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Investigating Compensation Schemes for Hydropower in Sweden

Overview of Swedish Compensation Schemes for Hydropower and their Applicability to Wind Energy Development

Bachelor Thesis in Global Systems Engineering

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Abstract

The Swedish energy system is largely free of fossil fuels, mainly due to a large proportion of hydropower. Swedish climate policy has led to the need for an imminent electrification of previously fossil fuel dependent industry, resulting in the energy demand being predicted to double by 2035. The current pace of wind power development is deemed to be insufficient to meet the growing demand.

This thesis aims to compare the incentive mechanisms intended to increase acceptance of wind power development to the system of monetary compensation used for people affected by hydropower, historically and presently. The thesis provides an overview of how regulations and norms regarding environmental evaluation and compensation have changed over the 20th- and 21st century. The two main ways of compensation for hydropower that have been identified are: direct compensation determined by court rulings, and compensation through a system of community indemnity grants.

Information regarding hydropower stations in Sweden has been compiled into a data set, combined with information regarding the compensation payments that have been identified in the project. Some of the main trends discovered during the analysis of the data are that there seems to be a correlation between the monetary compensation and installed capacity for the community indemnity grants, but not for the direct compensation through court rulings. The attitude towards what types of value are compensated for has seemingly changed throughout the time period, with environmental values becoming seen as more important over time.

Sammandrag

Det svenska energisystemet har redan idag en stor del fossilfri energiproduktion. Detta beror huvudsakligen på den stora mängden vattenkraft. Dagens klimatmål gällande förnybar energiproduktion i kombination med en ökad efterfrågan av energi gör dock att ytterliggare utbyggnad av förnbybara energikällor är nödvändig. Takten av dagens utbyggnad av bland annat vindkraft är otillräcklig för att möta klimatmålen och det ökade behovet.

Denna rapport syftar till att jämföra de incitament som finns för att öka acceptansen av vindkraft med den monetära kompensation som användes vid utbyggnaden av vattenkraft, både historiskt och idag. Projektet ger en överblick av hur miljövärdering och kompensation har förändrats över 1900- och 2000-talet. Vidare har de två huvudsakliga kompensationssätten för vattenkraft identifierats. Dessa är direkt kompensation fastställda i vattendomar och kompensation genom bygdemedel.

Information angående vattenkraftverk i Sverige har satts ihop till ett dataset, tillsammans med information angående kompensationsutbetalningar som har identifierats i projektet. En av de viktigaste trenderna som upptäcktes i dataanalysen är att det verkar finnas ett samband mellan den monetära kompensationen och installerad effekt för bygdemedel men inte för engångskompensationer fastställda i domar. Uppfattningen av vilka typer av värden som man bör kompenseras för har till synes förändrats över tid, där speciellt värdet av miljön blivit allt viktigare.

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Contents

List of Figures:

List of Tables

1 Introduction

1.1 Background

Facing impending climate change combined with increasing energy demand, the world is at the beginning of a crucial transition towards sustainability. Anthropogenic activity and industry contribute to degradation of biodiversity and greenhouse gas emissions. Increased concentrations of greenhouse gases in the atmosphere leads to a rise in global average temperature. The International Panel on Climate Change (IPCC) has concluded that the international community should strive to keep the global temperatures below 1.5 °C higher than the pre-industrial average to avoid the worst effects of climate change (Masson-Delmotte et al., 2019). Therefore, the Swedish government has set the goal of achieving net zero CO2 emissions by 2045 (Regeringskansliet, 2017).

The accomplishment of this goal will require the electrification of industries currently dependent on fossil fuels and therefore an increased demand for fossil-free energy production. Forecasts indicate that the energy demand in Sweden could double by 2035 (Energimyndigheten, 2022). According to the Swedish government, 100% of electricity should be produced using renewable energy sources in 2040[1] (Regeringskansliet, 2015b). In the year 2021, the fraction produced by renewables was 60% (SCB, 2022). Hence, to reach the goal set for 2040, electricity production from renewable energy sources needs to increase.

The transition towards a sustainable energy system could in some ways be compared with the industrial revolution, where new advancements in technology and industry were sometimes met with resistance from local communities. These types of conflicts are not without precedent in Swedish history. Industrialisation started in Sweden in the late 19th century and the development of hydropower changed the conditions for the industries immensely. The first hydropower station generating electricity in Sweden operated indoor lighting in a cotton factory (Harnesk, 2019).

[1] The current Swedish government aims to change the goal from 100% renewable energy to 100% fossil free energy (Regeringskansliet, 2023b). However, this change has not been implemented yet.

The first commercial hydroelectric power dam in Sweden became operational in 1893 (Johansson and Kriström, 2013), and the development accelerated rapidly in the light of the new water law that was implemented in 1918 (Vedung and Brandel, 2001). The law of 1918 supported and encouraged the development of hydropower in Sweden and moved the approval of hydropower projects from the old municipality-based courts that had a locally elected board, to five new regional Water Courts[2]. This constituted a paradigm shift in the energy sector which favoured industrialisation and the hydropower developers in Sweden while the landowners' position was weakened. These courts were later merged with the Land and Environment Court[3] when they were introduced (Vedung and Brandel, 2001).

Since hydroelectric dams are disruptive to the local ecosystem and perceived by some to destroy the natural beauty of the landscape, the construction of such dams has in some cases been met with resistance from different actors (Vattenfall, 2020b). Despite some resistance, Sweden managed to build a well-functioning energy system based on hydropower. To solve the conflicts between local residents and energy companies, compensation schemes were implemented, where local communities as well as individuals affected by the hydropower expansion, received monetary compensation (Lundmark and Sandström, 2013). The development of hydropower in Sweden was ongoing until 1960-70 when people started protesting in order to protect the rivers and stop the exploitation (Ericson, 2021). Today, hydroelectric energy accounts for 43% of the energy produced in Sweden (SCB, 2022).

In Sweden, municipalities are authorised to reject larger projects in their immediate environment according to The Swedish Environmental Code (Anstrell, 2021). This is known as the municipal veto and is often applied to wind power projects (Anstrell, 2021). According to a report ordered by Swedish Wind Energy[4], 78% of wind turbines were affected by the municipal veto in 2021 (Westander and Risberg, 2022).

[2]Originally, five Water Courts were instituted in 1918. The geographical area that each court covered was changed at some point between 1954 and 1995 so, in 1995, six courts exists (Vedung and Brandel, 2001).

[3]Swedish: Mark- och miljödomstolen

[4]Swedish: Svensk Vindenergi

This shows that there is resistance among citizens concerning the development of renewable energy sources in their local environment.

1.2 Problem

Identifying the characteristics of historical energy transitions, for instance, the rapid expansion of hydropower in Sweden that is discussed above can provide valuable insights into how a sustainable expansion of renewable energy can be enabled today.

Research on historical energy transitions has led to some fundamental insights into common characteristics of previous energy transitions. To begin with, changes in energy supply often emerge as a result of a transition in energy end-use services (Grubler, 2012). This means that a change in energy demand will drive the transition on the supply side of the system and that there will not be any drastic changes in how the energy is supplied without this change in demand. Furthermore, the pace at which an energy transition occurs differs from country to country depending on the current situation and what the energy system looks like. In general larger systems change more slowly than smaller systems and the more complex and embedded the system is in society the slower it can be changed (Grubler, 2012). This is mostly due to path dependence and sunk investment costs.

In the European Union's European Green Deal (EGD), introduced in 2019, it was proposed that one trillion euros should be invested in efforts to support Europe's efforts to counteract the ongoing climate change (Fossilfritt Sverige, 2022). 100 billion of this investment was earmarked for the Just Transition Mechanism (JTM). The JTM will over the period 2021-2027 use these funds to facilitate a just and equitable green transition, by supporting regions that are especially vulnerable to climate change and the imminent transition (European Union, 2020). Sweden has been allocated 324 million euros from the JTM to help regions and industries that will be impacted by the rapid ongoing transition (Fossilfritt Sverige, 2022).

Historically, compensation has been used in Sweden in connection with the expansion of hydropower. Two main ways of compensation have been identified in this project. One is the compensation to property owners that are directly affected by the construction of a hydropower station. Before getting permission to build

a hydropower station the developer must investigate who is affected by the construction as well as calculate and present a reasonable compensation for everyone affected (Ryrberg. N, personal communication, 28 March,2023). This compensation was then agreed upon between all actors. Often, negotiations were done directly between the property owners and the developers, but in some cases, negotiations were brought up in court. Either way, the final compensation was decided upon in a court ruling. In most cases, the compensation was in the form of money that was paid directly to the property owners, but it could also be in the form of electricity to a household. The other type of compensation is called a community indemnity grant[5]. The principle of this type of compensation is that the owners of a hydropower station have to pay a yearly community indemnity fee to the County Administrative Board[6]. A community indemnity grant can then be applied for by people or, more commonly, local associations in areas affected by hydropower. The money from the community indemnity grant can be used to repair damage caused by hydropower or to promote the local community in some way.

Detailed information about the compensation in Sweden connected to hydropower operations is archived in different institutions using different administrative systems. Therefore, it is hard to get a proper overview of the compensation as a whole which results in several knowledge gaps when it comes to this type of compensation. This project will try to answer questions such as ”What is the monetary value of the compensation?” and ”What are the reasons for the compensation?”. Furthermore, this project will investigate how environmental values and damages have been evaluated when developing hydropower as well as how this evaluation has changed through the years. In addition, a large portion of wind power developments are currently rejected in Sweden (Hallberg, 2022). Therefore this project will also examine how, and to what extent, the findings from the analysis of compensation schemes during the hydropower development can be applied to wind power development today.

[5]Swedish: Bygdemedel
[6]Swedish: Länsstyrelsen

2 The Evolution of Hydropower Regulations in Sweden

This section will touch upon a variety of research topics that are relevant to the project. The review of prior literature will help create a basis for the latter discussions to build upon by painting a picture as to what prior knowledge already exists on relevant topics. Firstly, there will be an introduction to the Swedish administrative structure. Furthermore, a short summary of the early development of hydropower in Sweden and the emergence of compensation schemes in regard to this will be presented. A brief introduction to the topic of environmental assessment will then be given before moving on to how the environmental assessment in connection to the hydropower expansion has developed in Sweden.

2.1 Introduction to the Swedish Administrative Structure

To be able to fully understand this report, a basic understanding of Swedish institutions and the Swedish legal system is beneficial. In this section, a brief introduction to these in relation to each other is presented.

Sweden is divided into 290 municipalities which are responsible for most of the local community services such as schools and education, city planning, roads, and energy. They are run by locally elected politicians (Regeringskansliet, 2015a). In the context of hydropower expansion, a municipality as a whole might be much less affected or affected in substantially different ways than the people living in close proximity to a power station, often referred to as the local community in this report.

