make in hydropower? In this chapter, I will present a general investment plan for small hydros, based on information graciously given by representatives from Småkraft and Tafjord Kraftproduksjon, as well as Robert Rønstad, Project Manager for Small Hydro at the municipality of Norddal.

4.1 General Information

When performing the investment analysis for a hydropower project, the developer must consider several important factors, like future revenue, operating costs, and reinvestments. There is a risk factor connected to the future electricity prices and expected governmental attitude towards hydropower, and the reinvestments factor takes into account the wear and tear on the hydropower plant and its equipment. Naturally, it is not always easy to determine the precise parameters, but the respondents I have interviewed seem to have a somewhat similar approach to get the most accurate investment analysis for a hydropower project. Since the output of a hydropower plant is measured in kWh, developers use this term when considering the revenues and costs of a project, i.e. they estimate parameters in their kr/kWh or øre/kWh equivalents, and use these in their analyses. The developer will then determine whether the estimated revenue and costs are economically viable before starting an eventual license application. As mentioned earlier, NVE conducts its own investment analyses of the applicants, which they use as a benchmark in the application process.

Today, power companies and landowners base their future revenues on two income streams; the price the amount of sold electricity and the income from the el-certificates. Both of these parameters involve certain risks, as they are both market based and thereby subject to sudden changes, which I will describe further in Chapter 5.

4.2 Initial Investment Costs

The initial investment in a hydropower plant depends on the size of the project, and the developer calculates a project's investment estimate in kr/kWh, which I will refer to as the *investment indicator*. This estimate takes the sum of development expenses, like technical equipment, materials, preparatory costs, and perhaps unforeseen expenses, and divide it by the estimated annual average generation multiplied by one million to get the estimate in kWh.

$$Investment\ Indicator\ (kr/kWh) = \frac{Total\ Investment\ Costs}{Annual\ Average\ Generation\ (GWh)\ *\ 1\ 000\ 000}$$

We can interpret the investment indicator as a benchmark for how much a hydropower plant should earn per kWh generated to be completely debt-free within a year. It depends on expected production, and leaves out uncertain measures like future electricity prices. However, developers must take into account at least two potential factors when estimating the denominator in this formula. First, they estimate this based on the Norwegian weather throughout the year. This is of course hard to predict, and a dry year can decrease the denominator, effectively increasing the investment in kr/kWh, and vice versa. Second, it is the effect of the turbines and the general efficiency of the hydropower plant's separate parts that determine the annual average generation, and this is of course subject to change as the equipment wears out.

Mr. Rønstad has provided me with an investment analysis of a hydropower plant with an installed effect of 1.0 MW, i.e. a mini hydro. This project has a drop height of 353 meters, and the analysis suggests a Pelton turbine for this hydropower plant. The annual average generation of the project is 6.127 GWh, which results in an annual income of kr. 1 838 072, based on an electricity price of 30 øre/kWh. Through experience-based information given by NVE, an estimated investment cost of this project – including technical equipment, pipeline, and infrastructure – is kr. 18 858 888, which results in an *investment indicator* of 3.08 kr/kWh, according to the formula given above. In this analysis, it is the pipeline and its accompanying tunnel that hold the largest shares, with 15% and 28% of the total investment costs, respectively. These costs are depending on the topography and geology of the potential site, and may increase significantly in areas with mountains or stony grounds. The turbine and the intake, usually considered the most vulnerable parts of a hydropower plant, account for about 17% of the initial investment.

Each individual power company, depending on their attitude towards risk and future earnings, sets the upper profitability indicator. Through my interviews, I have established that the maximum investment limit seems to be quite transferable from one company to another, especially when considering small hydros. According to Arnulf Røkke, a project with a realistic estimated investment indicator of 1.5 to 4.0 kr/kWh is most likely a profitable project, accounting for future dividends and other financial goals. Naturally, these goals may differ between power companies and landowners, thus creating a difference in upper investment limit. Per Kåre Skudal, Project Developer at Tafjord Kraftproduksjon, points out that an investment up to 5.0 kr/kWh is justifiable for landowners whom are able to fulfill their commitments with less focus on immediate dividends. Developers also use the initial investment indicator when seeking financial support for a planned project. Rønstad explains that he uses an upper investment limit of 3.5 kr/kWh when analyzing projects, and with this, or a lower, investment cost; private developers are usually able to get the project fully financed through a bank. Considering the fact that mini hydros normally demand a kr. 15 million investment, a partially or fully financed loan is often necessary for landowners to realize their projects. For small hydros, Røkke estimates an average investment cost of kr. 30 to 50 million, and Småkraft has developed hydropower plants in the kr. 16 million category, as well as some that have crossed the kr. 100 million mark.

Due to the uncertainty connected to the electricity prices and el-certificates value, a hydropower developer usually calculates a project’s profitability with relatively conservative electricity prices, and often both with and without the el-certificates income, to get a clear view of the future profits. Both Rønstad and Skudal consider a long-run electricity price of 30 øre/kWh a conservative estimate. For a kr. 15 million hydropower plant with the income mentioned above, and the regular operating costs, Rønstad suggests that an initial investment loan can be down-paid within 20 to 22 years, i.e. about half of the financial 40 year lifespan of a small hydro.

4.3 Reinvestment in Equipment

In an investment analysis, a developer generally calculates a lifespan of 40 to 60 years, depending on the size of the project. This is mainly a financial measure, used to calculate the net present value of an investment, based on the period the developer expects the hydropower plant to generate an income, and does not necessarily reflect the actual planned operation of a hydropower plant.

During the lifespan, it is, however, necessary with reinvestments in new equipment, as it is unreasonable that all parts of a hydropower plant should last as long as 40 years or more. According to Rønstad, a revising of the plant is performed every 10 to 15 years, in which the plant is thoroughly reviewed and the required reinvestments are made. The aforementioned wear on the intake and turbine is the most common reason for reinvestment, which can cause some financial distress if not included in the early stages of the development. Due to the rather frail nature of mechanical equipment, routine maintenance of the hydropower plant is imperative, throughout the year, to reduce the risk of system failure.

4.4 Operating Costs

With cold winters and relatively warm summers, hydropower plants in Norway experience quite a change in water input during a year, especially those based in watercourses. As I have explained earlier, a plant's electricity output is measured for both summer and winter, and the investment analysis described in Chapter 4.2 denotes *Summer* from May 1 to September 30, and *Winter* from October 1 to April 30. Summer accounts for 62.5% of the annual average generation, while Winter accounts for the remaining 37.5%. With this difference in electricity generation, it is clear that a hydropower plant must be able to handle quite different water input, depending on the season. While the technology today in most cases will allow for variation in water input, one must consider other factors connected to the changing of the seasons that may damage the plant in any way. One of the largest posts in the operation budget is protecting the plant against destructive watercourse sediments. I mentioned earlier the small pool that developers install in front of the intake in watercourse hydropower plants, and how this has a protective function. According to Skudal, the pool catches some of the heavier sediments that the water carries, before entering the plant, thus releasing some of the pressure on the intake. Consequently, owners must empty the pool from time to time.

Lighter watercourse sediments and leaves will continue to, and stop at, the intake. In most cases, this will lead to an accumulation of debris, which owners or those in charge must remove manually. Skudal explains that during the fall, it is often necessary to remove leaves and such from the intake up to two times a day, which of course increases operation costs. In general, developers estimate the operating costs based on calculations for each planned hydropower plant, and convert them to øre/kWh in the investment analyses. Although it is difficult to say without a specific project, Røkke estimates the typical operating costs to be around 2.7 øre/kWh, and Skudal suggests that an operating cost of 3-5 øre/kWh is feasible. Both of these estimates are comparable to the one in the investment analysis provided by Rønstad, where the miscellaneous operating costs – excluding costs connected to rent, accounting, and amortization – accounts for 4.9 øre/kWh. However, because a hydropower plant's lack of need for fuel, its operating costs are significantly lower than other electricity generating plants, like nuclear power plants or coal/ gas-fired power plants. Martin-Amouroux (2004) estimates that while it is unusual that the operating cost in its kWh equivalent exceeds 25% of the total costs of a hydropower plant, they can account for as much as 40% for nuclear power plants, and 70 to 80% of a coal or gas-fired power plant's investment.

4.5 Summary

As we have seem in this chapter, investments in mini and small hydros can be quite large, especially from a landowner's point of view. A landowner hoping to generate electricity, for example for his farm, will most likely not be able to invest kr. 15 million in a hydropower pant out his own pocket, and is therefore depending on investors, or a bank willing to provide financial aid through a loan. To secure such a loan, the watercourse in question must be able to secure an effective electricity generation through a high amount of GWh output, thereby decreasing the investment indicator. The respondents in my thesis suggested that a desired investment indicator is 3.5 kr/kWh or below, with which one is often able to secure an investment loan. A power company or a landowner must also take into consideration the risk of unexpected changes in future electricity prices, which will greatly affect the income, thus the need for an initial investment analysis. However, as we have seen, the initial capital costs accounts for a large amount – more than 75% – of a hydropower plant's total costs, according to Martin-Amouroux (2004), making the regular operation and maintenance costs in the future relatively low.

It is also apparent that the mechanical equipment of a hydropower plant poses a risk for developers. During the five months usually considered summer, the incoming waterpower results in a 60% increase in electricity generation compared to the seven winter months[7], making year-round maintenance and supervision to secure the equipment fundamental parts of the hydropower plant operation. The instrumental components of a hydropower plant are expensive, and their limited lifespan makes it necessary with relatively large reinvestments throughout the operation of the plant, which may come as a financially devastating surprise if neglected in the early stages of planning.

Despite the risks of changes in future income due to the various reasons described above, Røkke, Rønstad, and Skudal all seem to be quite optimistic when talking about the general investment analysis for a hydropower plant as long as you take the future risk into account and estimate the investment with conservative figures and calculations.

[7] Based on Rønstad's calculations: Production at 3.829 GWh during *Summer*, and 2.298 GWh during *Winter*.

Chapter 5: Electricity and El-Certificates

While projects involving newer forms of renewable energy sources, like wind power, are often eligible for financial investment support through governmental-owned *Enova*, the seasoned hydropower relied solely on the earnings of sold electricity to market price from 1991 until the introduction of the el-certificates on January 1 2012 (Skudal, 2013). In this chapter, I will first look at the evolution of the electricity prices since the late 1990s, which seemed to be the turning point for small hydro development, as seen in Chapter 2.3.1. Second, I will explain how the el-certificates work in Norway today, and present the development of the el-certificates' value.

5.1 Electricity Prices

With the deregulation of the market in 1991 came new solutions for the distribution and sale of electricity, as described in Chapter 2.2.12. The Energy Act opened up for competition in the wholesale market, and power companies lost their exclusive supply rights (Bergman et al, 2000, p. 125). In 1993, the government put *Statnett Marked*, a subsidiary of Statnett, in charge of the Norwegian power exchange, and there were no restrictions on membership – any producer, consumer, or trader could participate in the exchange. In 1996, as the Swedish power market joined in, Statnett Marked changed its name to *Nord Pool*, becoming the first cross-borders power market in the world (Nord Pool Spot, 2012a). Since then, the Nord Pool power exchange has grown to include the power markets of Denmark and Finland, gathering the entire Nordic power market on one exchange. In 2008, the financial component of Nord Pool was sold to NASDAQ OMX Commodities, while *Nord Pool Spot* became in charge of running the power market, which soon included the two Baltic countries Estonia and Lithuania. The currency used in Nord Pool Spot is Euros, and they measure the prices in EUR/MWh. This means that usually when we are talking about electricity prices in kr/kWh, we have not only converted from MW to kW, but also considered the appropriate exchange rate.

At Nord Pool Spot, one can trade electricity much like any other commodity. The Nordic Exchange follows the principles of a traditional voluntary pool model, where producers can submit their goods to the pool, whose mission is to function solely as a third-party handler (Harris, 2006, p. 165). Nord Pool Spot operates with two markets, a day-ahead market and an intraday market, named Elspot and Elbas, respectively (Nord Pool Spot, 2013a). The market-based price, based on supply and demand, is predominantly determined in the Elspot market, where most of the trade for delivery the next day happens. The seller, in our case an owner of a hydropower plant, decides the quantity of electricity he can deliver and to what price, while the buyer on the other side determines how much he needs and is willing to pay. The seller and buyer then register their order in the auction-based Elspot trading system. As the deadline for submitting orders and offers passes at 12:00 CET, the *system price* is set. This price marks the equilibrium between hourly generation and consumption, which is the reference price of the day, and we can describe it as somewhat theoretical. The reason for this is that the pool bases the system price on no transmission bottlenecks, i.e. a free flow of electricity throughout the Nordic market.

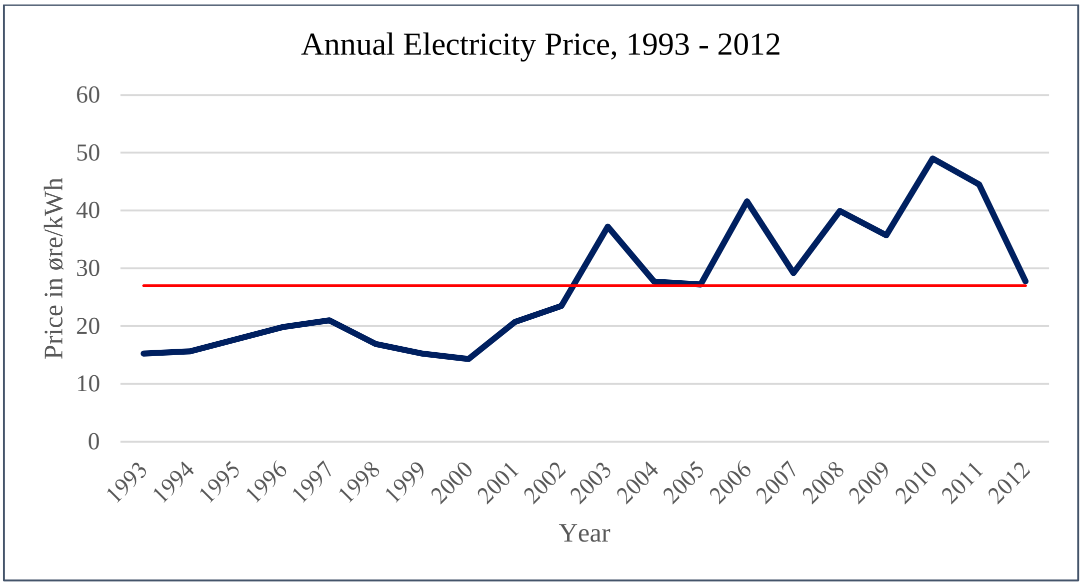
However, each country's network operator divides the country into so-called bidding areas based on transmission capacity, and this capacity, calculated for every hour, decides the eventual *area price*. If the electricity flow to or from an area exceeds the given capacity, the mechanisms of the pool calculates the area price to reduce the stress on the grid through the supply and demand theory. The mechanism introduces the grid constraint in the calculations, effectively increasing the price if the area experiences electricity scarcity, motivating power companies to produce more, or decreasing the price if the area has an abundance of generated electricity (Nord Pool Spot, 2013b). Nord Pool Spot uses its intraday market – the Elbas market – to support the Elspot market by allowing for almost immediate trades even after 12:00 CET. This may be necessary if the market powers in either the supply or the demand side malfunction because of unforeseen events in the electricity markets, like the temporary shutdown of a large power plant (Nord Pool Spot, 2013c).