There are also 20 regions[7] and 21 counties[8]. Regions are much like municipalities in that they are independent, self-governing, and led by locally elected politicians (Regeringskansliet, 2020). They roughly overlap with the counties. Each county has a County Administrative Board that acts as the regional deputy of the Swedish government. They are structured as 21 government agencies with a broad task of implementing and coordinating government decisions and the work of other government agencies in each county. Permits, grants, oversight of environmentally damaging operations, crisis management, and protection of heritage sites are just

[7]Swedish: Region
[8]Swedish: Län

some of the tasks managed by the County Administrative Board (Länsstyrelsen Västra Götaland, n.d.). In the context of hydropower, another important function is the distribution of community indemnity grants (Klintebäck. E, personal communication, March 14, 2023).

The general court system in Sweden consists of District Courts, Courts of Appeal, and the Supreme Court. These handle for example criminal cases. There is also a number of other separate courts[9] within the general courts (Sveriges Domstolar, 2022). One of them, the Land and Environment Court[10]and the Land and Environment Court of Appeal[11], is of particular interest for hydropower. These courts try cases regarding construction, properties, the environment, and water. This can for example be constructing a new hydropower station or upgrading an existing dam and deciding the compensation that affected locals will receive. There are five of them distributed across Sweden in the cities of Östersund, Umeå, Vänersborg, Nacka, and Växjö (Sveriges Domstolar, 2022). These stem from the Water Courts created in 1918 to specifically handle and facilitate the expansion of hydropower (Vedung and Brandel, 2001). When the Swedish Environmental Code was introduced in 1998, the courts were renamed and the scope was broadened.

2.2 Early Development of Hydropower and Compensation Schemes in Sweden

Sweden has a multitude of rivers well suited for building dams and producing electricity. The first rivers to be exploited were in southern Sweden where the distance to energy-consuming cities was relatively short. Technology for transferring electricity over longer distances came around the year 1900, and the great expansion of hydropower began (Paulsson, 2013). The legislation regarding water courses at the time did not, however, facilitate the expansion of hydropower. According to Vedung and Brandel (2001), the law was centered around a rather archaic formulation that would roughly be translated as "everyone has the right to reign over water by his shore"[12].

[9]Swedish: Särskilda domstolar
[10]Swedish: Mark- och miljödomstolen
[11]Swedish: Mark- och miljööverdomstolen
[12]Swedish: "Envar äger att […] råda över vatten, finnes å hans grund"

2.2.1 The Royal Waterfall Board

The government agency Royal Waterfall Board[13] was founded in 1909 to build a hydropower station in Trollhättan, south of Lake Vänern after the Supreme Court had ruled that the right to build there belonged to the state as this was seen as a public interest (Vattenfall, 2020a). The new agency soon built another large power station, the Porjus Power Station, far north in Sweden as the first railway electrification project and the mining industry required a substantial amount of energy. Hydropower was seen as the key to industrialisation and prosperity, and a method for reducing the need for importing coal (Hansson, 1994).

Hydropower was seen as a way to supply the growing industrial sector with cheap and reliable energy without relying on other countries. Vedung and Brandel (2001) point out that all political parties were in favour of continued development until roughly 1965. The first director of the Royal Waterfall Board, Vilhelm Hansen, argued that the government could ”gain an income of a substantial value” by building their own power stations through the Royal Waterfall Board (Vattenfall, 2020a). It is clear that the government as well as private interests had a lot to gain from an expansion in hydropower.

2.2.2 The 1918 Water Law and the Five Water Courts

In 1918, a new water law was introduced. The goal was to pave the way for hydropower and make use of the country's rich assets of natural energy (Vedung and Brandel, 2001). The new law was focused on simplifying for energy corporations to allow for and speed up the exploitation of water streams for hydropower. This law is important according to Nils Ryrberg, a lawyer with considerable experience in water-related court cases, as most hydropower stations have been built under the conditions of this law (Ryrberg. N, personal communication, 28 March, 2023).

A new idea that was introduced with this law was Water Courts. There would be five of them across the country with jurisdictions covering the entirety of Sweden. It was the task of the new Water Courts to give permission for constructions affecting water streams and decide what compensation affected landowners should be paid

[13]Swedish: Kungliga Vattenfallsstyrelsen

by the developer, something that was previously the task of the local courts[14]. This proved to be very beneficial for the hydropower corporations as it moved the permit approval from the local community to a new independent body (Vedung and Brandel, 2001). The permit process was, in essence, based on the hydropower corporation investigating the area and creating plans. They would then hand that over along with a list of properties that would be affected by the project to the Water Court. Following the negotiations, a verdict determined the terms from which the hydropower stations would be built, often including some of the one-time sums of money that would be paid to landowners as compensation.

Another new concept that was introduced was that of community indemnity fees[15]. The idea was that the owner of the hydropower station should pay a yearly fee to the government (SFS 1918:523). The law states that this money should be used for unforeseen damages related to hydropower. The government was to use this money to prevent and minimise damage not covered by direct compensation through court rulings. Money not used to compensate for damages was to be used to support the local community, especially promoting farming through trenching and expanding the availability of electricity.

Finally, an important new concept introduced with this law was that private interests, as opposed to only the government's, were being allowed to expropriate the land of private landowners to build hydropower stations. The expropriation was allowed when the following mathematical expression was true:

> Profit from the power station $>$ Cost of damages on land belonging to the developer $+ 3 \cdot$ Cost of damages on farmland owned by others $+ 2 \cdot$ Cost of damages on properties and land owned by others

There were, however, some exceptions according to Vedung and Brandel (2001). If all land that would be damaged was owned by the developer, the project could go ahead even if the condition above was not fulfilled. This also applied when the developer had negotiated contracts with the landowners (Vedung and Brandel, 2001).

According to Vedung and Brandel (2001), the Water Courts were obligated to base

[14]Swedish: Häradsting
[15]Swedish: Bygdeavgift

the verdict for each power station on the local conditions without any broader perspective taken into account (Vedung and Brandel, 2001). However, hydroelectric production has a great impact on the nature and ecosystem it is situated in (Renöfält et al., 2009; Yu and Xu, 2015). Hydropower stations drastically transform the river and control the natural river flow which impacts the ecosystem. When hydropower development emerged quickly in Sweden during this early period, environmental factors was not taken into account such as preserving biological diversity (Renöfält et al., 2009). Therefore, compensation was not given for ecological losses or irreversible activity. Nowadays, it is common to assess the value of nature and compensate for that as well (Yu and Xu, 2015).

2.3 Introduction to Environmental Assessment

One important aspect to consider when attempting to determine the value of the environment is that any valuation is subjective (Brännlund and Kriström, 2012). Thus, the valuation can vary, depending on how the value is measured and the agenda of the actor conducting the valuation. Two important types of value considered during environmental assessment are user- and existence values. (Brännlund and Kriström, 2012)

With private citizens being directly affected in many cases by the hydropower expansion, user and existence values play an important role in establishing the environmental value of certain areas. User values are usually associated with recreation and services the ecosystem provides. Existence values are a more recent concept, as the idea was originally formulated in 1967 and refers to the value people place on the very existence of a natural phenomenon (Krutilla, 1967). This can be seen as a shift in attitude towards environmental assessment, as this type of value had not generally been considered explicitly previously.

In addition to the existence value, some academic literature claims that other types of value are often underestimated when it comes to hydroelectric dams. The construction of these dams often lead to the displacement of people, particularly people with a lower socioeconomic status, and in some cases compensation for the cultural and social value of the land is not properly considered. The value of the lost social connections are usually not included in the cost-benefit analysis (Moran

et al., 2018).

The idea of a comprehensive approach towards sustainable development, where socioeconomic factors are taken into account is sometimes referred to as a just transition. According to proponets of such an energy transition, the transition should not be regarded as only reduction of carbon dioxide without a broader context of justice and equality (Newell and Mulvaney, 2013). Another aspect related to energy justice is the importance of internalising the external costs, of projects such as hydroelectric dams (Moran et al., 2018). Externalities in environmental economy are the positive or negative consequences that the responsible actor (e.g the developer) does not have to pay for but the society as a whole needs to reap the consequences for, either in monetary units or in the loss/growth of environmental services (Brännlund and Kriström, 2012). If the externalities are not internalised, a project with a net negative socio-economic result may incorrectly be seen as beneficial, and still be conducted.

2.4 Environmental Assessment in Sweden

Based on the general introduction to environmental assessment, the following section presents how this concept has been used and evolved in Sweden in the context of hydropower.

2.4.1 Growing Environmental Concerns Regarding Hydropower

The resistance against the expansion of hydropower did not originate from the local communities affected by the projects. The first sign of resistance came in the form of a written request by the Swedish Tourist Association[16] to the government in 1951. The request was modest in that it asked for a government investigation to see if it might be possible to spare at least one water course from hydropower construction (Vedung and Brandel, 2001). After the request was denied, several non-profit organisations joined forces in creating a private investigation instead. This eventually lead to the formation of a nature preservation committee with both government and private interests involved (Bostadsdepartementet, 1974). There was a growing debate according to Vedung and Brandel with, in very simplified

[16]Swedish: Svenska Turistföreningen

terms, associations such as The Swedish Society for Nature Conservation arguing for nature conservation and tourism while, for example, locals and The Royal Waterfall Board argued for job opportunities and the benefits of cheap electricity. In some communities, lists of signatures were collected to continue the expansion despite the consequences on the surrounding nature (Vedung and Brandel, 2001). The nature preservation committee was later converted to a governmental nature conservation board with only government representatives and started negotiating with the Royal Waterfall Board. In 1961, the Sarek agreement was reached. This agreement meant that The Royal Waterfall Board was to spare some water courses while the preservation advocates were to not oppose other expansion projects such as constructions in the yet unaffected river of the Vindelälven (Bostadsdepartementet, 1974).

The discussion continued between different actors within the governmental organisation. When a plan was presented by the Royal Waterfall Board to exploit the river of Vindelälven, new negotiations began between them and the newly created Swedish Environmental Protection Agency[17], formed from the nature conservation board. The plans were changed to only include construction of the lower parts of the river before the parliament decided that the entire river should be spared in 1974 (Bostadsdepartementet, 1974). It is clear that the perceived value of nature was increasing and that more aspects and values than previously were being considered. Vedung and Brandel argue that cultural, ecological, and recreational values have grown in importance when evaluating if and where to construct or further develop hydropower stations in Sweden since the 1970s (Vedung and Brandel, 2001).

In 1972 a proposition was passed demanding an investigation to be made weighing developing interest against conservation interest of the rivers. This meant that a governmental committee would be appointed to evaluate these interests for the first time since the development of hydropower started in 1893 (Vedung and Brandel, 2001). Through the different government investigations, some main interests that were considered were the geological features as well as the flora and fauna in the area, the river's importance for recreational fishing and tourism and the potential impact on farmland, reindeer, and employment (Bostadsdepartementet, 1974).