An article in SINTEF (2007) explains that the basis of electricity prices in the Nordic market lies in the costs of generating the electricity – the power plants with high marginal costs drive the prices up, which is why we see fluctuations in prices throughout the year. Hydropower plants are, as mentioned earlier, relatively cheap to operate, so in periods with warm temperatures the hydropower-generated electricity can deliver a large percentage of the total supply, decreasing the electricity prices. However, as the temperature sinks, power plants fired by natural gas, coal, or oil, must generate electricity to meet the demand, increasing the marginal costs, thus increasing the electricity price.

5.1.1 The Development of Electricity Prices in Norway

The electricity prices were quite low after the introduction of the Energy Act in 1991. Thue (2006) lists full reservoirs and higher temperatures as two of the main reasons, while the article in SINTEF (2007) gives credit to the effectiveness of the newly liberalized electricity market, as power companies in the 1980s sold the abundant electricity generated cheap to Sweden, leaving the Norwegian electricity consumers with most of the costs.

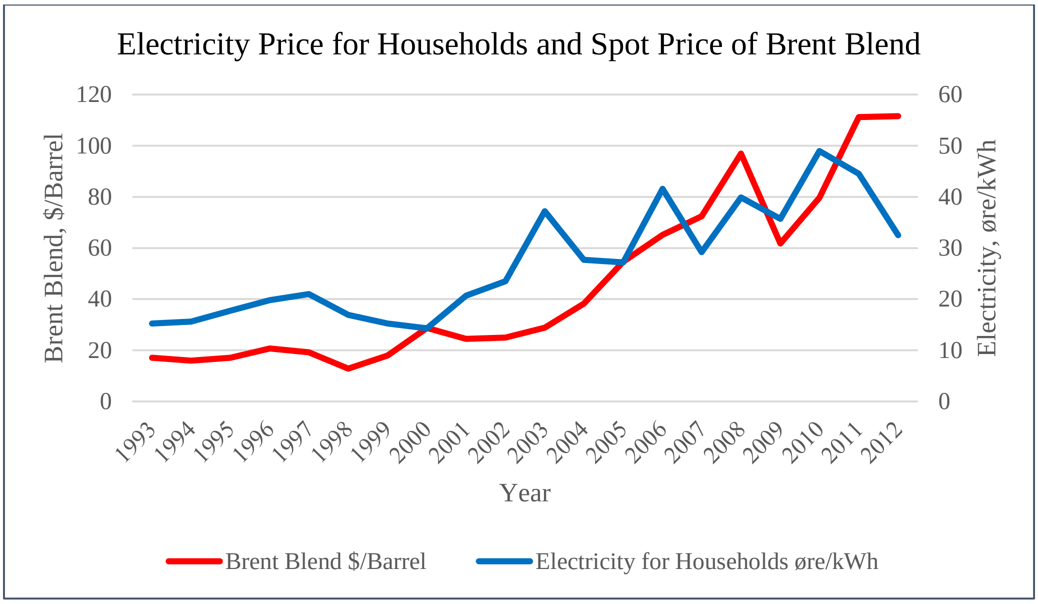
Data on annual Norwegian electricity prices for households from SSB, running from 1993 to 2012 show that the electricity price differs quite a lot between households, agriculture, energy intensive industries, and wood processing industries. I have chosen to just include the households variable, as I consider this the most relevant when it comes to the public opinion on electricity prices. Graph 4 illustrates this development.



Graph 4. Source: SSB (2013c).

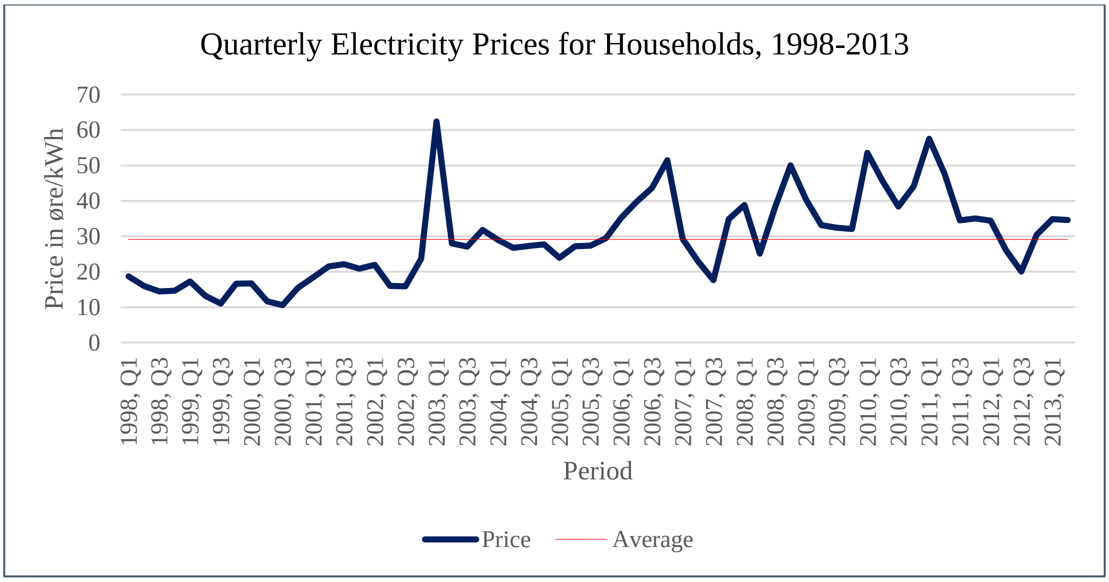
My calculations reveal that the average price during this period was 26.98 øre/kWh, represented by the horizontal red line in the graph. As we can see, the price fluctuates quite a lot, and there seems to be signs of a *break*, i.e. a discrete change at certain date (Stock & Watson, 2012, p. 598), in 2001/02. Holstad and Pettersen (2011) argue that the significant increase in electricity prices during this period comes as a reaction to higher prices of oil, coal, and natural gas, which raises the marginal costs of power plants based on these fuels.

To look at the impact of the price of petroleum on electricity prices, I have collected data on the historical spot price of Brent Blend, which is the benchmark for the North Sea oil. Graph 5 on the next page shows the price of electricity for households combined with the price of Brent Blend.



Graph 5. Source: SSB (2013b) and the U.S. Energy Information Administration (2013).

The data from the U.S. EIA tell us that the 1990s was a period with relatively low and stable oil prices, and that the oil price has in fact experienced quite a growth since 2002, with the exception of a sudden drop around 2008, most likely due to the global recession. When comparing the oil and electricity prices, we see that the patterns are very similar, with an almost identical path during the 1990s. From the early 2000s, both series share a resembling development, after which they appear to be moving in a coherent fashion. Worth noticing is the stabilization of the oil prices from 2011, and the sudden drop in electricity prices for households at the same time. When we look at the quarterly data on electricity prices since 1998, represented by Graph 6, we get a clearer picture of the seasonal trends.



Graph 6. Source: SSB (2013d).

The quarterly data supports the argument made in the SINTEF (2007) article that there is a connection between electricity prices and time of year, and we see that the lower temperatures in the winter usually increase the price, as shown by the spikes that occur around the first and fourth quarter of each year. Two points are worth pointing out. First, the quite dramatic increase in the beginning of 2003, where the price increased to 62.4 øre/kWh. Second, the "missing" spikes in the winters of 2003/04, 2005/05, and 2011/12, when the electricity price declined from the fourth quarter to the first quarter. One explanation for the relatively low electricity prices these winters can be full reservoirs due to heavy precipitation during the year, diminishing the need for expensive-fueled electricity generation.

In the previous chapter, I briefly talked about hydropower developers' conservative estimate for future electricity prices, which currently revolves around 30 øre/kWh. According to Skudal, owners of hydropower plants base their estimates on the Elspot price, which is the actual price they get for the electricity they deliver. To get more knowledge about this exact price path, I collected data on the annual reference spot price since 1998, and compared this to the Brent Blend spot price, see Figure 1 in Appendix D. The average Elspot price was in this period 25.35 øre/kWh, though seemingly weighted down by the low Elspot price before 2002. If I adjust the calculation to find the average Elspot price from 2002 to 2012, the result is 29.86 øre/kWh. Once again, we see a similar pattern of the electricity price and the oil price. This is of course because of the price path of Elspot is almost identical to the electricity price for households, albeit constantly a little lower. Because the Elspot data was restricted to 1998 and onwards, I decided to use the electricity price for households going back to 1993 to illustrate the electricity price path in this chapter.

5.2 El-Certificates

The El-certificates system is an incentive-based instrument used by governments to increase the national interest for – and hopefully, the development of – renewable energy sources. The desired targets are power companies, developers, industries, and others that deal with or generate electricity, and what it does is introducing a second income for those who invest in renewable energy.

5.2.1 Background

The Kyoto Protocol first introduced a way for producers of renewable energy to make money on their clean energy through its three market-based mechanisms *Emissions Trading*, *Joint Implementation*, and the *Clean Development Mechanism*. These mechanisms puts a price on carbon, which countries can trade in the international carbon market (UNFCCC, 2013b). The

Emissions Trading scheme involved the UNFCCC assigning a certain amount of pollution permits to each participating country, based on their emissions and reduction goals. Countries could then sell excess permits, i.e. if they polluted less than expected, to countries that exceeded their goals. The Clean Development Mechanism opened up for countries to harness renewable energy through projects in developing countries; while the Joint Implementation scheme let developed countries work together on renewable energy projects. However, economists and environmentalists have raised concerns about these mechanisms, see for example Talberg and Nielson (2009), fearing that they may lead to exploitation of developing countries, as well as a false sense of "green action" in developing countries due to renewable energy project that are in fact accredited someone else.

The el-certificates system is more restricted, as they usually are confined within one nation, but the goal is the same: reduce national CO_2 emissions by rewarding developers of renewable energy. Sweden introduced the el-certificates system on May 1 2003, and on January 1 2012, the joint Swedish-Norwegian certificates system went into effect, with the collective goal of increasing renewable energy-based electricity generation by 26.4 TWh – which accounts for the electricity consumption of about half of Norwegian households (NVE, 2013d) – by December 31 2020. The system includes all power plants based on renewable energy, such as wind, hydro, wave, and geothermal power, to mention some. The Ministry of Petroleum and Energy, the Norwegian system's legislative body, decided that all power plants built after September 7 2009 were eligible for el-certificates, making the system retroactive. Also included are upgrades of existing hydropower plants within the same period, as long as the developer can demonstrate a permanent increase in the upgraded plant. However, it is only the new electricity generated that is eligible for el-certificates.

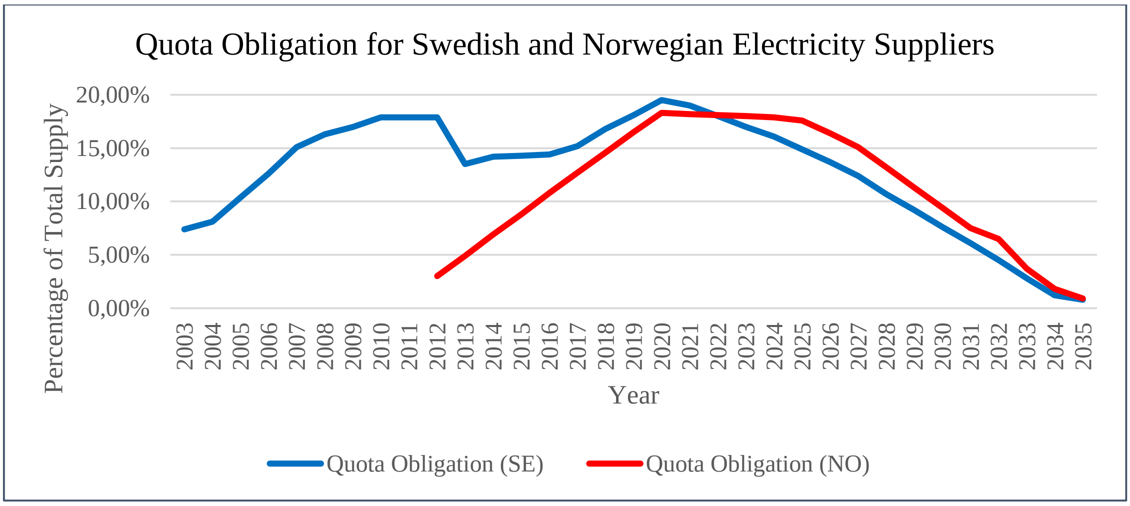
5.2.2 How They Work

NVE manages the el-certificates, which Statnett then distributes to electricity-generating companies or persons for each new MWh generated by the use of renewable energy sources, who will receive such certificates for 15 years. The government finances the system through the electricity suppliers, enforcing an obligation to buy el-certificates, thus securing the supply and demand needed to set the value of the el-certificates (Ministry of Petroleum and Energy, 2012b). Electricity suppliers deal with this extra cost by adding a fee to the consumers' electricity bill, meaning that the el-certificates are in the end consumer-financed.

In determining the value of the el-certificates, one must look at the market mechanisms. First, NVE determines which power plants that are eligible for receiving el-certificates through the

Electric Certificates Act, and informs the distributer, Statnett. This part of the supply function is somewhat fixed as it is determined by the act, and of course the number of new eligible power plants. The Electric Certificates Act's §16 sets the demand, thus this side of the valuation process is also somewhat fixed, and possible to determine in advance. Nevertheless, the value of the el-certificates varies quite a lot, posing a risk of over-valuation to developers of hydropower. How is this possible?