[17]Swedish: Naturvårdsverket

Furthermore, Vedung and Brandel (2001) thoroughly present the rational calculations made by the Sehlsted Investigation in 1974. This analysis calculated long-term environmental and economic values regarding the rivers Klarälven, Dalälven, Ljusnan, Ljungan and Indalsälven. To properly evaluate mentioned values, experts in relevant fields were summoned. Profitability was measured in production value and was then compared to the costs. The production value took the amount, and the adjustability of capacity as well as the possibilities to increase capacity in already existing hydropower stations located in the river into account. From this, the rivers were classified into groups, 0-4 with group 3 being separated into 3A and 3B. 0 meant that the river was not assessed, 1 meant rivers least prioritised to preserve, 4 meant rivers most prioritised to preserve. Group 3 should also be preserved, however, if one needed to use a river in group 3, 3A should be exploited first because of their possible ability to produce more power. In 1974, a similar analysis was made, The Ekström Analysis, covering the most northern part of Sweden (Vedung and Brandel, 2001).

2.4.2 The 1983 Water Law

In 1983, a new water law was introduced that replaced the law of 1918 (Vedung and Brandel, 2001). Ryrberg asserts that the new law contained roughly the same approval process with the same focus on compensation, although the law introduced a new focus on environmental protection (Ryrberg. N, personal communication, 28 March, 2023). A new method for calculating community indemnity fees was created, which is further explained in the results section [5].

2.4.3 Green Labelling of Energy Production

In 1995, the Swedish Society for Nature Conservation[18] expanded their green labelling Good Environmental Choice[19] to also include energy production (Naturskyddsföreningen, 2023). The following year when the labelling took effect, each hydropower station that was built before 1996 automatically got labelled as green (Yu and Xu, 2015). This faced criticism since it reduced the incentive to

[18]Swedish: Naturskyddsföreningen
[19]Swedish: Bra miljöval

re-regulate hydropower production for biological conservation purposes (Renöfält et al., 2009). The Good Environmental Choice-labelling has thus changed its environmental requirements several times since 1996. For a hydropower station to get the label today it is required to have a base flow of water in order to at least imitate a natural flow and possibilities for fish migrating through the river (Naturskyddsföreningen, 2023).

2.4.4 The Environmental Code and Hydropower in the 21st Century

The Environmental Code, introduced in 1998, replaced the old water law and had a much broader focus on environmental protection. A new workflow was introduced, but the methods for compensations stayed the same as in the law in 1983.

In contrast to the first water law that was passed in 1918, where ecological development was not highly prioritised, today's environmental code dictates that measures should be implemented to safeguard riverine ecosystems (SFS 1998:808). Also, the European Union water framework directive states that

> "the importance of protecting and, where necessary, restoring water bodies in order to reach good status, and to prevent deterioration."(European Union, 2000).

Which plainly states that the conservation of different environmental services should be accounted for as something important and valuable.

When the water law from 1983 was replaced by the Swedish Environmental Code in 1998[20] it was stated that the benefits of a hydropower station must outweigh the costs, from both a general and individual perspective (SFS 1998:808, original version), this was the so-called Benefit Rule[21].

In 2017 a proposition from the Swedish Government was made to make a greater amount of changes to the Swedish Environmental Code. One important addition was to add paragraphs[22] that states that a re-evaluation should be done regarding each hydropower station in order to meet modern environmental standards (Skog and Löfven, 2017, SFS 2018:1407) . However, how this should be done and by who

[20] Chapter 11, §6 of the Swedish Environmental Code
[21] Swedish: Båtnadsregeln
[22] Paragraphs 27 and 28 §§ in chapter 11 of the Swedish Environmental Code

was not specified. Another important proposal was to remove the above mentioned Benefit Rule. The rule entails an obligation for The Review Authority[23] to make a special assessment of the socio-economic admissibility (Skog and Löfven, 2017). The motivation behind the proposal of removing the Benefit Rule was to make the re-evaluation faster and easier. The proposition also motivates the proposal because the formulation of the law could be interpreted that the cost-benefit analysis was meant to be an ongoing process, which could result in an already built hydropower station needing to be dismantled.

The proposition regarding the Benefit Rule was met with a mixed reception. In general, most referral bodies were positive to the proposal and most County Administrative Boards and Land & Environment Courts were negative to the proposal. The law consisting of the Benefit Rule was then removed in 2019. However, the Swedish government argued that the removal of the Benefit Rule would not mean a decreased level of protection of the rivers since the values of this regulation are considered in chapter 2 of the Swedish Environmental Code and in the new paragraphs in chapter 11 (Skog and Löfven, 2017).

In June 2020, the Swedish government made the decision about how and when Swedish hydropower plants would be re-evaluated in accordance with the new requirements (Havs- och Vattenmyndigheten, 2022a). This regarded all hydropower plants with a permit older than 40 years, with the goal of implementing measures to preserve the biodiversity in water courses while not affecting Swedish electrical production in a too extensive way. In addition, this re-evaluation is going to be implemented with EU directives[24](Havs- och Vattenmyndigheten, 2022b).

2.5 Incentive Mechanisms for Wind Power

As seen in the historical review, Sweden has a long history with hydropower and has developed a robust, codified system of compensation for the damages caused. In a similar vein to how the hydropower expansion was conducted due to a growing need for energy in the industry and society, an expansion of wind power is needed due

[23]Swedish: Prövningsmyndigheten
[24]Swedish: EUs ramdirektiv

to the electrification of industry and growing demand for green electricity ("SOU 2023:18", 2023). According to The Swedish Energy Agency[25] until 2035 the annual energy generation needs to expand to at most 280 TWh and most of the expansion is predicted to come from the development of wind power (Energimyndigheten, 2022). At the same time, the municipal veto has led to a rejection of 78% of all wind power developments in 2021 ("SOU 2023:18", 2023). According to Ryrberg, the ability of the municipalities to veto wind power developments leaves the process to the local political system, which creates large uncertainties for developers. This may lead to a waste of resources, as money that is invested in wind power projects may go to waste if the political majority in the municipality decides to reject the proposal (Ryrberg. N, personal communication, 28 March, 2023). The difficulties of wind power expansion have led the government to conduct a report, "The Value of Wind - compensation, incentives and planning for a continued sustainable development of wind power"[26], investigating possible mechanisms for incentives of wind power ("SOU 2023:18", 2023).

The objectives of the report include suggesting a system of compensation for wind power, suggesting mechanisms to increase the incentives for municipalities to participate in the wind power expansion, and disclosing possible mechanisms apart from compensation for the municipalities to support wind power development. As of today, the compensation regarding wind power is not codified in the same way as hydropower. Today the compensation is mostly conducted by voluntary bargaining between the developers and the affected community ("SOU 2023:18", 2023).

The report was presented on April 27th with suggestions on how to handle the development of wind power in regard to compensation. This report recommends the following four kinds of compensation and suggests that they should come into force from May 31, 2023. In the results section [5.5], calculations of the second proposition are compared to other compensation systems used for hydropower in Sweden.

- Adjacent properties:

[25]Swedish: Energimyndigheten

[26]Swedish: "Värdet av vinden - Kompensation, incitament och planering för en hållbar fortsatt utbyggnad av vindkraften". In this report it will be referred to as the governmental report "The Value of Wind"

People owning properties within 6 times the total height of the wind turbine have the right to get their property expropriated at market value prior to the construction of the wind turbine park.

- Nearby residents:
  Residents living within 10 times the total height of the wind turbine have the right to revenue share.
- Local community:
  Part of the revenue each year should go to the development of the local community.
- Municipality:
  This particular suggestion is not enough for the municipalities and revenue for the municipalities should be further investigated.

The authors of the report conclude that these four compensation suggestions are not sufficient to develop wind power to the extent that is needed to meet the growing energy demand. The current suggested compensation will not give enough incentive to most municipalities ("SOU 2023:18", 2023). In particular, revenue for the municipalities is needed and an additional investigation regarding this should be appointed immediately. The report also highlights the lack of a legal framework in the context of wind power compensation, which can call into question what type of compensation is allowed. A clear system, similar to the community indemnity grant system which has strong support from the municipalities, is expected to decrease the resistance towards wind power development by local communities. ("SOU 2023:18", 2023).

3 Aim and Scope of the Research

This section will present the aims of the project as well as their associated objectives. Additionally, the scope of the research will be defined.

3.1 Aim and Objectives

The project has two main aims. The first aim is to gauge, identify and quantify different aspects of hydropower and compensation schemes in Sweden. Based on the analysis of historical hydropower expansion in Sweden, this project's second aim is to compare the historical compensation regarding hydropower with the current plans for the development of wind power. The project will look further into the impacts that compensation schemes have had historically and possibly will have in the future when it comes to a just transition to renewable energy. The focus will be on hydropower and wind power, two highly pertinent energy sources for Sweden's expansion of renewable energy generation. To achieve the main aims of the project, the following objectives were identified as well as the order they will be addressed, where each step builds on the previous steps.

1. Compile a database of all hydropower projects within the scope built in Sweden after 1918. This step is crucial to enable further analysis.

2. Identify the hydropower projects that had compensation schemes and understand the mechanisms for this.
   To be able to collect relevant data, hydropower projects which used compensation schemes need to be identified. How the compensating mechanism works is also important to understand. This will enable the collection of relevant data in the upcoming steps.

3. Collect qualitative and quantitative data on the compensation schemes. The parameters that will be collected will depend on the available data. Examples of possible parameters are given below.
   a) Qualitative: Geographical location, time duration, company, municipalities, type of compensation, list of projects supported by the funds, criticism it has received, reasons for starting and ending, any changes to the compensation schemes along the way (when and why), whether there were conditions for

how the compensation should be used.

b) Quantitative: Capacity of individual projects, SEK/MW, SEK/GWh, SEK/number of people compensated, and SEK/county and year.

4. Develop dataset.

   To analyse and visualise how compensation during hydropower expansion in Sweden was carried out a dataset needs to be developed. This will mainly consist of cleaning and processing the collected data.

5. Carry out a quantitative and descriptive analysis of the identified hydropower compensation schemes.

   With access to the previously developed dataset, this aims to analyse and visualise compensation schemes for hydropower in Sweden.

6. Compare the current Swedish renewable energy expansion plans to the historical development of hydropower.

   Sweden is set to reach 100% renewable electricity in 2040 (Regeringskansliet, 2015b). This part of the project aims to apply the gained knowledge from previous steps to the current plan of energy development in Sweden.

Objectives 1-3 are related to the first aim of identifying and quantifying different aspects of hydropower and compensation. Objectives 4 and 5 connect to both of the research aims since the analysis needs to quantify the different aspects of hydropower with regard to compensation but nevertheless, it is also needed in order to consider the possibilities in today's context. Objective number 6 is the objective that connects closest to the second research aim because that is when today's context is considered with respect to wind power development.

3.2 Scope

The scope of this project is mainly limited by three major aspects: temporal, geographical, and technological. The timescale of the project, within which data collection is of significance, will be from 1918 to the present day. 1918 marked a significant acceleration in the expansion of hydropower in Sweden (Vedung and Brandel, 2001). The scope is geographically restricted to Sweden's borders. Counties without hydropower stations will be excluded from the analysis. Currently, there are

around 2000 hydropower stations in Sweden where 200 of these are considered larger and have a capacity of 10 MW or more (Lindholm, 2018). Regarding the analysis of court rulings, hydropower stations with a capacity lower than 10 MW will be excluded. However, when analysing community indemnity grants, all hydropower plants were included. This was because the available data on community indemnity grants include all hydropower stations regarding a specific waterbody or county with no condition on capacity.

In Sweden, the expansion of wind power is currently encountering resistance (Westander and Risberg, 2022). Because of this clear resistance, this project has focused on hydropower and onshore wind while excluding other renewable energy sources. If hydropower plants have been expanded to greater capacity, this has been noted to make sure that the expansion is not considered as an additional new hydropower plant.

Processing the court rulings is a time-consuming task. Having received the Water Book[27] for around 50 hydropower stations with a capacity over 10 MW, the conclusion was that each can have somewhere between just a few and sometimes around 100 court rulings. Under the assumption that most compensation was paid in connection to the initial construction, the project was limited to only processing compensation from court rulings labeled ”construction approval” or ”approval to finalise hydropower station” or any other label considered a synonym for the above[28]. Some court rulings have been appealed and since rulings from higher courts are stored at the National Archives and not accessible through the courts, and as it would take considerable time to distinguish what the higher court changed, hydropower stations with appeals have been excluded. Some hydropower stations where the court ruling was too unclear to distinguish reliable data have been excluded.

References to court districts are based on the current court jurisdictions. These have changed through the years. An example is Kilforsen hydropower station, where the court ruling that approved the construction is from Umeå even though the hydropower station is under the jurisdiction of Östersund today.

[27]Swedish: Vattenboken. A document with a list of all court rulings regarding a hydropower station

[28]Swedish: ”Tillstånd att uppföra” and ”Tillstånd att färdigställa”

When it comes to regulations regarding the community indemnity fees, the amount of money is based on mainly three things: the capacity of the hydropower plant, the size of the dam, and the amount of water that is diverted (SFS 1998:812). More about this can be read in the Results [5]. The data collection has due to practical reasons been restricted to only cover data connected to the capacity and not the size of the dam or the amount of water diverted. This affected what type of analysis that could be done. For instance, it was not possible to do calculations of how much community indemnity fees a company needs to pay yearly regarding a certain hydropower station with the data collected.

There is also another type of fee paid by the company responsible for a certain hydropower plant connected to the impact on fish. The fish fee is not something covered in our analysis. Unlike the community indemnity fee, the fish fee is not paid and processed by the County Administrative Boards but by the Swedish Agency Marine and Water Management[29]. Therefore, together with practical reasons, no data on fish fees have been collected and therefore it is not covered in the analysis or result.

[29]Swedish: Havs-och vattenmyndigheten

4 Method

This section provides a step by step description of how the project has been carried out. It is divided into two main parts: data collection and data cleaning and processing.

4.1 Data Collection

The starting point of the project was data collection. This section first describes how the initial and more general data collection was carried out and then separately goes through the process for data collection for the two different types of compensation schemes, direct compensation to property owners in connection to the construction of a hydropower plant and the community indemnity grant. Data collection for these two compensation schemes was carried out in parallel after the initial round of general data collection was made.

4.1.1 General Data Collection

As a first step, data for all hydropower plants owned by the following 12 companies were collected in a spreadsheet.

- Fortum Abp
- Vattenfall AB
- Mälarenergi AB
- Uniper SE
- Statkraft Sverige AB
- Skellefteå Kraftaktiebolag
- Tekniska verken i Linköping AB
- Holmen Energi AB
- Sollefteåforsen AB (Owned by Sollefteå municipality)
- Jämtkraft AB
- Gävle energi AB (Owned by Gävle municipality)
- Jönköping energi AB

Data regarding the name of the hydropower plant, in which watercourse, municipality, and court district it is located, installed power in MW, normal annual

generation in GWh, construction year, and if it is currently operational or not was collected from the websites of the respective companies.

If this information was not provided through the website, the information was achieved by calling or emailing the company.

4.1.2 Direct Compensation to Property Owners

Data on direct compensation to property owners in connection to the construction of the hydropower plants are found in court rulings connected to the hydropower plants. These court rulings are archived in the five Land and Environment Courts [30]. Before these court rulings were requested, the data set over the hydropower plants was used to identify the large hydropower stations, i.e. the ones with an installed capacity over 10 MW, according to the scope of the project. The work of requesting these court rulings was then done in two steps. The first step was to request an excerpt from the Water Book[31] for each hydropower station of interest. The excerpts from the Water Book includes a list of all the court ruling connected to a specific hydropower station. With the help of that list, the court ruling for the permission to build the hydropower station was identified. The second step was to request this specific court ruling. These two steps were done several times in order to get more court rulings. Firstly, the court rulings for the biggest hydropower station in each court district were asked for, and then the next biggest, and so on. The data collection has due to time constraints not covered the entire time span from 1918 to the present day. Court rulings that are included in this report are from 1949 to 1984. Furthermore, some court rulings were not included in the data collection because of a lack of access to information due to the following reasons:

- The court ruling was later changed in the Supreme Water Court
- The court ruling was not scanned and therefore required an additional cost in order to receive it

In total data regarding compensation has been collected from 12 court rulings and thus 12 hydropower plants. The hydropower plants were the following:

- Forsmo

[30] Swedish: Mark- och miljödomstol
[31] Swedish: Vattenboken

- Åsens
- Kymmens
- Höljes
- Lettens
- Kilforsen
- Lasele
- Hylte
- Röjdåfors
- Stornorrfors
- Trängslet
- Letsi

From the court rulings data was collected and put into a spreadsheet where each row represents one compensation. The data were sorted into several columns. Information about the compensations was often found in the court rulings under the title Compensation Length[32]. The data that was collected were the following:

- Name of hydropower station
- Court district
- County
- Court ruling ID
- The year of the court ruling
- Name of the property that is being compensated
- Reason for compensation
- Number of people being compensated
- Compensation recipient
- Sum of compensation the year of the court ruling

The spreadsheet was then completed with information on the Consumer Price Index (CPI)[33] for the year of the compensation, which later on was used to calculate the current worth of the compensation. Data on CPI was taken from SCB (SCB, 2023c).

[32]Swedish: Ersättningslängd
[33]Swedish: Konsumentprisindex (KPI)

4.1.3 County Indemnity Grant

Simultaneously, data concerning county indemnity grants was collected. This information was achieved by personally contacting case managers at County Administrative Boards through phone calls. Afterwards, documentation on the county indemnity grant was received through email. The data was often received as an excel file which was compiled into one spreadsheet with information from all counties.

Out of 21 counties in Sweden, data on county indemnity grants were collected from 11. The time span in which data was collected ranges from 1997 to 2022. In some of the counties where data was not collected, there are no county indemnity grants paid out, for instance in the county of Kalmar (Palmblad Örlander, 2023). For some counties, we did not receive data due to practical or time-related issues. As relevant data was collected, the geographical scope was limited to 11 out of 21 counties in Sweden concerning the community indemnity grant.

The type of information included in the data gotten from the counties varied. This is due to the fact that there are no regulations regarding how the counties are going to work with this and therefore each county on its own needs to decide how to handle applications and transactions of community indemnity fees and grants (Klintebäck. E, personal communication, March 14, 2023). From some counties, data on project type, application date, date of payment, recipient, and water court was given. From other counties only the amount of money, the recipient, and the year were given.

All data received was collected into the spreadsheet. As with the direct compensation each row represents one compensation and the columns represent different types of information listed below:

- Application ID
- Year of application
- Year of payment
- Court district
- County
- Municipality

- Water body
- Compensation recipient
- Project
- Purpose
- Sum of compensation

4.1.4 Interviews

Simultaneously as the data collection was carried out, three interviews were held in order to fill knowledge gaps of how the system of compensation works. Two interviews were held through digital meetings and one through personal contact through e-mail. The people interviewed were all found randomly by strategically reaching out to people who are experts in their area. One interview was with Elisabeth Klintebäck who is a case manager at the County Administrative Board of Västerbotten. She contributed with a deeper understanding of how the county indemnity grants were paid out and how the County Administrative Board works with this. The second interview was with Nils Ryrberg, Senior Advisor at Åberg Law firm, through a digital meeting. Nils almost exclusively works with environmental rights, energy rights, and property rights. This includes both water rights and permit examinations for wind power. Therefore, Nils could contribute with knowledge of how negotiations regarding the development of hydropower stations could look as well as interpreting the laws regarding water. The third interview was held with Erik Cardell, a technical advisor on the Land and Environment Court, via email. He contributed with information regarding the calculation of community indemnity fees and provided literature on the topic.

4.2 Data Cleaning and Processing

When the data collection was done the data set was cleaned in order to look coherent and easy to navigate. In cases when data was missing it was marked with MD (missing data) and if it was not applicable it was marked with NA. Furthermore, the compensation sum was adjusted with regard to inflation for both direct compensation and community indemnity grant. This was calculated using the CPI and the following formula:

Consumer price index 2023 = CPI_{2023}
Consumer price index year of compensation = CPI_x

$$\frac{CPI_{2023}}{CPI_x} \cdot \text{Compensation sum} = \text{Value of compensation 2023} \tag{1}$$

The next step was to categorise the reasons for compensation into broader categories, both for the direct compensation and the county indemnity grant. Each compensation was put into a certain category based on the given reason for compensation and using inductive thematic analysis. Thematic analysis is used to categorise a wide range of data, where the themes, or categories, "capture something important about the data in relation to the research question, and represent some level of patterned response or meaning within the data" (Braun and Clarke, 2006). In this case, the categories are intended create clear answers to why compensation was given as well as what it was used for. Due to the differences in how specific the data received from each court ruling or county was, there were some uncertainties in the categorisation. For example, some counties have not specified what the community indemnity grant has gone to, just to whom. For example, a football association might have gotten the grant, but the purpose was not specified. Taking the football association as an example, this payment has been categorised as "Culture and leisure" even if the money potentially could have gone to the renovation of the football association building, which if we would have gotten that data, would be categorised as "Renovation of property" even if it is a football association getting the money. Below, the different categories are listed and briefly explained (more detailed explanation of the categorisations is found in the appendix G:

- Renovation of property - Money that went to restore and renovate properties, both properties that were damaged by the construction of the hydropower plant and renovation made from funds from the county indemnity grants.
- Culture and leisure - Money that went to different kinds of culture and leisure activities. Mostly to associations and clubs.
- Business sector - Money that went to promote business and local companies.
- Fishing - Money that went to restore the habitat for fish and to other fishing activities.