In fact, it is the government, through the Ministry of Petroleum and Energy, who decides the final "mobile" demand, because electricity supplies do not have to buy el-certificates to cover their entire supply. A *quota obligation* rate is set for each year until the final year of el-certificates in 2035, 15 years after the system closes. In 2013, the quota obligation for electricity suppliers was 4.9% of their total supply, and it is expected to increase until its peak of 18.3% in 2020, after which is will slowly decline to .9% in 2035, as described in the Electric Certificates Act, §17, see Graph 7. The rates are set to reach the desired target of 13.2 TWh by 2020, i.e. half of the combined Swedish-Norwegian new renewable energy target. Included in the graph is also the Swedish quota obligation, represented by the blue line.

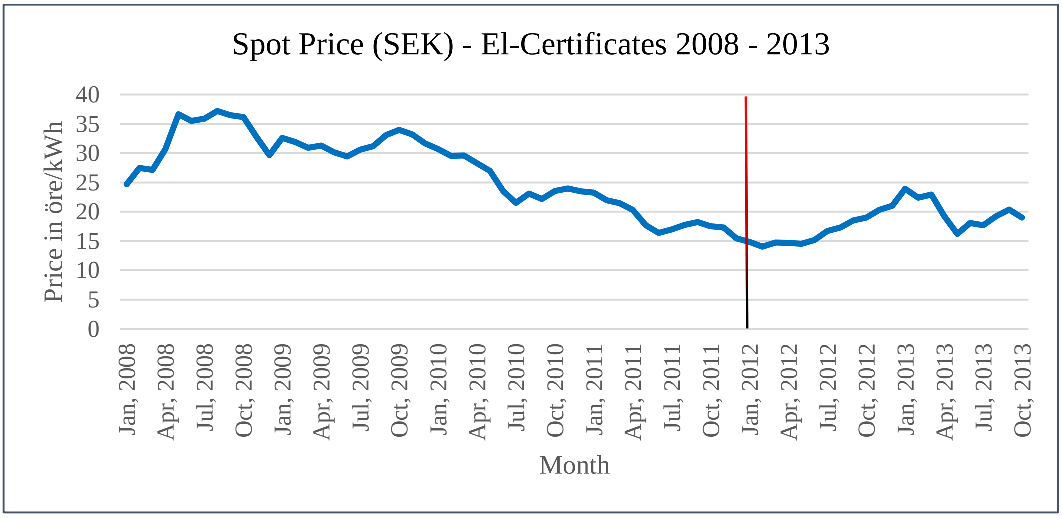


Graph 7. Source: The Electric Certificates Act of 2012, §17 and Energimyndigheten (2012).

<u>5.2.3 Value of El-Certificates</u>

As noted in the section above, the value of the el-certificates fluctuates. The Swedish and Norwegian governments have carefully estimated the quota obligation rates to encourage the desired amount of new renewable energy, and to secure the value of the el-certificates as best they can. However, because the system base the quotas on the amount of electricity supplied, the value is prone to changes as electricity generation and consumption shift. In its estimations, the legislative Ministry assumed an annual increase in electricity consumption of .3%, although they note that this is hard to predict (Ministry of Petroleum and Energy, 2010).

Thus, if the quota obligation is too high, compared to the actual amount of new renewable electricity generated, the value of the el-certificates will increase, and vice versa (Energi Norge, 2011). The development of the el-certificates' value is shown in Graph 8 below.



Graph 8. Source: Svensk Kräftmekling (2013).

The vertical line represents Norway's entrance into the joint Swedish Norwegian market on January 1 2012, and as we can see, the price has indeed varied over the years, from close to 40 öre/kWh[8] in 2008, to 15 öre/kWh in the beginning of 2012. Skudal states that he operates with a conservative el-certificates estimate of 15 øre/kWh, which appears to be a little below the historical average spot price.

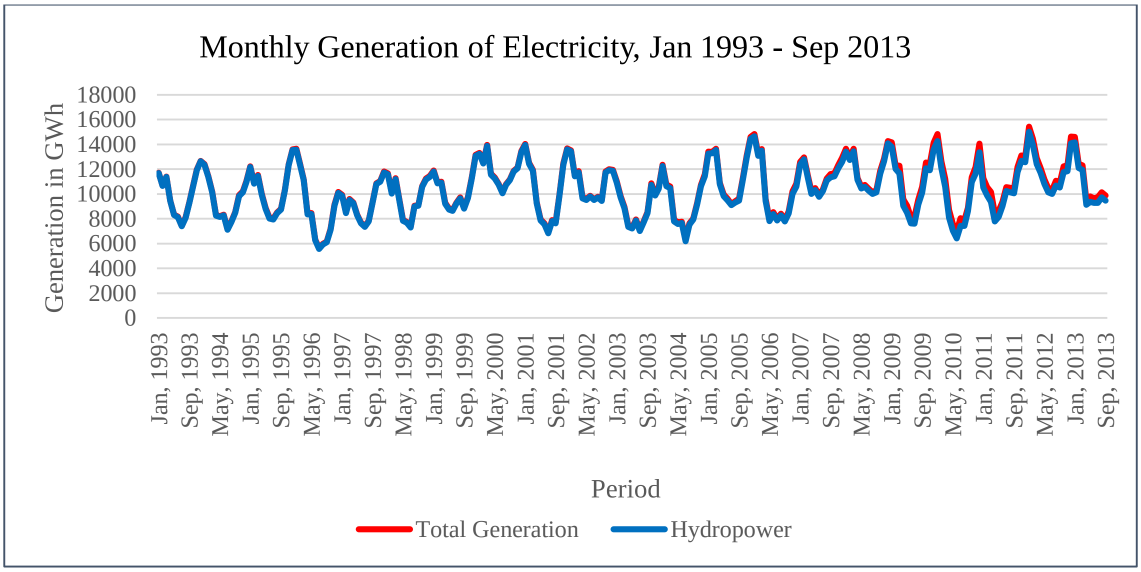
The Swedish and Norwegian governments will also evaluate the el-certificates system from time to time, at so-called *checkpoints*. The first checkpoint is in 2015, and the agenda of these is to secure that the market functions as desired, and make necessary adjustments concerning the quota obligation, length of the system, and so on (Ministry of Petroleum and Energy, 2011).

5.3 Electricity Generation

In Chapter 2.3.1, I presented the development of hydropower plants the past 40 years, and in this chapter, I have thus far described the electricity prices and the underlying supply and

[8] We measure the value of El-Certificates in Swedish kronor (SEK). The past years the value of 100 SEK has been equal to about 85 NOK (Norges Bank, 2013), thus the value of the El-Certificates is a little lower in NOK.

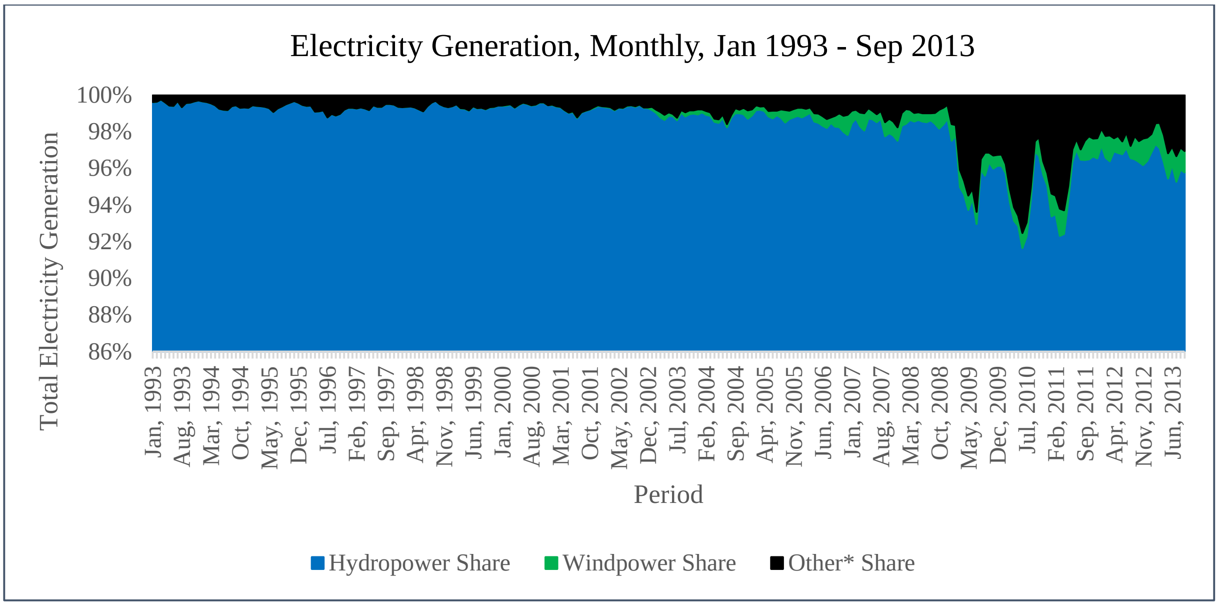
demand in the Nordic market. Another factor I feel it is important to include in this thesis is the electricity generation, and how this has evolved through the years of varying number of new hydropower plants and electricity prices. Norway is one of the world's largest consumers of electricity per capita (EEA, 2012), but does the national electricity generation meet the demand? As we can see from Figure 2 in Appendix D, this depends on the time of year. During the summer months, consumption is lower than generation, resulting in a national electricity surplus, ready for export. During the winter, however, the Norwegian electricity generation does not always meet the demand, resulting in a need for import. Graph 9, below, shows the total monthly electricity generation from 1993 to 2013, together with the amount of electricity generated by hydropower, to illustrate the idea that hydropower cannot always deliver, as mentioned in Chapter 5.1.



Graph 9. Source: SSB (2013e)

The data show a clear seasonal pattern, with high generation during the winter and low during the summer, as expected. However, the electricity generation from year to year seem surprisingly stable, and only a slight upwards trend is detectable when looking closely at the data. Further, as visible by the red, and sometimes indistinguishable, *Total Generation* line, other sources of power have played a role in the total electricity generation since late 2008 and onwards. Graph 10 on the next page shows the shares of the three main power sources in Norway, hydropower, wind power, and thermal power, where the latter consists of power plant heated by either natural gas or biofuels. The graph shows a somewhat decreasing importance of hydropower, although at its lowest in June 2010, we are still talking about a 91.65% share. The share of wind power in Norwegian electricity generation appears to have grown since

2004, claiming 1.44% of the total generation at its peak in October 2012, yet reduced to 1.16% by September 2013.



Graph 10. Source: SSB (2013e)

Over the entire period, hydropower holds an average of 98.28% of the total electricity generation in Norway, but the actual share in September 2013 was 95.78%.

5.4 Summary

In this chapter, I have concentrated on the Norwegian electricity prices, generation, and consumption, as well as characterized the el-certificates system and described the mechanisms behind it. The electricity prices appear to have permanently increased since the 1990s, resulting in a higher income for hydropower plants. There are also clear signs of seasonal trends in the prices, indicating restricted supply from Norwegian hydropower plants during colder periods, which could account for the increasing share of other energy sources in the total Norwegian electricity generation. As for the el-certificates system, this seems to be based on thorough calculations concerning electricity generation and consumption, even so, the value of the certificates still fluctuates with increased demand and supply of electricity.

Chapter 6: Presentation of the Case-Companies

The companies I interviewed are, as mentioned earlier, of different sizes and have different types of ownership. In this chapter, I will therefore give a short description of the case-companies, in which I will include details that I consider relevant for the subsequent analysis.

I have based the company presentations below on information given during the interviews, as well as information available at the companies' websites, including "about us" documents and financial reports.

6.1 BKK

The municipality of Bergen and eleven other nearby municipalities formed what was going to be Western Norway's largest power company, BKK, in 1920. Since then, the ownership structure has changed some, with Statkraft AS, subsidiary of the government-owned Statkraft SF, now owning 49.90% of the stocks in BKK. The municipality of Bergen owns 37.75%, and various municipalities hold the remaining 12.35%. BKK has about 1 100 employees, and had in 2012 a net income of kr. 835 million, making it the largest company I interviewed for my thesis, both in number of employees and financially.

BKK owns and operates 32 hydropower plants with an estimated annual average generation of 6.7 TWh, which also include the partially owned Sima hydropower plant. The sizes of BKK's hydropower plants vary a great deal, from Stend power plant, with an installed effect of .9 MW, to the Evanger power plant, with an installed effect of 330 MW. Further, the plants differ in type, with most of them categorized as reservoir-based hydropower plants. However, most of the plants are located in the same areas, and base their water input on the same regulated watercourses and lakes. BKK operates with six "main" watercourses, in which 23 of the plants are located, with the remaining nine plants located elsewhere.

The respondent from BKK, Erik Skorve, is the Division Manager of BKK Produksjon, a subsidiary of BKK, and Skorve holds a Civil Engineering degree from the Norwegian University of Science and Technology (NTNU). My interview with Skorve was conducted through e-mail, and is therefore not as extensive as some of my other interviews, but I received relevant information that I found very useful in my analysis.

6.2 Småkraft

In 2002, Statkraft, Agder Energi, BKK Produksjon, and Skagerak Kraft formed Småkraft, a company with a focus on developing small hydros on a national scale. Småkraft is through its parent companies both government- and municipality-owned, and its headquarters is in

Bergen, Norway. Småkraft receives applications from landowners who wish to develop a hydropower plants on their land, reviews these, and determines whether the projects are economically viable. Thus far, 270 projects have started with a landowner agreement, of which Småkraft has discarded many due to findings of red-listed species and other issues. A total of 35 projects are licensed, but are currently located in areas with restrictions on the power grid, and by the fall of 2013, Småkraft owns and operates 35 hydropower plants, where most of the plants have an installed effect of around 5.45 MW or less. Småkraft's power plants account for a total annual average generation of about 400 GWh (.4 TWh). Småkraft's goal is to reach an annual average generation of 1.5 TWh. The company employs about 30 people.

All of Småkraft's hydropower plants are watercourse-based, so they are used to less interference in nature than other companies with varying types of hydropower plants, and its focus is on increasing the efficiency in such plants through the equipment.

The Head of Project Development, Arnulf Røkke, was the respondent from Småkraft, and he is educated at the Norwegian School of Economics (NHH). I met with Røkke in Småkraft's offices in Bergen, of which he also gave me a quick tour.