- Loss in potential growth - Compensation for loss of growth, such as loss of growing forest.
- Impact on land and watercourses - Money that went to restore and compensate for damage on land and watercourses due to the construction of hydropower plants.
- Loss of property - Compensation for loss of property due to construction of hydropower station.
- Encroachment during construction period - Money paid out to compensate for trespassing on the property during the time the hydropower station was under construction.
- Other - Compensation due to reasons that do not fit into the other categories and are too uncommon to be assigned a category of its own

Note that the same categorisation system and categories have been used for both types of compensation schemes. Payments that did not have data on the reason for compensation were marked with MD in the categorisation column. After all the data cleaning and processing were done visualisation of the data was done using Python.

5 Results

The result of the project starts with a description of the collected data which later was compiled into a data set. This data set has been an integral part of the data analysis and subsequent conclusions. Next, a description of which hydropower stations data has been collected from is given before moving deeper into a presentation of the results regarding the two main types of compensation in focus, direct compensation and community indemnity grants. The subsection about the direct compensation shows both data visualisation from the data collected from court rulings and the analysis which further helps shed light on this form of compensation. The part regarding the community indemnity grants begins with a description of the law regulating the grants before moving into data visualisation and analysis. Lastly a comparative part of wind development in Sweden with regard to the governmental report of incentives for wind power.

5.1 Description of Dataset

During the investigation of Swedish hydropower, a large amount of data concerning compensation schemes and hydropower developments has been collected. This information has been compiled into an data set for the purpose of data analysis. The data set is stored in a spreadsheet-file consisting of three sheets as well as a cover sheet where the following sheets are explained. Throughout the data set, MD and NA will be used. In this particular case, MD stands for Missing Data, and NA stands for Not Applicable.

The first sheet of the dataset (except for the cover sheet) contains information about the capacity, annual generation, location, construction year, owner, court district the power station belongs to as well as other information.

The second sheet of the dataset contains the information collected about compensation from the various court verdicts which were conducted during the construction process of the power station. Among the parameters collected in this document are the names of the hydropower station associated with the verdict, the court ruling ID, the year of the ruling, the name of the property associated with the damage and compensation, the reason for compensation, amount of people

compensated, compensation sum, consumer price index for the year and inflation-adjusted compensation.

The third sheet of the data set contains information about the community indemnity grants. The data set is not a complete record of the transactions of every County Administrative Board due to difficulty accessing certain information. The sheet contains information regarding 11 out of the 21 County Administrative Boards. The years of the information available vary depending on the county, the information contained in the document can be visualised in figure 5.8. The spreadsheet contains the record of the payments made by the municipalities; the year of application and payment, municipality, water body, court district, recipient, purpose/project, the ID of the transaction, and the amount of money, both adjusted for inflation and not as well as other information. The purpose and project the payment contributes to have been condensed into categories, using thematic inductive analysis for easier data visualisation and analysis (Braun and Clarke, 2006).

5.2 Hydropower Stations

As explained above the first sheet in the data set consists of information regarding hydropower stations in Sweden, including a majority of the hydropower stations above 10 MW. Figure 5.1 shows a map of hydropower stations in Sweden from the compiled data set. In this particular map, only hydropower stations with an installed capacity of 10 MW or higher are shown, where the size of the dot represents the installed capacity. In general, most hydropower stations are located in the northern parts of Sweden, where most of the larger ones also are located. However, this map shows that the data collection has covered large parts of Sweden even though the density of power plants is higher in the north.

5.3 Direct Compensation

Hydropower developers have historically had to pay compensation directly to individuals affected by the construction process. The data regarding this is found in the second sheet of the dataset and will be presented, visualised and analysed in this section.

Court rulings pertaining to direct compensation were, as mentioned earlier, obtained

from the courts. These court rulings are directly connected to the construction of the hydropower stations, which can be seen highlighted in blue in figure 5.1. This data is also fairly spread, starting from the county of Halland in the south all the way to the county of Norrbotten in the north.

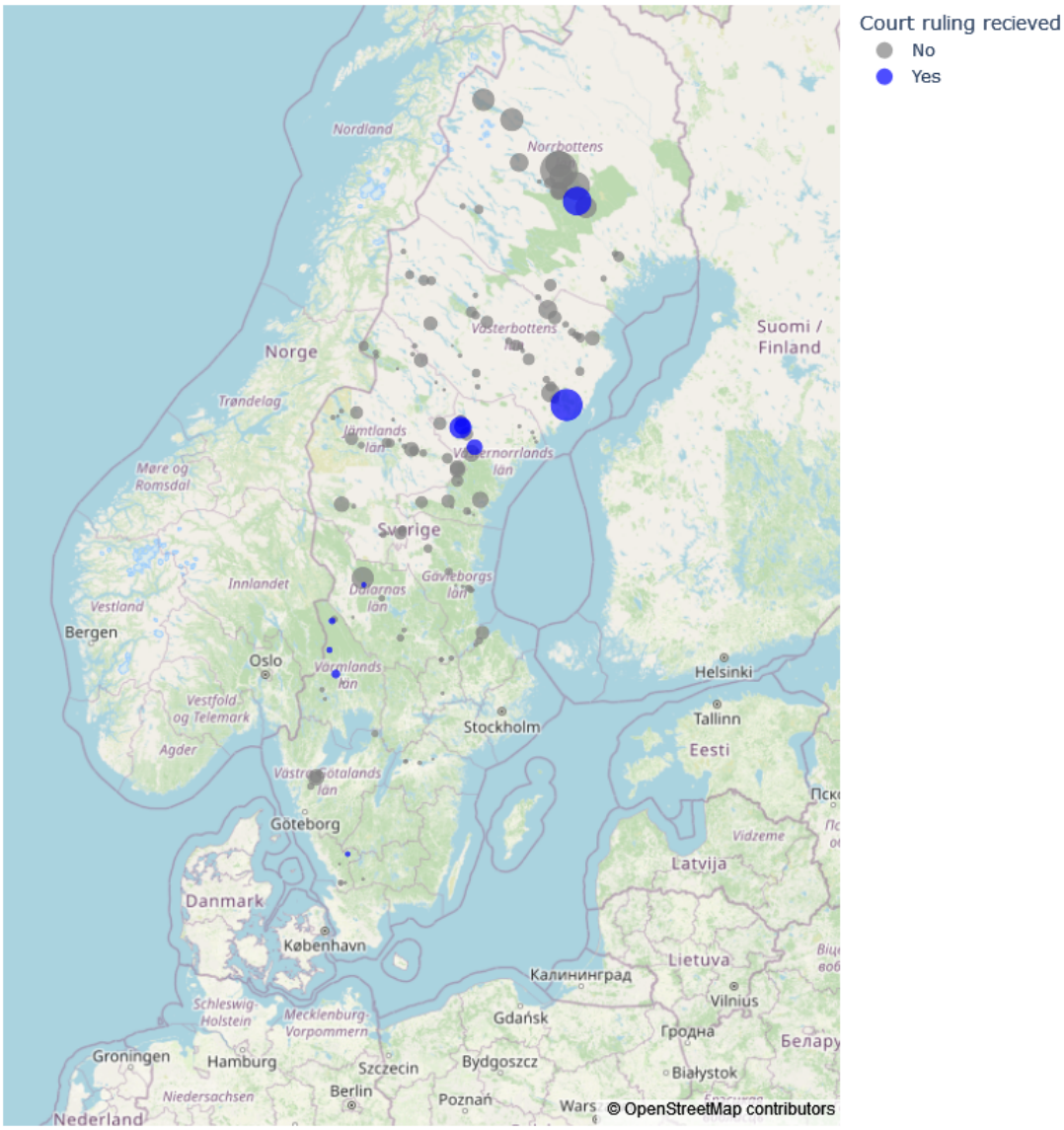

Figure 5.1: Map of hydropower plants with an installed capacity over 10 MW where the size is based on the capacity. Hydropower stations where court rulings have been received and analysed are marked with blue.

The following two diagrams in 5.2 show the number of compensation transactions made in each ruling and the total amount in SEK these compensations were. This clearly shows that the number of transactions does not necessarily correlate with the total amount of money. For example, Åsens Hydropower Station has the greatest number of transactions but only the fourth largest total sum of compensation.

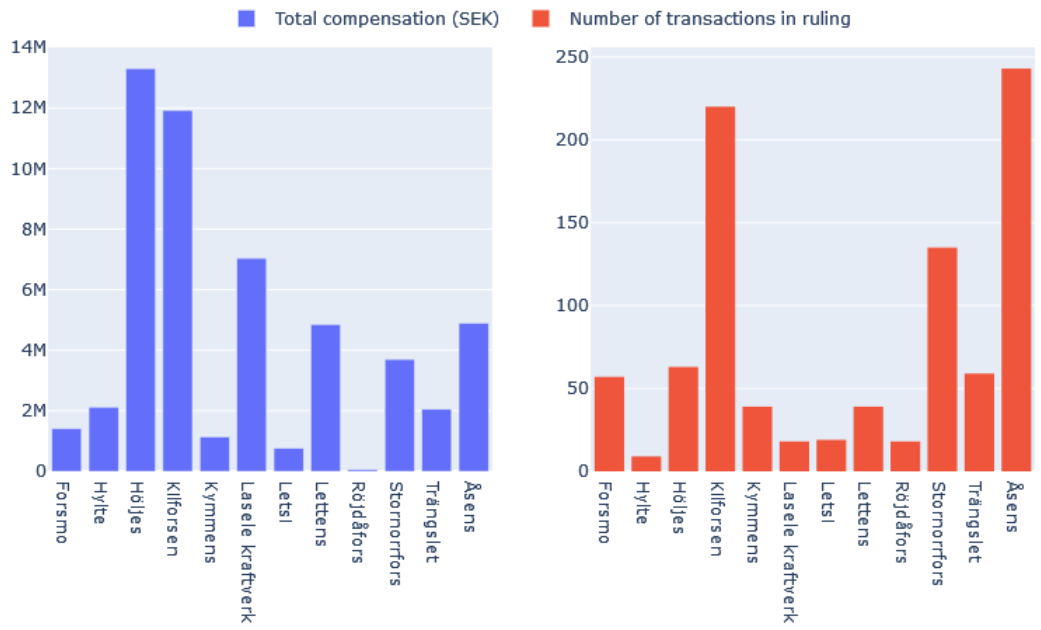

Figure 5.2: Total compensation from each hydropower station

To put into perspective, the size of the respective hydropower plants as compared to the total compensation sums, figures 5.3 and 5.4 display scatter plots of the direct compensation paid out in relation to the installed capacity in MW and normal annual generation in GWh. Figure 5.3 shows the correlation between normal annual generation in GWh and the total sum of compensation. Furthermore, figure 5.4 presents this but from the perspective of installed capacity in MW. Comparing these two figures, they look very similar except that the hydropower stations Trängslet och Forsmo are not as close in installed capacity as they are in annual generation. In general, it also shows that high installed capacity or high annual generation does not correspond to having the most compensation. For example, the hydropower stations Kilforsen, Höljes, and Lasele are all below 400 MW and 1500 GWh while at the same time having compensation between 6 and 14 MSEK which represents

the highest total compensation sums.

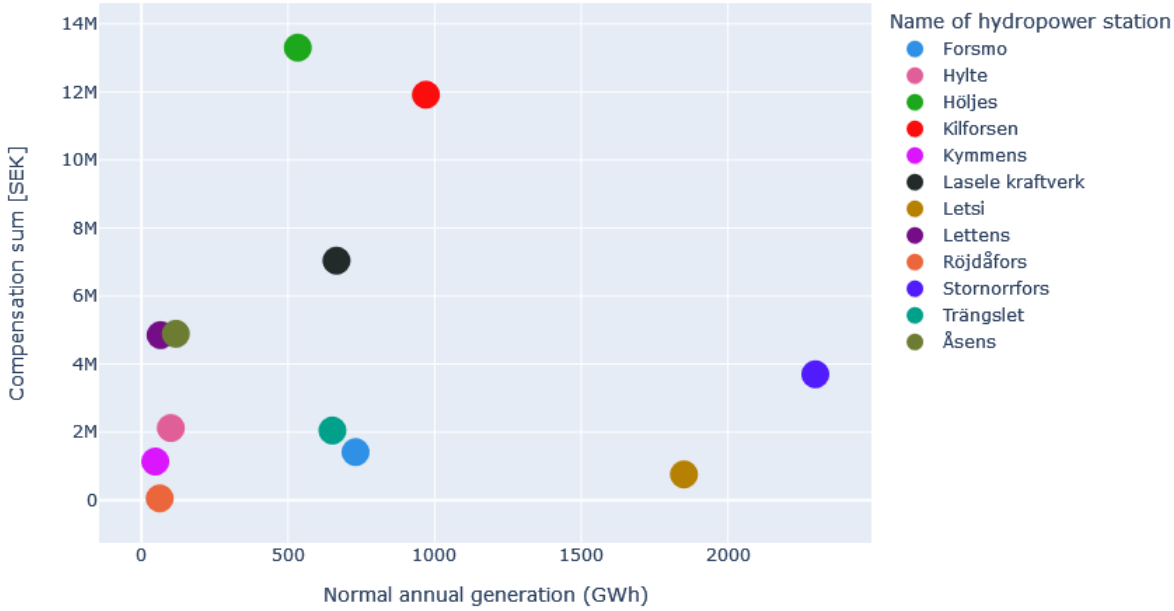

Figure 5.3: Compensation paid in inflation adjusted SEK, at Jaunary 2023 value, in relation to the normal annual generation for the powerplants in the court rulings.

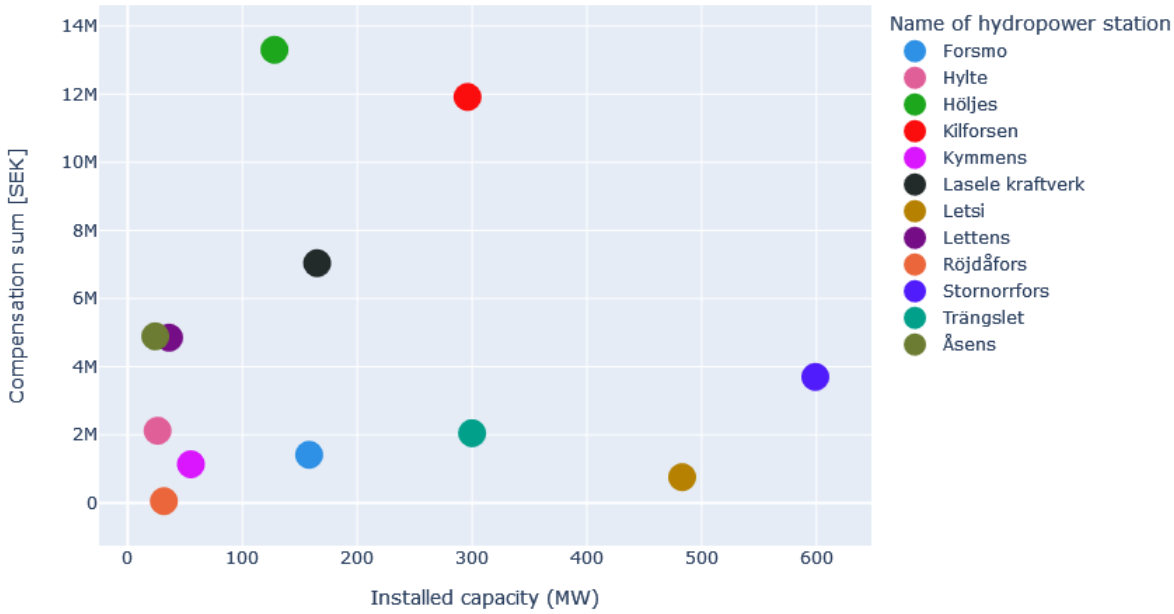

Figure 5.4: Compensation paid in inflation adjusted SEK, at Jaunary 2023 value, in relation to the installed capacity for the power plants in the court rulings.

To build further upon the scatter plot in figure 5.4, figure 5.5 visualises the total compensation per installed capacity in MW for each hydropower station. From this graph, it is clear that the amount of money paid in compensation does not correlate with the installed capacity. Both Stornorrfors and Letsi are two of the largest hydropower stations in terms of effect but when normalising the effect to compensation it is clear that these power plants did not compensate even close to the sum of for example Åsens Hydropower station per installed MW.

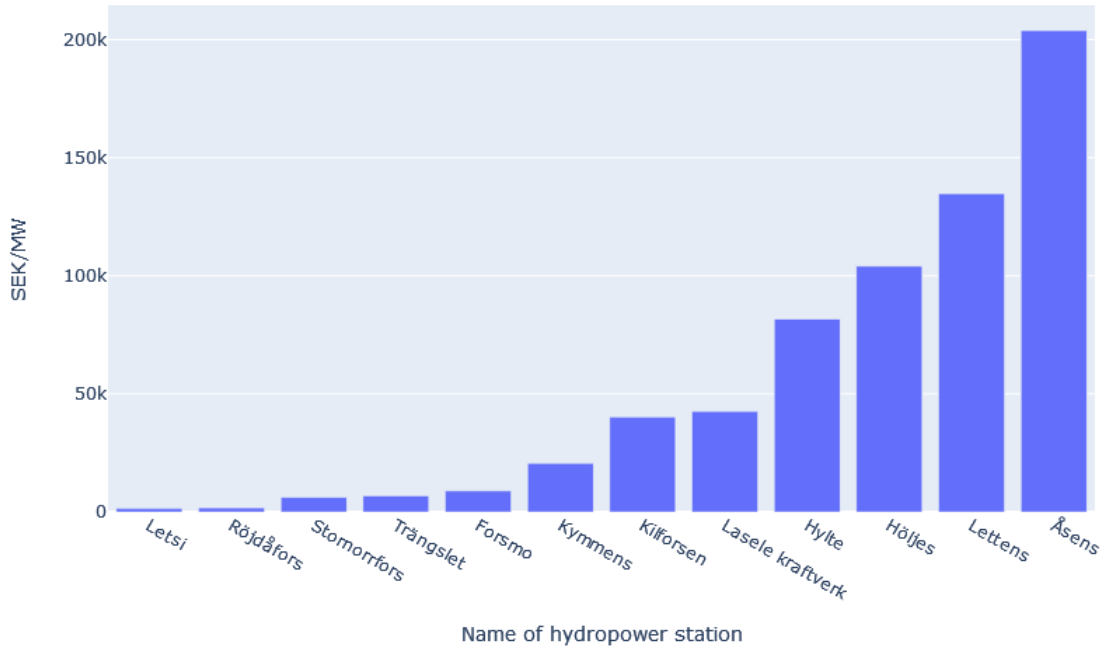

Figure 5.5: Total compensation per MW for each hydropower station

The reasons why someone was compensated through direct compensation were divided into categories. The pie chart in figure 5.6 highlights the division of the total compensation sum in accordance with the categories. Most of the direct compensation did not specify the reason for the compensation which is why MD stands for about 60% of the amounts. However, as the second largest party, the category ”Impact on land and watercourses” stand for about 23%. ”Loss of property” stands for about 9% while the remaining categories only cover about 5 % together. This could be interpreted as the reasons for compensation in the legal documents being mostly based on impact on user values of the people living near the dams and not the existence value of the environment around the dams. The reasons for compensation are mostly due to impact on land and watercourses, loss of property, and loss of growth or other losses of user values.

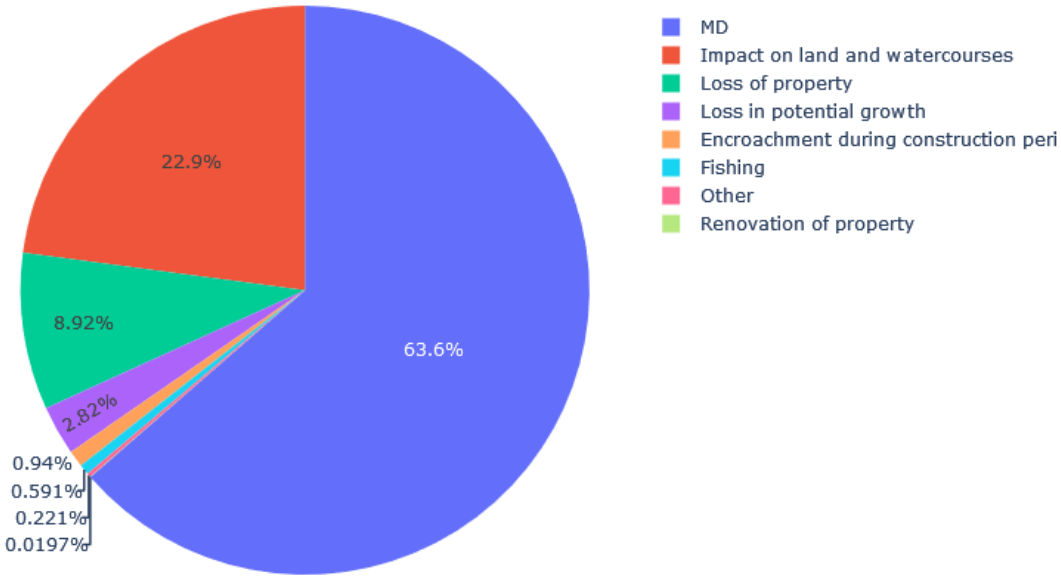

Figure 5.6: Distribution of compensation categories for court rulings.