6.3 HelgelandsKraft

Established in 1995, HelgelandsKraft (HK) is a municipality-owned power company based in Mosjøen, Norway. The largest shareholders are the municipalities of Rana and Vefsn, with 26.85% and 18.28%, respectively. In 2012, HK reported a net income of kr. 55 million, and they currently have about 300 employees.

Today, HK owns and operates ten wholly owned hydropower plants, in addition to Kolsvik power plant, in which HK owns 50% of the shares, with Nord-Trøndelag Elektrisitetsverk (NTE) as the other shareholder. The sizes of HK's power plants vary, from an installed effect of 2.0 MW to 55.0 MW, and the category of the plants varies as well, depending on the size of the plants, with the small hydros being watercourse-based and the larger ones being based on reservoirs and regulated watercourses. The annual average electricity generation for HK's power plants is approximately 1.0 TWh, of which HK's share of Kolsvik power plant accounts for 252 GWh. In total, three of HK's ten power plants account for close to 80% of their total generation.

HK usually confines its developments to the Helgeland area in Mid-Norway, and is currently developing the Øvre Forsland power plant, which they affectionately refer to as "the most beautiful hydropower plant in Norway". The plant will have an installed effect of just below

10 MW, and an annual average effect of about 30 GWh. In the fall of 2013, HK has eleven projects under planning or construction.

The respondent from HelgelandsKraft was Tore Bjørnå-Hårvik, who has worked as Project Developer at HK for two years, and graduated in 2008 from NTNU with a Civil Engineering degree, with focus on hydropower. I conducted the interview with Bjørnå-Hårvik though a video conference.

6.4 Tafjord Kraftproduksjon

Tafjord Kraft established its subsidiary Tafjord Kraftproduksjon in 1997, to manage the company's power generation and transferring. Based in Ålesund, Norway, Tafjord Kraftproduksjon is through its parent company owned by the municipality of Ålesund and BKK. For simplicity's sake, from here on I shall refer to Tafjord Kraftproduksjon as Tafjord.

Tafjord wholly owns and operates eleven hydropower plants. Furthermore, the company owns 34% of the shares in Svelgen Kraft Holding AS, which owns two hydropower plants and rents an additional two. The largest of Tafjord's power plants, *Tafjord 1* to *5*, are located in the Tafjord Mountains, and are reservoir-based, while the company's smaller plants are watercourse-based. In total, the annual average generation of Tafjord's plants is about 1.1 TWh, and their installed effects varies from 2.0 MW to 132 MW. Tafjord is also working on a few acquisitions, which the company have not yet announced. Tafjord's Dyrkorn power plant, opened in 2011, was the first plant in Norway with an installed Coanda intake. Both the supplier and Tafjord market this intake as gentler on the environment, and more efficient, especially during the fall and winter. I will discuss this intake further in my analysis.

The respondent from Tafjord, Per-Kåre Skudal has worked close to 30 years in the Tafjord Corporation, and holds the position as Project Developer at Tafjord Kraftproduksjon. He has an educational background in electrical engineering with an additional focus on energy and hydropower law. During the interview, Skudal gave me a tour of the Dyrkorn power plant, which was very enlightening.

Chapter 7: Analysis

In this chapter, I will present the information I have collected through my interviews. The chapter will focus on the findings according to the topics of this thesis, and I intend to compare the findings of each case to the secondary data I have presented earlier in my thesis, where applicable. As the interviews involved four respondents from different companies, the cases would naturally differ in focus based on the respondent's interests, and I intend to illustrate the differences as a part of my analysis. I have structured this chapter somewhat similar to my thesis, to ensure that the information runs in an intuitive, chronological flow.

7.1 Hydropower Development So far

Some of the information I got when introducing the subject of past developments was quite similar, which I expected when talking about events in retrospect. However, the respondents listed various reasons concerning the development, which I found very interesting, and it is by looking at these I kick off my analysis.

All of the respondents noted the date January 1 1991 as a turning point in modern hydropower history. On this date, the Norwegian Parliament adopted the Energy Act and liberalized the power market, and based on the interviews, this shall be the starting point of my analysis.

7.1.1 The 1990s

> *"The most important – triggering – factor of the entire [power] market is the Energy Act, and when it came in 1991, it turned the market upside down."*

- Arnulf Røkke, Småkraft

The power market based on monopolies in electricity generation and supply was deregulated, and the companies controlling the power grids now had to allow for open access. Røkke continues,

> *"The fact that the landowner now had the opportunity to develop because the [power grid] companies were required to accept electricity was the legal change that opened up for the [small hydropower] market."*

- Arnulf Røkke, Småkraft

After the liberalization of the power market, Thue (2006) notes that the development stalled, which the respondents confirmed.

> *"From an almost complete stop in hydropower development after the introduction of the Energy Act […], the development has rebounded since 2000."*

- Erik Skorve, BKK

The respondent from HelgelandsKraft (HK) concurred, saying:

> *"… And it [the hydropower market] was dead for approximately 10 to 15 years, until the mid-2000s, when small hydropower started to take off."*

- Tore Bjørnå-Hårvik, HK

Bjørnå-Hårvik adds that it was in the mid-2000s that HK saw the possibilities of small hydros, and began reviewing the most attractive small hydro projects. However, the company held a critical and selective position, which is why their small hydro portfolio today is somewhat limited, but quite good, according to Bjørnå-Hårvik.

The statements of the respondents fit well into the secondary data and information I have collected, see Chapters 2.2.12 and 2.3.1, which tell us the same story of a decade of relatively calm hydropower development, for small as well as larger hydros. So how does the respondents explain the stagnation in the hydropower development?

> *"… The low real prices of energy – especially electricity – in Norway during the 1990s prevented the small hydro development from starting."*

- Arnulf Røkke, Småkraft

I last spoke about the electricity prices in context to the Energy Act in Chapter 2.2.12, in which Thue (2006) accredits the public's disinterest in the act to the low electricity prices. As we know, hydropower plants back then were solely depending on the income from generated and sold electricity, and low electricity prices result in reduced income, which reduces the willingness to invest, leaving the entire hydropower industry rather undesirable.

7.1.2 The 2000s

However, as the new millennium approached, the global spotlight turned to renewable energy:

> *"… Around 2000, there was talk of incentives for new renewable energy in the EU area and one began to imagine a market for el-certificates in Norway too."*

- Arnulf Røkke, Småkraft

Further, the electricity prices seemed to increase somewhat permanently in the 2000s, as seen in Graph 6, and Skudal had the following comments to parts of this price development:

> *“Something happened in 2005. We got CO_2 quotas that suddenly added 15 – 17 øre to the electricity price. […]. The price level of 2005 did something to the willingness to invest in small hydros. […] the landowner awakened, as did the investment companies.”*

Per-Kåre Skudal, Tafjord

Skudal adds that during the summer of 2005, Tafjord and other power companies sold large amounts of floodwater for 25 øre/kWh, a price they could only have dreamed about a decade earlier. He adds that increased license application queue at NVE in the period 2007 to 2010 reflects the small hydro popularity. Bjørnå-Hårvik refers to the increased demand after small hydropower in and subsequent of 2005 as a *boom*, and explains that HK has the past few years worked on expanding their hydropower portfolio, focusing on GWh, not necessarily on the goodness of the projects. Regarding this denoted *boom*, Røkke is under the same impression:

> *“I would say the optimism was at its highest from 2005 until the financial crisis of 2008”*

- Arnulf Røkke, Småkraft

The early optimism showed in Småkraft’s 2002 goals, in which the company aspired to develop a portfolio consisting of 2.5 TWh worth of annual generation within a ten-year period. However, Småkraft failed to recognize three important issues facing small hydropower development that forced the company to adjust their goals. First, NVE’s license application process was longer than expected, second, the costs of building and operating small hydros were higher than initially estimated, and third, the limit on the power grid prevented development in certain areas. I will get back to some of these factors later in the analysis. Røkke brings up the global recession that hit in 2008 and suggests that this did indeed affect the hydropower industry as well, which is the same impression Bjørnå-Hårvik is under.

7.1.3 Electricity Prices

Skudal accredited the mid-2000s small hydropower boom to the generally high electricity prices of 2005, making small hydropower a lucrative investment. In Chapter 5.1.1, I investigated the development of the electricity prices, and found several noteworthy moments. Skudal had the following to say about the recent price path:

> *"We had a cold winter in the fall of 2009, the spring of 2010, as well as in 2011. The spring of 2011 was very cold, with almost empty reservoirs and soaring [electricity] prices."*

- Per-Kåre Skudal, Tafjord

This information fits well with Graph 6, represented by the last two peaks in the graph. As for the price movement after these periods, Skudal connected this to the price of oil and coal, saying:

> *"But then, we had a year of high precipitation in 2011, which filled the reservoirs. […] the price of oil declined, and the price of coal declined, and these are references for the power prices. […]. So, it is clear that we see a much lower power price in 2012, and 2013, and onwards, compared to the price from 2005 to 2011."*

- Per-Kåre Skudal, Tafjord

Skudal's thoughts concerning the electricity price development confirm the connection between oil and coal and the electricity price previously mentioned by Holstad and Pettersen (2011). The statement above also fits Graph 6, represented by the lack of spikes in the fall of 2011 and 2012. Skudal adds that the falling electricity prices clearly affects the small hydropower development, and in some cases, power companies may even have to devaluate existing small hydros.

7.2 Developing a Small Hydro Plant

According to the respondents, the hydropower development industry consists of power companies and hydropower consultants. While the power companies either hold the rights to a watercourse or team up with a landowner in the early stages of a project, the hydropower consultants usually work with landowners who want to establish their own, privately owned hydropower plants. In the interviews that the topic of hydropower consultants came up, the respondents were mostly negative, suggesting that because the consultants have very little ties to the finished private hydropower plant, the focus on for example new equipment and methods is often overshadowed by the focus on "getting things done". However, as I have not had the chance to interview a hydropower consultant, I only have one side of this discussion, which is why I feel that it would not be right to focus too much on this subject.

7.2.1 Current Development Philosophy

What I found during the interviews was that the companies do in fact prioritize differently. That said, certain stages and aspects of the development, like the standardization of equipment and methods, were quite similar.

> *"Basically we are looking for the best quality possible, at the lowest possible cost, naturally. In certain areas standardization and buying in bulk contribute to this and in other areas and projects the opposite applies, with customization and the ability to take bold choices."*

- Arnulf Røkke, Småkraft

Røkke brings up the power station building as an example of a component that is fairly standardized. Småkraft operates with a standard building, designed in stone and glass by architect Paal Karhs, with some local variations. By doing so, Småkraft can save costs, while at the same time present an appealing front. Further, Småkraft is determined never to settle with traditional methods, and runs a continuous search for new methods and solutions. Bjørnå-Hårvik tells me that HK tries to standardize as much as possible, to avoid having to special order a large amount of components. However, HK believes it is also important to be creative, and search for methods to save costs, and the company is always open to smart solutions.

According to Skudal, Tafjord has focused on environmental solutions in their small hydros the past few years, with a special focus on the impact of drilling the tunnel for the conduit, and the intake. Skorve expresses that BKK is committed to the idea of maximum resource utilization, and thus focuses on increasing the efficiency in their plants.

When it comes to the separation between developing new hydropower plants and investing in existing plants, the respondents also shared similar views. Skorve notes that for BKK,

> *"Both alternatives can be evaluated."*

- Erik Skorve, BKK

By investing in existing hydropower plants, my respondents separate between upgrades of their companies' own plants, and acquiring new power plants, notably from private citizens who invested in their own plant. According to Røkke, the life as a private hydropower owner is often not easy and lucrative as initially believed, especially because of the patience required. Småkraft gets many inquiries concerning sales of small hydros, and are currently in the last phases of two acquisitions.

> *"While we speak a substantial amount of GWh is for sale in the market, through existing projects."*

- Arnulf Røkke, Småkraft

I will elaborate more on the renovation projects when I reach the topic of el-certificates.

7.2.2 Investment

In Chapter 4, I explained the general structure of an investment in small hydro. As the key estimates in such an investment relies on macroeconomic factors such as electricity prices, global recessions, and governmental incentives, the investment analyses of different power companies will often be very much alike. As developers use the same, or very similar, equipment in their small hydros, the need for reinvestment is also present. From my interviews, I learned that the companies estimate about the same lifespan for a small hydro, at about 30 to 40 years, with necessary reinvestments every 10 to 20 years. The lifespan represents the period of which the power company measure the costs against the expected revenue. There is naturally a difference between the financial lifespan and the actual lifespan, and a company's views on this difference determines, to a degree, what equipment it uses in development. According to Bjørnå-Hårvik, HK operates with a theoretical infinite ownership and lifespan of a hydropower plant, and he says that,

> *"There is probably a difference between the companies that have operated hydropower plants for decades, and those new in the industry who may have to think differently to stay in business."*

- Tore Bjørnå-Hårvik, HK

Which suggests that there are different "routes" a company or private citizen can take when developing a small hydro. This can relate to the choice of equipment and other structural parts of the planning and development.

An important factor when considering a new hydropower project is the profitability of the project, and developers try as best they can to estimate the future revenues and costs. However, when it comes to the return on investment for a small hydro, Skudal had the following to say:

> *"A large power company with a desired rate of return at 7.0% to cover loans and installments, as well as to secure some profits, must usually be patient during the first operating years."*

- Per-Kåre Skudal, Tafjord

In connection to the calculated net present value of a hydropower project, Bjørnå-Hårvik notes that

> *"It may take many decades before [the project] is on the 'right side' relative to the net present value."*

- Tore Bjørnå-Hårvik, HK

7.2.3 New Solutions and Methods

> *"[…] the hydropower industry is, however, based on modern technology"*

- Erik Skorve, BKK

In this part, I will present some of the new solutions that my respondents have informed me about during the interviews. I have found that the length of which each of the companies I interviewed go to in implementing new technology and methods is directly linked to their development philosophy. BKK, for example, focuses on R&D connected to maximizing the resource utilization in their plants, which involves research on improving the Pelton turbine, intake hydraulics, and the grating.

> *"The idea is that there is value in small improvements of the equipment. All improvements that result in increased utilization of the water resources will be valuable in the future of hydropower"*

- Erik Skorve, BKK

Further, BKK also focuses on improving the generator availability, to reduce downtime in the plants, as well as streamlining the project management for both new projects and upgrading projects.