Looking at the figures 5.3 and 5.4 it can be seen that the installed capacity or the normal annual generation of a hydropower station does not directly correlate with the direct compensation amount. A more pertinent and relevant value that was looked at was the amount of compensation per compensated individual. In figure 5.7 these numbers are visualised and provide quite a contrasting view as compared with SEK per MW in figure 5.5. There are clearly a plethora of factors that historically have contributed to the amount of compensation that needs to be paid out, including but not limited to the size of the power plant, location and impact on the surroundings.

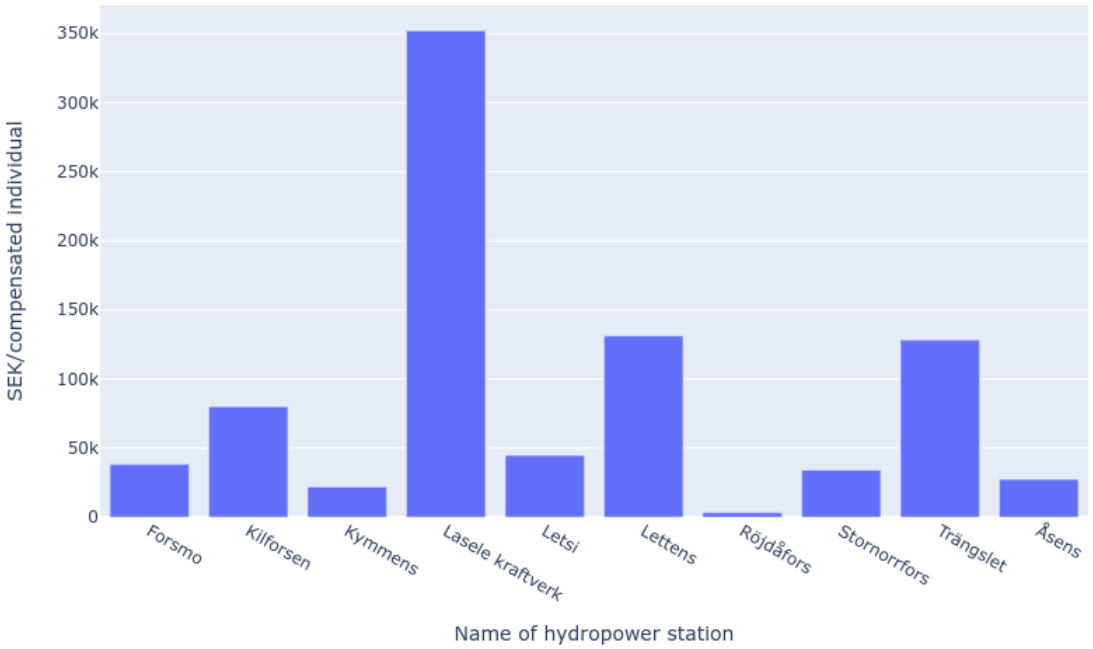

Figure 5.7: Sum of compensation through court rulings per compensated individual. (The hydropower stations Höljes and Hylte are excluded since the data on compensated individuals was missing)

5.4 Community Indemnity Grants

Hydropower stations pay community indemnity fees yearly to the County Administrative Board that distributes the money as community indemnity grants to mainly local associations. How the fee is calculated is described in section 5.4.1. The data regarding community indemnity grants, which is sheet three in the dataset, as well as an analysis of the data is presented in section 5.4.

5.4.1 Description of How Community Indemnity Fees are Calculated

Calculation of Community Indemnity Fees for Hydropower 1918-1983:
Each hydropower station with an average of 500 turbine horsepower (680 kW) or more must pay a yearly fee between 0.1 SEK and 3 SEK for each turbine horsepower. The exact fee is decided by the water court and is valid for 20 years. After 20 years the ruling must be reconsidered by the court. The water court bases the decision for the fee on how the hydropower station impacts the surroundings considering changes in water levels and runoff conditions as well as the impact on land and

water courses.

Calculation of community indemnity fees for hydropower built after 1983:
As described in the literature review, a new water law was introduced in 1983. This law changed how the community indemnity fee was calculated. The same formulation is used in a law introduced in 1998 in combination with the new Swedish Environmental Code that replaced the law of 1983.

According to Swedish law[34] a community indemnity fee decided by the Land and Environment Court should be paid yearly by the permit holder to some water operation (SFS 1998:812). There are four types of water operations for when this fee should be paid, and the calculation method differs depending on the type. The fee should be paid if it infers:

- Type 1: Operation of a hydropower station.
- Type 2: Regulation of water flow on a yearly or multi-yearly basis.
- Type 3: Transferring water between bodies of water.
- Type 4: Using a surface water body as a water source.

A concept of community indemnity units[35] is introduced which is calculated first and becomes the basis for the fee. The method for calculating the units differs depending on what type the water operation belongs to. No fee should be paid if the number of units is less than 500 (which is 5 MW for type 1 or 12,5 million cubic meters for type 2 (Strömberg, 1984)). Each facility is in addition to the different types classified into one of four impact classes by the court. When classifying facilities the court should consider the magnitude of the change in water flow and positive or negative consequences on the local community (SFS 1998:812). In practice, class 1 is meant for facilities with little to no impact on the surroundings or if it is located in very remote areas. This class is meant to be used sparsely and only in rare cases. Class 2, 3 and 4 are meant for facilities with moderate, greater and massive impact on the water course and surrounding communities. Benefits for the local community should also be considered when deciding on the class and could warrant a lower class (Strömberg, 1984). Below, it is described how the community indemnity units (C) are calculated for each type. This is followed by how large a fee one community

[34] Act Containing Special Provisions Concerning Water Operations
[35] Swedish: Avgiftsenhet

indemnity unit represents based on the class a facility belongs to.

Type 1: For a hydropower station, a community indemnity unit represents each 10 kW capacity up to 150% of the capacity at the average flow of a hydropower station plus each 20 kW capacity of the difference between total installed capacity and 150% of the capacity given at average flow.

X_i - installed generator capacity $[W]$
X_a - generator capacity at average water flow $[W]$
M_i - installed water flow $[m^3]$
M_a - average water flow $[m^3]$
C - community indemnity units

$$X_a = X_i \cdot \frac{M_a}{M_i} \tag{2}$$

$$C = \frac{1.5 \cdot X_a}{10} + \frac{X_i - 1.5 \cdot X_a}{20} \tag{3}$$

Equation 3 means that each 10 kW of the installed capcity gives one compensation unit up to 150% of the capcity at average water flow as well as one compensation unit for each 20 kW above that.

Type 2: For a water dam or other type of water regulation, a community indemnity unit is instead each 25 000 m^3 up to a total water volume of 100 000 000 m^3 and then each 50 000 m^3 up to 1 000 000 000 m^3 in total volume and one compensation unit per 100 000 m^3 above that.

$$C = \frac{V}{25000} + \frac{V - 100,000}{50,000} + \frac{V - 1100,000000}{100000} \tag{4}$$

Type 3 and 4: The number of compensation indemnity units for transferring water between bodies of water or using a surface water body as a water source is the number of cubic meters per second that the permits allow to be extracted or moved from the original water course.

Table I: The percentages of the price base amount that each community indemnity unit represents based on the four types.

	Type 1 and 2	Type 3 and 4
Class 1	0.5 ‰	5 %
Class 2	1.0 ‰	10 %
Class 3	1.5 ‰	15 %
Class 4	2.0 ‰	20 %

To calculate the actual fee from the community indemnity units, the classes mentioned above is used. Each community indemnity unit is converted to a fee using a percentage of the price base amount that is adjusted each year by the government. The table I represents these percentages.

5.4.2 Description and Analysis of Community Indemnity Grants

The data on the community indemnity grants were collected from 11 different County Administrative Boards (Data from Gävleborg was excluded in most of the visualization and data analysis since there was no data on the compensation sums). The community indemnity grants are paid out annually. In table II the number of individual transactions and the total compensation sum for each county are represented.

Table II: The years, the number of transactions and the total compensation collected in terms of community indemnity grants from each County Administrative Board from the data set, excluding Gävleborg (since data on compensation sums was missing).

County	Years	Amount of transactions	Total compensation [SEK]
Dalarna	2014-2022	370	36 902 188
Halland	2006-2022	77	4 998 867
Jämtland	2012-2022	1 588	202 050 931
Norrbotten	1997-2002, 2010-2021	1 256	1 238 217 872
Skåne	2017, 2019-2022	9	151 751
Uppsala	2013-2022	26	1 464 396
Värmland	2014-2023	268	13 845 611
Västerbotten	2016-2021	315	81 426 264
Västernorrland	2018-2022	11	1 399 201
Västra Götaland	2014-2022	67	4 587 458

For the data analysis it was important to shed light on which years had the highest abundance of data across counties, something which is illustrated using a histogram in figure 5.8. This gives a picture of the span of years that each county had data for, how many transactions each year had along with the data quantity across the years. Most counties had data from about 2014 and onwards, with a couple of counties having data from even earlier than that. This figure points out that the years from which we have gotten data differ greatly. From Norrbotten the data received goes back as far as 1997 but the data received from Västerbotten only goes back until 2016. In the figure, a gap can be seen in the data between 2002 to 2010 regarding the data collected from Norrbotten. This implies especially that our data collection is not complete. Most likely there were community indemnity grants paid out during this time span but the data retrieved did not include transactions between those years. The same can be seen when looking at Västerbotten. The fact that the plot only shows transactions over community indemnity grants from 2016 is because we have not received older data and not because there were no grants paid out before

2016. For Västebotten the County Administrative Board changed the system in 2017 which can explain why no older data was enabled to be collected (Klintebäck. E, personal communication, March 14, 2023). Considering Västerbotten it seems like the amount of transactions increases between the years data was received from this county. For Jämtland it seems like the number of transactions decreased immensely compared to the years before. This is probably because of the incompleteness of the data and not because they did not pay out any community indemnity grants. This could for instance be due to the fact that the county administrative boards have not yet completed their compilation and digitisation of the data. For the rest of the counties, the number of transactions over the years is more consistent.