> *"I think it is important to grasp that the market actors do not necessarily react the same when it comes to innovation, and do not feel the same need for innovation."*

- Arnulf Røkke, Småkraft

Småkraft focuses on reducing costs in certain aspects of the hydropower plants, and uses the knowledge and experience gathered from an implemented solution to determine whether to use the same solution in other projects. In the Eidsetelva power plant, they used a new aluminum-based pool solution to reduce costs, and they intend to use an improved version of this in an upcoming small hydro. In addition, in one of its small hydros, Småkraft used a GPS-controlled method to drill the tunnel for the conduit, not unlike the technology used to drill for oil in the North Sea. This method reduced the costs and resulted in less interference in the surrounding nature than usual.

Most of HK's hydropower plants are remote controlled from its headquarters in Mosjøen. Although Bjørnå-Hårvik considers this practically a standard in today's hydropower market, he believes that further developing this technology will result in less operating costs, as video surveillance in various components of the company's plants would streamline the process for the technical responders and potential repairs. Further, in line with HK's infinite time perspective, the company focuses on purchasing components and materials that would serve this long-term view, even though this usually means increased investment costs. HK's Øvre Forsland power plant project, scheduled for opening in 2015, focuses on aesthetics and the fact that hydropower and nature can go hand in hand. According to Bjørnå-Hårvik, the surroundings of the projected plant inspired HK to focus on design in the early phases of the planning, and the company has actively publicized the project, through traditional media, as well as social media, which has resulted in both national and international interest.

"There are good reasons to be adept and focused on the environment."

- Per-Kåre Skudal, Tafjord

Skudal made Tafjord's focus on the environment very clear during our interview, in which he described the Dyrkorn power plant and its accompanying *Coanda intake*. Tafjord installed the intake, which utilizes the *Coanda Effect*[9], when developing the plant in 2009, after doing research on foreign hydropower plants and their equipment. The Norwegian and British suppliers, Brødrene Dahl AS and Dulas Ltd., respectively, advertise the intake as environmentally friendly due to the technology that allows for fish and smaller organisms to pass the intake unharmed, which is not necessarily the case with traditional intakes. After three years of operation, Skudal states that the project has indeed been a success. In addition to being gentle on the surrounding nature, the intake also increases the efficiency, as it requires less maintenance and downtime during the cold winters, and Skudal estimates that the Dyrkorn power plant generates 98.7% of its theoretical maximum, which, according to him, is very efficient. Tafjord is also looking at ways to manufacture the Coanda intake on a different

[9] The Coanda Effect, named after Romanian aerodynamics pioneer Henri Coandă, says that a stream of water will follow a surface, even as the surface curves.

location, and have it transported by helicopter to the hydropower plant site, thus reducing the need for superfluous roads.

> *"In retrospect, we felt extremely innovative, […] we adopted a new technology and we built Northern Europe's first Coanda intake."*

- Per-Kåre Skudal, Tafjord

7.3 NVE and the License Application Process

In Chapter 2.4, I described the application process that either new hydropower plants, or certain restorations in existing power plants, must go through to earn the right to utilize water resources. Ahead of my interviews, NVE was one of the topics I was most curious about, as this appears to be a sore subject, especially in the media. To gain further knowledge about this subject for my analysis, I contacted Asle Selfors, Senior Consultant in the Licensing Department of NVE, via e-mail, who was very helpful and clarifying.

> *"Large hydros, small hydros, and wind power are all desirable projects that contribute to the Norwegian goal of permanently increased renewable electricity generation […]. We therefore want and accept all cases."*

- Asle Selfors, NVE

When asked about NVE's routines connected to socioeconomically viable projects and projects that best serve the common good, whether NVE prefers, or prioritizes, such project, Selfors states

> *"Both small and large hydro projects can be socioeconomically viable […]. NVE does not discriminate with regards to size."*

- Asle Selfors, NVE

Selfors implies that NVE processes the incoming license applications according to standard routines and the number of available caseworkers. NVE does not appear to choose socioeconomically viable projects, which are often larger hydros, over other projects. Nevertheless, as Selfors also mentions, there are currently no waiting line for larger hydros (10 MW and over), while there is a long waiting period for small hydros, and Selfors explains:

> *"This is because the processing time per MW license-given is significantly longer for small hydros than large hydros, and therefore larger hydros are somewhat prioritized when allocating internal resources."*

- Asle Selfors, NVE

Thus, there seems to be some prioritization when it comes to large hydropower development. Selfors adds that in the recent years, NVE has received about 10 to 20 applications annually concerning larger hydro projects, and NVE has approved most of these, though perhaps with some limitations connected to minimum flow requirements, for example.

When discussing the general license application process, Røkke has the following to say:

> *"NVE collects all views connected to a project, and determines if the project is controversial or not. […] NVE makes a decision based on an overall perception of whether the total positive consequences outweighs the negative ones […]."*

- Arnulf Røkke, Småkraft

When a developer delivers a license application for a hydropower project, the project goes through several stages within NVE until they make a decision. "Controversy", is as mentioned a key term, and the caseworkers at NVE focus on determining the extent of this term, in addition to the physical attributes of a projected plant. Røkke continues,

> *"There are large differences between what NVE considers damning reasons in a project, and these vary from visibility of waterfalls, findings of red-listed species, or loss of scenery, etc."*

- Arnulf Røkke, Småkraft

Røkke estimates that NVE approves about 60% of the license applications today, while back in 2004, he suggests that NVE approved almost all. Graph 3 supports this theory, with 2004 being the year when the number of applications increased rapidly, thus moving away and increasing the difference between number of total and approved applications. According to Selfors, today NVE actually approves closer to 70 to 80% of the applications, and they get from 100 to 150 applications each year. NVE has about 600 cases waiting to be processed, and thus hydropower developers must expect to wait a while for NVE to process their applications. When asked about his thoughts on the quality of the applications today, Selfors answers:

> *"What limits the number of applications is in many cases profitability; many of the best projects are already built or protected."*

- Asle Selfors, NVE

While in the previous chronologically based application process the developer somewhat knew long he had to wait, the new geographically based process is much less predictable. The respondents in my thesis were all positive to this new method, which NVE introduced to speed up the process and thereby allow more projects to enter the el-certificates market.

> *"[...] an application submitted in 2006 – those still exist – and one submitted right before Christmas [2012], were both at the same stage of the NVE process in February. This happened to us (referring to the newest application)."*

- Arnulf Røkke, Småkraft

As the quote above indicates, NVE's new processing method is quite unpredictable, and this is something that developers must consider when planning a hydropower plant. Bjørnå-Hårvik and HK are also positive to changes made to increase efficiency at NVE, though they have yet to experience it first-hand. By organizing the applications according to geography, NVE is able to prioritize areas that for example have available power grid access, and this is something that the power companies, the ones I interviewed included, are aware of, so they can adjust accordingly. Thus, a developer can ensure some prioritization in the NVE application line by doing research on the relevant areas and the local power grid. Bjørnå-Hårvik had the following to say about the process, which I believe represents the general opinion in all four of my interviews:

> *"It takes a long time. Perhaps too long, as it may take up to ten years from initializing a project until the license is approved and one is ready to develop."*

- Tore Bjørnå-Hårvik, HK

There is no arguing that the application process is time-consuming. However, Skudal notes that NVE used to process only 30 to 40 applications a year, so of course it is going to be difficult to manage three, four and five times as many every single year. Skudal continues by stating that he believes there are many bad projects currently waiting in line at NVE – projects based on an unrealistically high electricity price or el-certificates value. Many of these projects may pass NVE's initial investment analyses only for the caseworkers or developer to discard the application at a later point, thus wasting time. Skorve gives NVE credit for being thorough and meticulous, and adds that NVE must follow certain acts and regulations that demand extra time. However – he adds – the long process is absolutely a challenge for BKK.

In Norwegian politics, there have been discussions about how they can reduce the waiting lines at NVE, and the new government has included a passage about on this topic in their Political Platform. This part explains that the government aspires to move the legislative power over licenses from NVE to the municipalities. This was not included in the government's revised national budget for 2014, but they may include it later. Skudal, and Robert Rønstad who was also present during the Tafjord interview, commented on this, saying that such a solution would be costly for the municipalities, as well as somewhat time consuming, as the municipalities have to hire people with hydropower expertise who may then need a certain training period.

Bjørnå-Hårvik suggests that a change in NVE's appeal procedures could reduce the total processing time. It is Bjørnå-Hårvik's impression that this part of the process is unnecessarily long and time consuming, as the Ministry of Petroleum and Energy usually reviews the appeal case very similarly to how NVE reviewed the original case, except with new caseworkers. Bjørnå-Hårvik suggests that a change in the appeal procedures, like a more detailed and critical review of the complaints at NVE before sending the case to the Ministry, can reduce the processing time for each individual application, thus the total processing time.

During my interviews, the respondents were surprisingly positive towards NVE and its routines, even though they are time-consuming and often criticized in the media. It appears that the companies have settled with the idea that the process takes time, and that there is very little to do about this as the process is subjected to Norwegian acts and regulations.

7.4 Environmental Aspects and Conflicts

Although my focus in this thesis is on small hydros, which are often watercourse-based and therefore requires less regulation, thus less interference in nature, some of the companies I interviewed own larger hydros, so I chose to include this topic in my interview guide. What I have gathered from my interviews is that the locals and the environmentalists are usually quite skeptic during the planning phase of a hydropower project.

> *"[Hydro] power development triggers associations to submerged landscapes, reservoirs, and large technical measures […]"*

- Arnulf Røkke, Småkraft

Røkke goes on explaining that this does not necessarily apply to Småkraft, being a developer of small hydros. He continues,

> *"I believe that in advance there is some skepticism, but then the locals see, [...], that the projects are less dramatic than what one usually connects to [hydro] power development."*

- Arnulf Røkke, Småkraft

In fact, he adds, when the power plant opens, the architecture and structure of the plant seem to impress the locals, and this is often the focus in the local media coverage. Skudal seems to be under the same impression as Røkke, with some negative attention during the development, but in the end generally satisfied landowners and locals. Concerning environmentalists, Røkke adds

> *"Paradoxically, from the environmental movement there are many who deem small hydros undesirable, but this is often ideologically grounded."*

- Arnulf Røkke, Småkraft

By this, Røkke refers to the environmental views that small hydros are destructive in nature, as he has not experienced that certain plants lead to significantly more protests than others do.

The respondents from BKK and HK did on the other hand have more experience with conflicts, concerning both locals and environmentalists. Skorve says that BKK usually meets a certain level of conflict in connection to its hydropower projects, especially those involving regulating and changing watercourses, which does not always sit well with neither locals nor environmentalists. By wanting to change a watercourse, BKK's project often compete with landowners and their own plans for the watercourse, thus sparking a conflict. According to Bjørnå-Hårvik, it is HK's impression that emotions and different perceptions play important roles in the conflict, and being located in the Helgeland area, the company must consider reindeer husbandry and grazing areas, as a power plant may affect these. Therefore, HK tries to keep an open dialogue with landowners and the possibly affected farmers, while NVE decides whether the project is too interfering in the nature.

All of the respondents seem to be very committed to an open and bilateral relationship with possible landowners, which they consider important both for the initial development of a hydropower plant, and for the future operation of the plant. The general perception of landowners is that they are enthusiastic and engaged, and they do rarely take a passive or indifferent stand during the development.

When it comes to the impact of small hydros on water organisms, Skudal is not very impressed with the industry. When he investigates the Coanda intake by contacting foreign developers and owners, he realized that other hydropower countries seem to focus much more on the hydropower plants' impacts on the environment and ecosystem. When asked what he believes are the reasons this appears to have a low priority in Norwegian hydropower, he suggested that

> *"[…] perhaps we have too many watercourses – and we have gotten a bit spoiled."*

- Per-Kåre Skudal, Tafjord

He also adds that for example South Africa has stricter rules than Norway when it comes to minimum flow requirements. Such rules and regulations are subject to change, and minimum flow requirements is one of the measures NVE can impose during its revision of a plant's license terms, as mentioned in Chapter 2.4.1. Skudal estimates that today, hydropower plants accounting for about 3.6 TWh of annual electricity generation do not have minimum flow requirements. In addition, he explains that Tafjord works closely with the local Tourist Association to ensure that possible interferences are not too large and interfering with hiking or tourism.

Skudal believes that environmental issues have become more important in today's hydropower industry. He states, for example, that the focus of the caseworkers at NVE has somewhat shifted, from an economic and technical point of view to an environmental one. Skudal estimates that in certain areas, NVE denies about 50% of the application based on environmental reasons, which is not necessarily bad, according to Skudal, who also has positive things to say also about the Environmental Protection Agency and their work. Although often used as a scapegoat in the media, Skudal estimates that the agency is actually positive to at least half of the proposed hydropower projects.

Regarding the governmental resource rent tax used to capture rents from hydropower plants with an installed effect larger than 5.5 MW, Skudal believes the government should, and will, increase this level to include all small hydros, i.e. to 10 MW, which they have discussed, but not yet implemented. Opponents of the low resource rent tax base, like Skudal, argue that it prevents optimal utilization of a watercourse, as it could be expensive for developers to get an additional tax of 30% on their production if the installed effect were to slightly surpass the 5.5 MW limit (Lie, 2012b).

7.5 El-Certificates

While the cases showed certain similarities when it comes to hydropower development, the opinions and thoughts of the respondents concerning the el-certificates system seemed to differ more.

The Norwegian government introduced the joint Swedish-Norwegian el-certificate system on January 1 2012, as mentioned previous in my thesis. However, other countries, Sweden included, had introduced el-certificates almost a decade earlier, and because of this, the Norwegian hydropower industry had waited a long time such a system. As mentioned in Chapter 7.1.2, the much-anticipated el-certificates were part of the optimism that drove the small hydro development in the beginning of the 2000s, which resulted in the inception of Småkraft in 2002, according to Røkke. Alas, it would take a long time for the extra income to benefit the owners of Norwegian hydropower plants.

> *"[…] so [the el-certificates] will increase the possibilities for development, without a doubt. […] and it will be easier to make investment decisions."*

- Tore Bjørnå-Hårvik, HK

The respondents all agreed that the el-certificates system encourages hydropower development, in new projects as well as restoration projects, as they provide an extra revenue that can increase the net present value in the investment calculations. In Chapter 5.2, I described how the el-certificates system works, and how the value of these certificates has developed. As we saw, the value, i.e. spot price, of the certificates has moved up and down quite a bit the past few years, forcing some power companies to use a conservative estimate of 15 øre/kWh, when it was 25 to 30 øre/kWh[10], a couple of years ago under the Swedish system. Of course, with such volatile values, the el-certificates pose a certain risk for the hydropower industry, if developers decide to include this extra income in their investment analyses. Bjørnå-Hårvik stated that

> *"I believe that in today's market, […] [the el-certificates] have been necessary for realizing a lot of projects."*

- Tore Bjørnå-Hårvik, HK

[10] Measured in NOK, not SEK as in Chapter 5.2.

When it comes to upgrading existing power plants, the same principles apply, except that NVE only issues el-certificates for the extra electricity added because of the upgrade, and Skorve says that

> *"[…] so the costs of upgrading existing hydropower plants are not directly outweighed by the el-certificates."*

- Erik Skorve, BKK

That said, Skorve adds that the el-certificates system has made it interesting to review the hydropower project portfolio once more. Røkke is a bit more positive to these kinds of investments:

> *"Non-profitable rehabilitation projects can quickly turn profitable because you get 15 years of el-certificates in addition to the revenues."*

- Arnulf Røkke, Småkraft

However, it is important to mention the dates set for the el-certificates system. The construction of the plant must have started *after* September 7 2009, and construction must be finished *before* December 31 2020. If a power plant does not meet these criteria, it is not eligible for el-certificates. Although the hydropower industry both hoped and expected the Norwegian government would introduce the el-certificates for many years, the actual implementation, and the start and end dates, came quite unexpected on some of my respondents. According to Røkke, Småkraft started development of a power plant a mere week before September 7 2009, and so this was ineligible for el-certificates. The debate concerning the retroactive effect of the el-certificate system has long been on the political agenda, with some political parties – the Conservative Party included – pledging to move the starting date further back. Skudal refers to the start-date as

> *"The so-called 'great injustice' towards small hydros built between January 2004 and September 2009 […]"*

- Per-Kåre Skudal, Tafjord

and he believes the current government will push the start-date back eventually, as he finds it difficult to imagine that the government can get easily away from these promises. Røkke doubt this will actually happen, and adds that this is his personal opinion and this does not necessarily reflect Småkraft's thoughts.

The final date for entering the el-certificates market in 2020 is also the cause of dispute. My respondents are all fully aware of the limited time left to secure el-certificates. If the power company has not completed the hydropower plant, or the renovations necessary to add a permanent increase in electricity generation, by December 31 2020, the plant will not be eligible for el-certificates. With only nine years left, the respondents know that the moment has passed for some projects. As I mentioned in Chapter 2.4.2, NVE pledged to review all license applications handed in before January 1 2013 by 2017, so that the approved projects could make the el-certificates deadline.

> *"The general perception is that the projects that can make the el-certificates system by 2020 already have licenses. Thus, it is less likely that the projects in line at NVE will be completed before 2020."*

Erik Skorve, BKK

This perception creates new obstacles and risks for the hydropower industry. As my respondents have informed me, many projects are dependent on the extra income from the el-certificates, and without this income, the companies may not have developed certain plants.

> *"Towards the end the risk of not being included in the system increases."*

Tore Bjørnå-Hårvik, HK

However, Skudal suspects that the deadline could possibly change, saying:

> *"I do believe that the 2020 deadline will be changed with the new government, […] to stick to that date [December 31 2020] would be a catastrophe."*

- Per-Kåre Skudal, Tafjord

Skudal bases this statement on, among other things, the pressure on components suppliers towards 2020. As I conducted the interview with Skudal on October 23 2013, the results of the election were fresh, and in an e-mail sent on December 3 2012, Skudal informs me that the government will leave the final date unchanged for now, but the Swedish and Norwegian governments may change it during the first *checkpoint* in 2015.

With this in mind, I will in the next part focus on the period from now until December 31 2020, and the last part of this chapter will cover the respondents' expectations for the hydropower market after 2020.

7.5.1 Before 2020

In the previous part of this chapter, I have presented some of the opinions and thoughts of my respondents regarding the el-certificates system. The system is closing, and the power companies are aware of this. Nevertheless, what will happen to the hydropower as the system closes?

First, as there are only nine years left, the companies I have interviewed are all under the same impression that new hydropower plants that have yet been approved by NVE will have difficulties reaching the 2020 deadline. Røkke comments on this, saying

> *"The [hydropower] market is beginning to fill up because it is about to be too late for the el-certificates."*

- *Arnulf Røkke, Småkraft*

This realization has forced the hydropower developers to consider other options to gain the extra income, which include restoration projects. According to Skudal, the turbine in older hydropower plants often generates around 87% of its potential, and by replacing the turbine one is able to increase the efficiency to 92% or more, and be eligible for el-certificates. Power companies are working on such restoration all over the country, and Tafjord currently has two restoration projects applications waiting in line at NVE. Another option to increase the efficiency of a power plant – and thus receive el-certificates – includes regulating a watercourse to ensure a higher water input in the power plant, thus increasing the amount of generated electricity. Skudal continues with explaining that for Tafjord to start developing new hydropower plants at this moment, this must be through collaborations with landowners that already have project approved, or close to approval, by NVE, or else there is not enough time. BKK started in 2013 renovating the Matre Haugsdal power plant, which will lead to a substantial increase in generated electricity, and this renovation project entails an additional income from el-certificates once it is finished.

Bjørnå-Hårvik expresses that HK's focus right now is to realize their projects before 2020. If a project is unlikely to make the deadline, the future of the projects is very uncertain, and HK may never realize the project.

Towards the end of the 2010s, the respondents expect a rush of hydropower plans hoping to secure the 15 years of income from the el-certificates.

> *"The small hydropower market will be pressured, and there will be a race to get one's project realized."*

- Erik Skorve, BKK

> *"There must occur a substantial activity boom in the coming years if the el-certificates system is going to work as intended."*

- Arnulf Røkke, Småkraft

Røkke adds that for the Swedish-Norwegian el-certificates system to reach the goal of 26.4 TWh of new renewable energy, the bottlenecks effects must be mitigated, and he mentions Statnett's current billion NOK investments in the power grid as part of a solution to these problems. I previously mentioned Skudal's worries concerning the suppliers, and their ability to deliver the components and materials necessary for the coming "Klondike Rush", as he denotes it. Skudal estimates 600 to 700 new hydropower plants until 2020, which is close to 100 per year, which he believes is cause for concern, in terms of materials supply. Røkke agrees with this, saying:

> *"We expect there to be a struggle over scarce resources such as excavators, blasting capacity, access to equipment, and so on."*

- Arnulf Røkke, Småkraft

Skudal also raises concerns about the quality of the equipment if such a struggle was to occur, fearing that hydropower developers in desperate need of reaching the 2020 deadline may turn to equipment of lesser quality to circumvent the struggle and possible delays. In addition to possible shortage of equipment, Røkke suggests that the explosive increase in new hydropower plants may negatively affect the prices.

> *"The prices in the spot market show signs of a downward trend, and many point out that the reason is the expectation of this new power that affects the supply side."*

- Arnulf Røkke, Småkraft

Røkke raises a relevant point in terms of general market economics, which would suggest that an increase in supply, such as the expected increase in new hydropower plants until 2020, would effectively decrease the price, unless the demand rises with an equivalent amount in the same period.

7.5.2 After 2020

When the el-certificates system closes on December 31 2020, NVE and Statnett will have distributed the last of the certificates, which will still generate an income until 2035 for the power plants opened in 2020. By this time, the goal of the Swedish-Norwegian system is to have increased renewable energy-based electricity generation by 26.4 TWh, preferably through a 13.2 TWh increase in both countries. The Norwegian government controls the value of the el-certificates through the Electric Certificates Act, as explained in Chapter 5.2.2. Because of this, there is a lot of uncertainty involved, according to my respondents.

> *"There is also a risk connected to the expected prices [value] when the system closes."*

- Tore Bjørnå-Hårvik, HK

Bjørnå-Hårvik adds that power companies are depending on political decisions and demand after el-certificates to maintain the income that they may have used in their project's initial investment analysis. Therefore, it is important to decide whether to include this income in the calculations. HK does include the el-certificates income, but the company is well aware of the risks of doing so, as the value could suddenly drop in the near future. Røkke explains the uncertainty connected to the el-certificates in the following way:

> *"There is a great uncertainty as to what happens after 2020, because the el-certificates market is first and foremost a way to encourage investment decisions, […] and the best course of action for all, except the power companies, may be that the [el-certificates] market is rather impoverished afterwards."*

- Arnulf Røkke, Småkraft

As I mentioned in Chapter 4, in most cases, Skudal estimates the investment calculations both with and without the el-certificates income. However, Tafjord's newest project, Via power plant, currently under development, would not have been built without the el-certificates. The plant is located in a remote area with no road connection, and the investment cost was about 5.0 to 5.5 kr/kWh, which Skudal considers high, but Tafjord wanted to utilize the watercourse, and a conservative estimate of future el-certificates revenue allowed for this.

While Skudal suggested the government might postpone the 2020 deadline for the el-certificates system, as a way to cope with the inevitable rush close to the deadline, Skorve does not believe this would happen.

> *"We do not believe the el-certificate system will be extended [beyond 2020], nor do we believe the government will introduce other incentives."*

- Erik Skorve, BKK

The two other respondents seemed to be under the same impression as Skorve, that the end-date is absolute. All four of my respondents are operating with December 31 2020 as the final date, and my impression from the interviews is that their focus today is how to best utilize the el-certificates system. The more uncertain period after 2020 appears to be mostly based on estimations, speculations, and a healthy dose of wishful thinking.

7.6 The Future of Norwegian Hydropower

From the previous subchapter, it is clear that the el-certificates system currently plays an important part in the present and future of the hydropower industry. My respondents raised concerns about the future value of these el-certificates when the system closes in 2020, as they are fully dependent on political willingness and decisions. Skorve states that

> *"If the goal of the el-certificates system [26.4 TWh] is reached, there will be more than enough power in the system, and an extension of subsidies will be further destructive for the market."*

- Erik Skorve, BKK

We can connect what Skorve implies to Røkke's thoughts on the future electricity prices, and how these may decrease if the supply side of the electricity market increase substantially. The Swedish and Norwegian governments have conducted thorough calculations considering the future supply and demand of electricity that form the basis of the el-certificates system and the goal of 26.4 TWh of new electricity generation is the result of these calculations. It is therefore reasonable to believe that this, for the time being, is the optimal amount of supply for the market in 2020 and onwards.

> *"If there are no motivations to increase the share of renewable energy after 2020, and we have a situation with surplus production, then the hydropower development will stop after 2020."*

- Tore Bjørnå-Hårvik, HK

If the motivation, and the accompanying incentives, was to stop in 2020, Bjørnå-Hårvik believes that HK will shift its focus towards streamlining and rationalizing the operation and maintenance sections, and away from new developments. Skudal and Tafjord are under the same impression, by underlining the importance of the el-certificates' value and possible other incentives financed through the consumers' electricity bill for the future hydropower development. Skudal mentions that hydropower plants do have other possible revenue streams, among these the *guarantee of origin* program. This involves environmentally conscious consumers in for example England or other European countries who pay more to ensure that the electricity they consume is based on a renewable energy source. However, as Skudal points out, this is a niche market, thus it is limited and does not account for much in the grand scheme of things. He also adds that he believes that the development of wind power, also eligible for el-certificates, will decrease significantly in Norway because of the high investments costs, impact on the surroundings, and wind-dependent production, connected to this form of renewable energy, especially in comparison to hydropower.

Skudal mentions that he expects foreign investors will play a larger role in the future of development. He continues by stating that there is nothing in the governmental acts and regulations that prohibits a foreign investor in a small hydro – though this is different for large hydros – and when private small hydros owners grow old, their heirs may not want to continue the somewhat tedious work, and will probably be looking to sell. The hydropower plant is lawfully connected to the land, so it may also be financially difficult for one heir to buy out other siblings. This is when Norwegian investors, power companies, or foreign investors appear.

Most of my respondents painted a rather grim picture of the future of hydropower development – a future based on uncertainty, calculated guesses, and dependency on politicians. However, the respondent from BKK seems to be less worried, stating,

> *"Hydropower will continue to be the most important source of electricity in Norway in the future, and investments in good hydropower projects will be made also after 2020."*

- Erik Skorve, BKK

Selfors expects new projects in the future, once again pointing out the profitability of projects.

> *"Onwards, we believe there will be new projects in all categories, most within small hydropower and wind power. It is largely a developer's assessment of a project's profitability that decides the applications we get."*

- Asle Selfors, NVE

Chapter 8: Discussion

This chapter focuses on the results from the analysis, and I will include empirical data presented earlier in this thesis to compare against the collective findings of the analysis.

8.1 The Development of Hydropower Thus Far

A very clear common denominator from my interviews was the fact that the Energy Act changed everything about the Norwegian power market. The respondents consider January 1 1991 the "birth" of the small hydropower industry. Even so, the findings reveal, as the secondary data suggested, that the 1990s was a decade of very little activity in the hydropower industry. One respondent attributes this to the low price of electricity in the period, which corresponds to a theory mentioned by Thue (2006). This argument fits the idea that owners of hydropower plants base their income on the electricity price alone, if there are no additional financial incentives.

Towards the middle of the 2000s, the development of small hydropower started increasing, and from the mid-2000s, it shot through the roof, as explained by the respondents and supported by the secondary data. Several of the respondents believe this happened due to increased electricity prices, as well as rumors of future governmental incentives, mainly an el-certificates system. The increase in electricity prices is by the respondents explained by increased precipitation and temperature, CO_2 fees, and increased oil and coal prices. These explanations do also fit well with the empirical data mentioned in previous chapters. According to the respondents, the high electricity prices ignited the small hydropower development that the Energy Act had facilitated 15 years or so earlier.

One respondent brought up the topic of the resource rent tax during the interview, stating that this is likely to change with the new government, to include all small hydros. As we saw in Chapter 2.1.2, the government, owners of hydropower plants, and environmentalists all have different perspectives and agendas when it comes to this tax, and it is certainly a heated topic. One can argue that the tax discourages plants with an installed effect above 5.5 MW, even when this is economically advantageous, thus creating a barrier in the small hydropower development.

8.2 Developing a Small Hydro Plant

The companies in my case study have very different perspectives and missions when it comes to hydropower development. While some focus on environmental solutions, others aim at aesthetically pleasing or efficient plants. With such a wide range of focus, there appears to be little in common between the companies. This is either somewhat unusual or completely normal, depending on the following: As I have mentioned, some of the companies are connected through parent companies, with varying ownership shares, which could naturally lead to biased information. Although none of my respondents mentioned their company's owners, it is reasonable to believe that the parent company has some influence in the day-to-day operation of its subsidiaries. If we theorize that there is no particular influence present, and the companies manage their own goals and operation, the different motives and focus are rather unusual for an industry we can consider somewhat limited. On the other hand, it is reasonable to assume that the parent companies wishes to be present in each part of the hydropower market by diversifying their subsidiaries' expertise and knowledge, thus creating the differences. However, my impression from the interviews is that the companies act quite independently.

As the companies' motives and goals differed, so did their perception of innovation and new ideas. While some respondents consider their company very innovative, others focus on improving and perfecting their current methods and instruments, which of course involve certain innovative skills as well. As mentioned in the analysis, the respondents' views on new equipment and methods coincides quite well with my initial perception of the companies and their philosophy, with the environmentally conscious company focusing on eco-friendly solutions, the efficiency-targeting company focusing on streamlining their processes, and so on.

When it comes to the planning, structuring, and developing of a small hydro, the respondents' replies showed certain similarities. In Chapter 4, I described a general investment in a mini hydro, and explained the risks a developer must consider in the investment calculations. The respondents seemed to agree on the general characteristics surrounding such an investment, although there are naturally differences in the costs and types of equipment the companies invest in, based on their policies and philosophy. There are also some differences in what to base the future revenue on, and while some included an estimate of the future el-certificates value, others calculated both with and without, and in certain cases, this depends on the project. I will get back to the value of the el-certificates and the corresponding risk later in this chapter. The respondents were all positive to additional investments in existing plants – their own or through acquisitions – to increase efficiency and revenue, and they consider this very relevant in order to receive additional el-certificates at this point.

8.3 NVE and the Application Process

The views of the respondents concerning NVE were generally positive, though they all stated that the license application process is a time-consuming procedure that has affected both their previous and current developments. The respondents appear to be very familiar with NVE’s demands for both new hydropower projects, as well as restoration projects, which ensures a somewhat efficient and meticulous planning process to gather knowledge about what is necessary to get one’s license application approved. The respondents were also positive to NVE changing its routine to a geography-based one to accommodate for a quicker process, even though it makes the processing time more unpredictable from a developer’s point of view. That said, the respondents’ knowledge and expertise in the planning process could help mitigate the unpredictability of the situation. It is my impression from the interviews that the respondents think NVE is a fair and professional institution, with just views on the different forms and sizes of renewable energy sources. There appears to be some *de facto* prioritization, based on the amount of processing needed for different-sized projects, but in general, NVE initially consider all project applications equal.

Some suggestions for reducing NVE’s processing came up during my interviews, in addition to the government’s plan to decentralize NVE’s license authority to municipalities. The general perception of the respondents is that NVE follows the rules and regulations set by the government through various acts concerning watercourses and natural resources, and so it is difficult to make substantial changes in the license process. This realization appears to have greatly influenced the respondents, who now seem to focus on the quality of the license application rather than complain and argue about the waiting period. The respondents commenting on the government’s plan to move the process over to municipalities were quite skeptic, fearing this may lead to an expensive transition period with reduced efficiency in the midst of the hectic decade until 2020.

8.4 Environmental Aspects and Conflicts

Through the interviews, I learned that most hydropower-developing companies meets some resistance at one point or another. Protests and conflicts arise due to emotions connected to certain areas or rural industries, and it is often hard to reason against protesters with personal agendas. However, the respondents put a lot of effort into pleasing the affected communities, and staying in close contact with the landowners to prevent as much conflict as possible. Of course, in some cases, the company’s interests coincide with for example a landowner’s interests, and if so, it is up to NVE to make a decision based on the relevant arguments, as it is in most cases concerning hydropower projects. The responders gave the impression that protests usually arise in the early stages of the development, only to subside at a later point when realizing that the project perhaps does not involve as much interference as initially believed. Of course, the level of conflict correlates with the size of the projected plant. Earlier in my thesis, I described the controversy surrounding the construction of the Alta River hydropower plant in the late 1960s, which led to nationwide protests and civil disobedience. Today, protective governmental acts, as well as limited large-scale possibilities, have reduced the possible impacts of hydropower plants and as the respondents point out, small – and to a certain degree “smaller” large – hydros have far less impacts on the surrounding nature.

One of the respondents also points out that NVE seems to focus more on environmental impacts lately, which could possibly lead to developers devoting more time to studies concerning the impact on the surrounding nature in future projects, in line with the discussion in Chapter 8.3. Further, a respondent comments on the importance of environmental impacts in the Norwegian hydropower industry today, implying that this is taken much more seriously in other countries, and accredits this environmental indifference to Norway’s vast water resources. With the increasing importance of the subjects of nature and biodiversity, it is reasonable to assume that this is something that will influence the future hydropower development, though it is of course difficult to say to what extent.

8.5 El-Certificates and the Future of Hydropower

The el-certificates system and its corresponding market was, as expected, an important topic during my interviews. The respondents all had different opinions and thoughts concerning this incentive-based solution, especially in connection to the waiting period at NVE. With the expected application processing time, which of course is hard to predict, and the time it takes to develop a small hydro, the respondents all agreed that it is at this point too late to submit a new project and expect this to be up and running by December 31 2020. However, the respondents still consider smaller projects, like improvements and watercourse regulating viable options, as these application processes usually do not take as long, nor does the subsequent construction. Of course, there are some constraints, most notably the fact that the developer only gets el-certificates for the additional electricity generated, not for the total generation. This makes accurate calculations and preliminary studies two very important parts of the profitability analysis of a restoration project.

Because the government is the legislative body of the el-certificates, the respondents base their thoughts and opinions connected to the future of the system on election promises, theoretical estimations, and industry rumors. The respondents all acknowledge that the future of the el-certificates and their value is uncertain, and while some consider the possibilities of the government extending the el-certificates system, others believe that the system functions best if allowed to run its planned course. Concerning extending the el-certificates system, the most tangible solution is to shift the entrance date back further; making hydropower plants built some years before September 7 2009 eligible for el-certificates. The current government has mentioned this earlier, but so far, there have been no indications that this will change, which of course makes some of the respondents question whether this change will ever happen. The respondents expect a significant increase in new hydropower plants until 2020, a “Klondike Rush” as one so eloquently puts it, and this rush raises the two following concerns in the respondents. First, with an increased amount of new hydropower plants follows and increased demand in materials and labor. If suppliers are not able to meet this demand, the respondents fear that projects can be delayed, thus not making the el-certificates system deadline, or forced to resort to inferior equipment. Hydropower developers relies upon the good graces of both the media, environmentalists, and politicians, thus a step back, environmentally or otherwise, could damage its reputation, and compromise the future developments. The second issue concerns the increased supply of electricity that comes with the new hydropower plants, and how this affects the electricity price. According to market theory, unless the demand for electricity increases accordingly, an increase in supply will lower the prices, thus reducing the hydropower plant’s revenue. As we saw in Chapter 5.3, the electricity consumption in Norway from 1993 to 2013 shows very little signs of increase, and if this trend would continue, a large increase within the next ten years seems unlikely. However, as mentioned earlier, the Norwegian government has calculated the quota obligation for the el-certificates system using an annual growth in electricity consumption of .3%, meaning they are aware of the potential change in price, and perhaps are incorporating other factors, like increased electricity exports, to restore the equilibrium.

The future after 2020 is very unpredictable, as the respondents do not know how the el-certificates value will develop. If the government sees it fit to reduce the quota obligation imposed on electricity suppliers (see Chapter 5.2.2), the demand for el-certificates will decrease, thus decreasing their value and the power companies’ revenues. The respondents do therefore have very different opinions considering the future of the hydropower industry, most likely based on personal outlook and their company's motives and business plan. Some of the respondents expected a rather dramatic decrease in hydropower development, on par with the effects of the Energy Act in 1991, as the possible revenues would be too low for many hydropower projects, reducing the investments willingness of power companies and investors. Others were more uncertain, arguing that *good* projects will still be profitable enough to attract investors. One of the responders brought up the subjects of foreign investors, once a heated topic in Norwegian hydropower, as we saw in Chapter 2.2.3. Despite the foreign investors being part of the reasons for the Norwegian acts concerning licensing, watercourses, and water regulation, there are currently no rules against foreign investors in small hydros with limited watercourse regulations. Further, the respondent is under the impression that hydropower plants often involves more work and costs than the owner's heirs are ready for, which could result in sales of existing plants, either to other private investors, power companies, or foreign investors.

Based on the respondents' statements, I believe it is fair to assume that the profitable projects left will be the main target of many power companies in the coming decades, as the amount of electricity sold eventually becomes the main source of revenue. Nevertheless, these projects are, like the total hydropower plant possibilities, limited. In Chapter 1.2, I mentioned that until now, power companies and private citizens have utilized about 60% of the available hydropower in Norway. In Chapter 2.2.10, I explained the governmental protection plans and how the currently protected watercourses accounts for an estimated 23% of the electricity generation potential, leaving only 17% untapped. If the Norwegian el-certificates system works as intended, new renewable energy-based electricity generation – mainly by hydro and wind power – will have increased by 13.2 TWh by 2020. As we have seen, wind power currently accounts for a very low percentage of the total electricity generation in Norway, thus a feasible theory, which the respondents seem to support, is that new hydropower will be responsible for a substantial share of the goal. If so, a large part of the estimated available 36.1 TWh of hydropower will most likely be developed by 2020, effectively decreasing the possibilities for further hydropower development.

Chapter 9: Conclusion

In this thesis, my goal was to investigate the Norwegian hydropower industry, and to locate and describe the important factors that play determinant roles in the hydropower development with focus on small hydros. I found it necessary to study the historical development as a backdrop for my thesis, to serve both as theoretical support for the findings, and as reference for comparison. The different perspectives of the respondents provided this thesis with a detailed view of the hydropower development from the power companies' point of view, and the respondents seemed eager to explain and discuss the subject of my thesis, and talk about the past and future development of the hydropower industry.

The multiple-case studies gave me valuable information that formed a detailed picture of the hydropower development, with each respondent adding their opinions and what they believed contributes to, and brakes, the development. In the interviews, some of the topics raised similar thoughts and opinions, while other pieces of information were solely the product of the respondents' own perceptions of the development. When comparing the different statements from the cases, one thing that struck me was the different views on how the el-certificates system, and its duration, affects the hydropower development. These different perspectives lead me to question the sustainability of the Norwegian hydropower development, as the responses to whether the government should continue with an incentive-based solution differed so much. One can argue that an industry depending on incentives for progress is not very sustainable at all, which may be the case for Norwegian hydropower, when interpreting the different perspectives.

Further, as with most natural resources, the number of watercourses is finite, and at one point, there will be only protected watercourses left. Thus, the future of hydropower development may very well shift from new hydropower projects to renovations of existing hydropower projects to accommodate for the decreasing market potential that developers are likely to see in in the 2020s. In addition, some also consider the increase in electricity supply because of the increased amount of new hydropower plants troubling, and fear the consequences this may have on the electricity prices.

My findings connect the Norwegian price of electricity to the global prices of oil and coal, as studied by Holstad and Pettersen (2011). With the global impact on the prices of oil and coal, one can tie a link between the global economy, electricity prices, and Norwegian hydropower development. The findings seem to indicate such a pattern, especially concerning the global recession of 2008, with the drop in number of license applications and new hydropower plants from 2007 to 2011, although whether we can accredit this drop to the recession alone is hard to determine with the current information. However, it is worth mentioning that the spot prices of electricity have been very volatile in this period, which increase investment uncertainties, and as the Nord Pool Spot market trade electricity in EUR/MWh, fluctuations in the NOK/EUR exchange rate will influence a hydropower plant’s revenue.

In addition, the el-certificates have played an enormous part in the development. Despite the driver the certificates have been the past few years, the respondents recognized the uncertainty of the system, and the risk this uncertainty entails concerning future revenue. However, if you are fully aware of the risk, it is possible to use conservative estimates for the future value in a project. The focus on renewable energy shifts across political parties in Norway, which makes it difficult to estimate how the government of, let us say 2025, will view the system, and if they might feel the need to reduce the quota obligation because of other political motives.

Many of the issues facing small hydropower developers connect to the government. Arguably, the most influential bottleneck a hydropower plant developer faces is the license application process at the Norwegian Water and Energy Directorate (NVE). Due to the strict rules and regulations imposed by the government through the Ministry of Petroleum and Energy, NVE’s processes are time-consuming and usually last years. Hydropower developers are painfully aware of this, and even though the directorate has proven to be a difficult obstacle to overcome the past few years, the respondents express that there are rarely any quick solutions and fixes to deal with issues in governmental bureaucracy. Connected to the long NVE application process is the issue with power grid access. In certain areas, the possibilities of hydropower development are simply non-existing because they do not have the power grid access needed to transport the electricity, effectively “blacklisting” these areas.

The current resource rent tax on small hydropower plants also seem to inhibit the hydropower development. Enforced at the 5.5 MW level, it splits the small hydros with regards to taxes, and results in developers building hydropower plants with less installed effect than what they consider optimal. Until the event that the government might change this, the resource rent tax represents a bottleneck for optimal utilization of watercourses.

In addition to the three aforementioned bottlenecks, I believe there are two important potential issues the hydropower may meet in the near future, the first being access to materials and contractors in the coming years. With the closing of the el-certificates system in 2020, there will be a rush of projects, small and large, to make the deadline, and the responders worry the possible shortage of important components or labor may lead to projects not making the deadline, thus posing a threat to some project developments.

The globally increasing focus on the environment and biodiversity may also turn into a future bottleneck for hydropower development. NVE is focusing on the quality of watercourses affected by hydropower plants in its license terms revisions and the focus on biodiversity may increase, as one respondent indicates. If so, NVE’s demands are likely to increase, leading to hydropower developers spending more time on time-consuming preparatory environmental assessments, to get their license applications approved.

Further Research

This thesis includes a limited number of respondents, thus it could be relevant to include a larger spectrum of research units, like private hydropower owners, environmentalists, politicians, and so on. This way, a researcher can be able to create a complete picture of the hydropower industry, social aspects and all, and determine whether there are more issues facing the future of the industry. It could also be interesting to study the effects of the closing of the el-certificates system, to see if this does in fact reduce the developments significantly, perhaps by studying other countries that have similar experiences, and determine how well the incentive-based solution has actually worked.

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Appendix A

Illustration 1. Google Trends

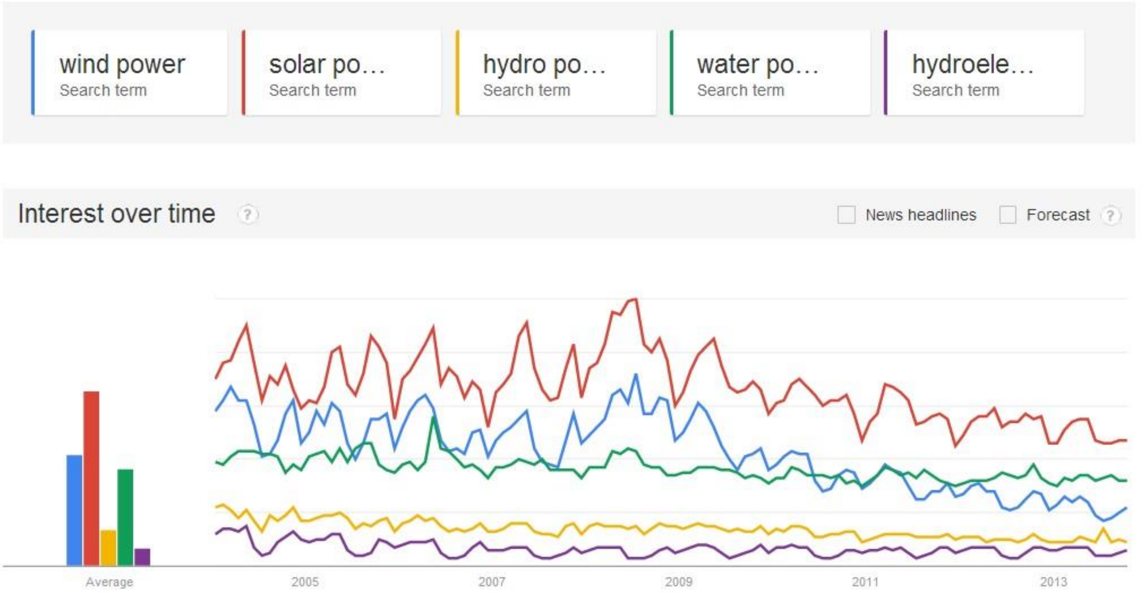
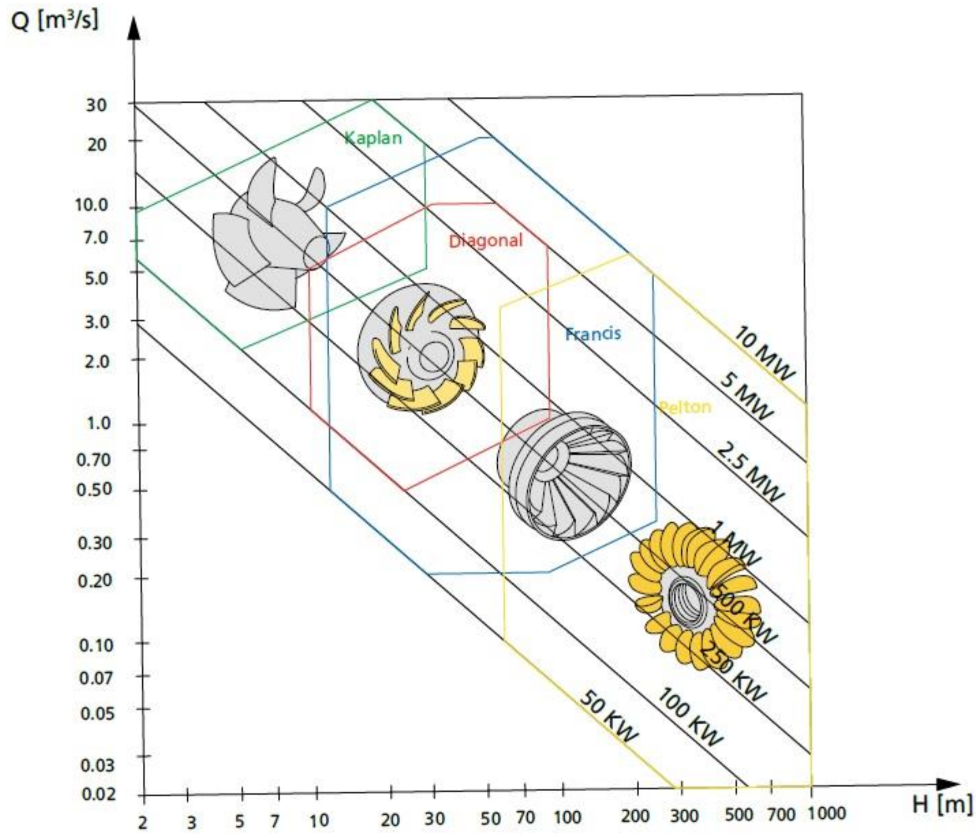


Illustration 2. Brødrene Dahl's graph for selecting a turbine, with intake (Q) and height (H) as determinants:



Appendix B

Table A. The relative changes in small, large, and total hydro, 1974 – 2012:

Year	Rel. Δ Small Hydro	Rel. Δ Large Hydro	Rel. Δ Total Hydro
1974	0,00 %	0,00 %	0,52 %
1975	-0,56 %	2,27 %	0,52 %
1976	0,00 %	0,44 %	0,17 %
1977	-0,56 %	3,54 %	1,03 %
1978	-1,70 %	2,99 %	0,17 %
1979	0,58 %	3,32 %	1,70 %
1980	-0,86 %	2,41 %	0,50 %
1981	-0,29 %	3,14 %	1,16 %
1982	-0,87 %	3,04 %	0,82 %
1983	-3,22 %	2,95 %	-0,49 %
1984	0,60 %	0,72 %	0,66 %
1985	1,80 %	1,78 %	1,79 %
1986	-0,88 %	1,40 %	0,16 %
1987	0,30 %	1,03 %	0,64 %
1988	0,00 %	1,37 %	0,63 %
1989	0,30 %	2,69 %	1,42 %
1990	0,30 %	0,66 %	0,47 %
1991	-1,18 %	0,00 %	-0,62 %
1992	0,30 %	0,00 %	0,16 %
1993	-5,36 %	0,00 %	-2,80 %
1994	-0,63 %	0,98 %	0,16 %
1995	0,63 %	-0,97 %	-0,16 %
1996	-1,89 %	0,00 %	-0,96 %
1997	-3,21 %	1,63 %	-0,81 %
1998	0,66 %	0,64 %	0,65 %
1999	1,32 %	0,64 %	0,97 %
2000	-0,65 %	1,58 %	0,48 %
2001	2,94 %	-0,93 %	0,96 %
2002	-0,32 %	0,31 %	0,00 %
2003	1,27 %	-0,31 %	0,47 %
2004	1,89 %	0,00 %	0,94 %
2005	1,85 %	0,94 %	1,40 %
2006	2,12 %	1,56 %	1,84 %
2007	4,15 %	-0,31 %	1,96 %
2008	3,70 %	0,62 %	2,22 %
2009	13,46 %	-0,31 %	6,95 %
2010	7,02 %	-0,61 %	3,65 %
2011	26,02 %	0,62 %	15,27 %
2012	8,26 %	0,00 %	5,21 %

Source: SSB (2013b). Small Hydro ≤ 10 MW, Large Hydro > 10 MW

Appendix C

Interview Guide – Power Companies

1. Questions Connected to the Respondent:

- What is your position in the Company, and for how long have you held this position?

2. Questions Connected to the Company and Hydropower:

- How many hydropower stations does the Company own/operate?
- Does the Company currently work on any hydropower projects?
- How has the demand for hydropower developed the past ten years in the eyes of the Company?
- Is the hydropower development affected by macroeconomic and/or political events?
- Does the demand after hydropower follow the general macroeconomic cycles?
- When building new hydropower plants, does the Company follow a standardized development plan, or schematic, or do you customize each plant?
- To what degree does the Company focus on new instruments and methods, i.e. is the willingness to invest present when considering entirely new inventions?

3. Questions Connected to the Company and Their Customers:

- Does the Company normally take on new hydropower projects, or is investing in existing plants an option?
- What are the factors that play a role when purchasing equipment for a new plant?
- Does the Company experience that landowners have their own prioritizations or wishes when contacting the Company?
- Has the Company experienced that landowners wish to focus on the environment, or esthetics, when developing a hydropower plant on their property?
- Is the Company in charge of the operating of the plant, or does this vary from landowner to landowner?
- Has the Company experienced any conflict with the landowner concerning the questions mentioned above?

4. Questions Connected to the Company and the Locals

- How much does the Company usually intervene in the nature, c.f. reservoirs, etc.?
- Does the Company experience conflicts with the locals when planning and developin g a hydropower plant, and if so, does the conflict persist?
- How would you describe the attitude towards hydropower in Norway today? Compared to wind power.

5. General Questions Concerning Hydropower Development:

- Is it possible to say anything about the general investment- and operating costs for a small hydro?
- Fjellkraft AS say on their home page "… it may take a long time before the investment pays off", is the Company under the same impression? If so, how long are we talking?

- How long is a small hydro expected to generate electricity, and is this the lifespan used in investment analyses?

6. El-Certificates

- Background: “Until 2020, Sweden and Norway will expand the electricity generation based on renewable resources by 26.4 TWh”.
- Has the el-certificates system made investing in hydropower more attractive?
- Has the el-certificates made investments in existing plants more economically viable?
- What is the Company’s views on a system like this?

7. License Applications

- What is the Company’s attitude towards NVE and its license applications process?
- NVE changed their routines recently to process all applications from one geographica l area at the same time to speed up the process, has the Company been affected by thi s?
- Do you have any suggestions as to what could further reduce the waiting line?

8. The Future of Hydropower and Political Influence

- How does the Company view the future of hydropower in Norway?
- How will the el-certificates system affect this future, and what does the Company expect will happen before and after 2020?
- Now that there has been a change in the Norwegian government, does the Company expect any changes in hydropower development, based on the new governing parties’ politics or pledges? C.f. Competition, profitability, investments, and research.

Appendix D

Figure 1. Elspot Prices and Brent Blend spot price:

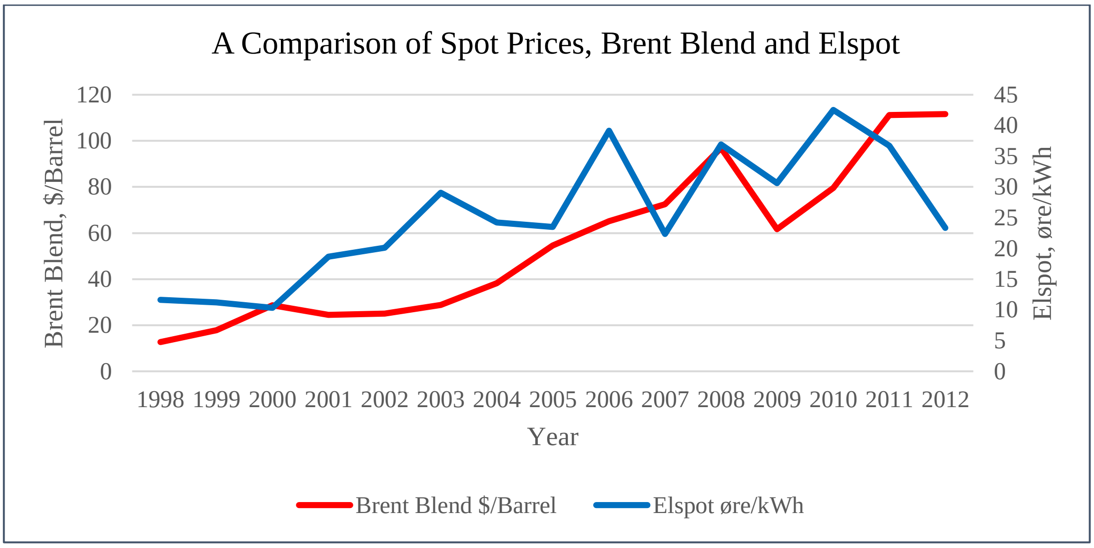


Figure 1. Source: Nord Pool Spot (2012b) and the U.S. Energy Information Administration (2013).

Figure 2. Electricity Generation and Consumption:

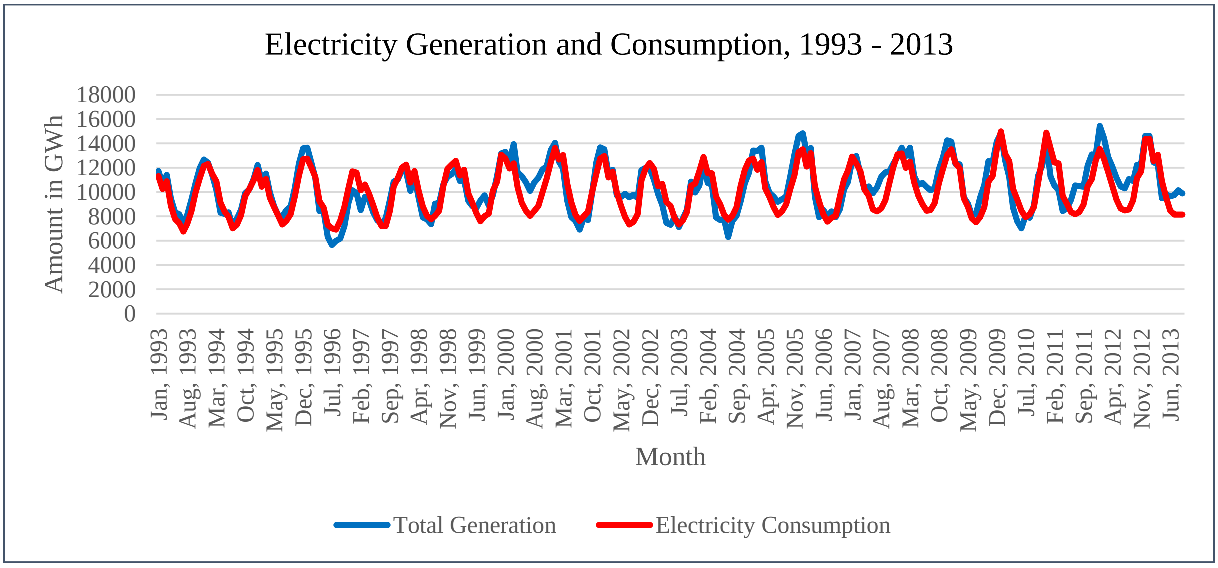


Figure 2. Source: SSB (2013e)