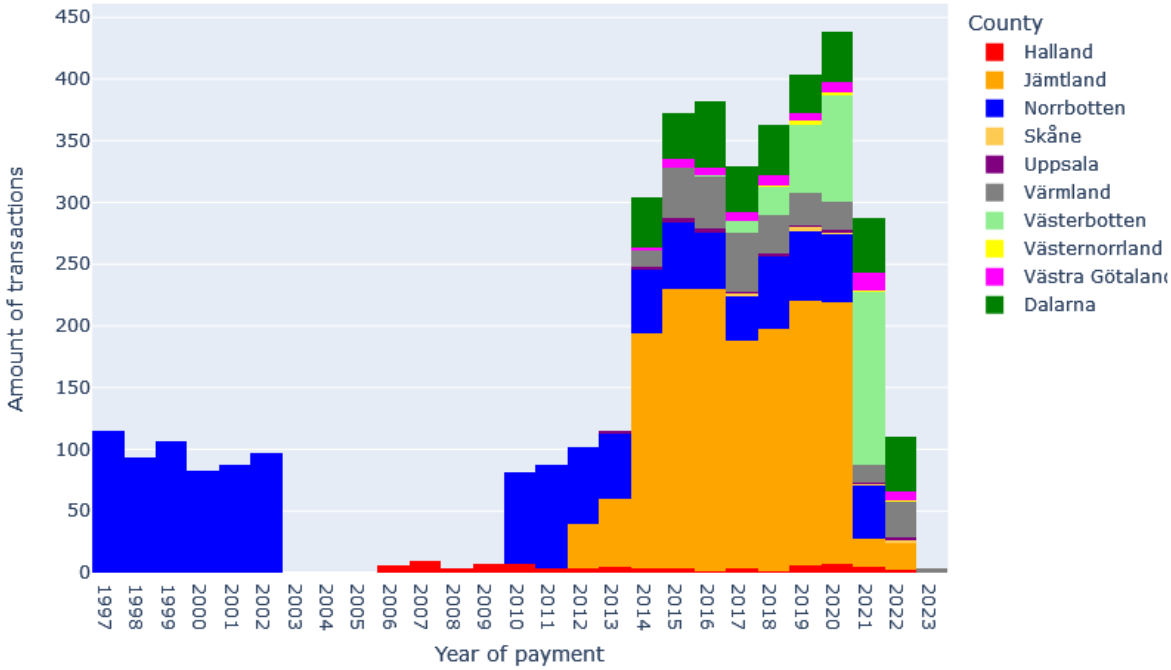

Figure 5.8: Number of transactions per county and year

From figure 5.8 it is apparent that the majority of the data on community indemnity grants were gathered from fairly recent times. Building upon this, data from the years 2017 to 2022 were used for a first avenue of data analysis in figures 5.9 and 5.10. The first of which shows the amount of compensation per capita in the respective counties across the six years (SCB, 2023a). Norrbotten and Jämtland generally have the highest amount of compensation per capita over the years. There are most likely

a few contributing factors to this. As was presented earlier in table II, these counties rank number one and two respectively in terms of total compensation in the data. These counties also have a fairly low population density as compared to the more southern regions.

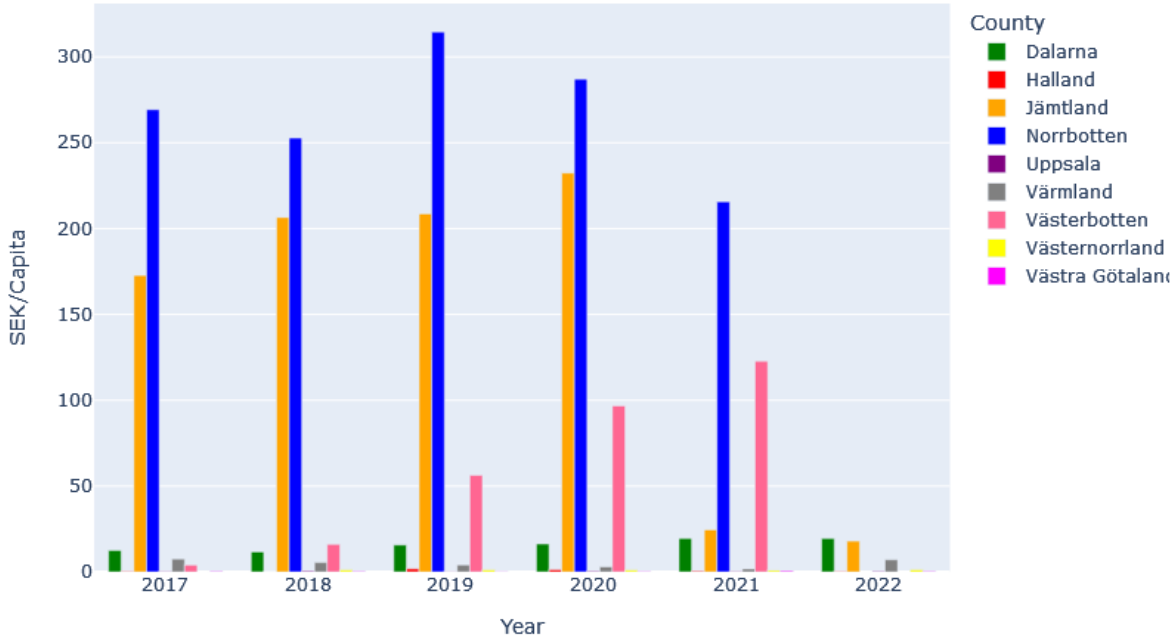

Figure 5.9: Compensation per total capita in each county from 2017-2022

Furthermore, figure 5.10 follows a similar approach as the previous bar graph. The population of the counties have been substituted for the installed capacity of all hydropower plants from which data was collected from (over 10 MW). This graph paints a similar picture to 5.9, with Norrbotten and Jämtland firmly in the lead. However, the gap to the other counties is not quite as significant as in figure 5.9. Across both the figures, a fluctuation of the levels of both SEK per capita and SEK per MW can be observed. Some, like Norrbotten decline towards the later years, whereas counties like Dalarna, Jämtland and especially Västerbotten increases as time approaches the present day.

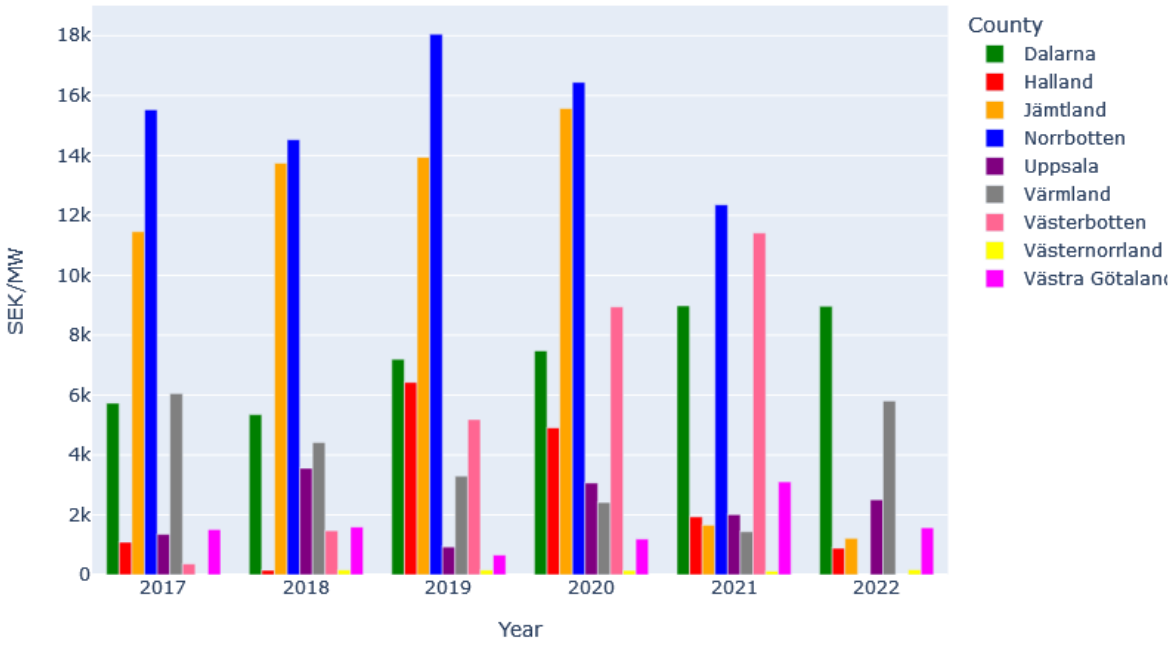

Figure 5.10: Compensation per MW in each county from 2017-2022

The second avenue that was explored in terms of data analysis for the community indemnity grants was to identify the average compensation for the respective counties. Figure 5.11 shows the average compensation per year. This further reinforces what has been quite apparent from the graphs thus far, which is that Norrbotten is in a league of its own in terms of compensatory transactions. However, when the installed capacity of the hydropower plants is taken into consideration the disparity is not as great, which can be seen in figure 5.12. This also changes the order a bit, with Dalarna climbing to the third place as well as things slightly changing among the bottom municipalities.

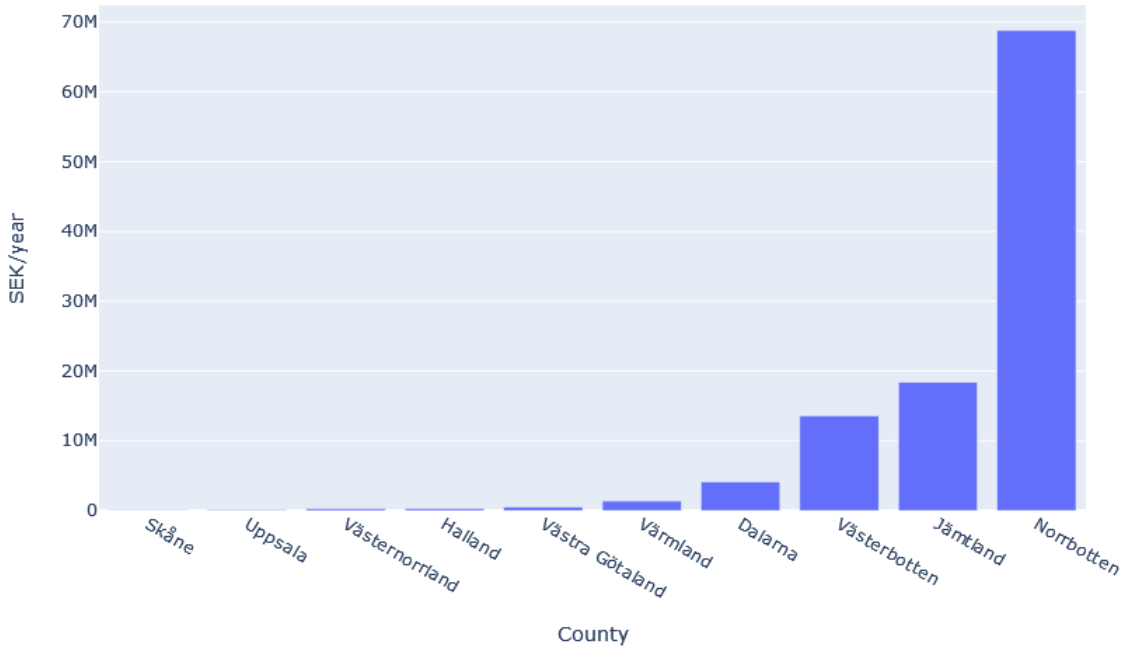

Figure 5.11: Average compensation per year for each county

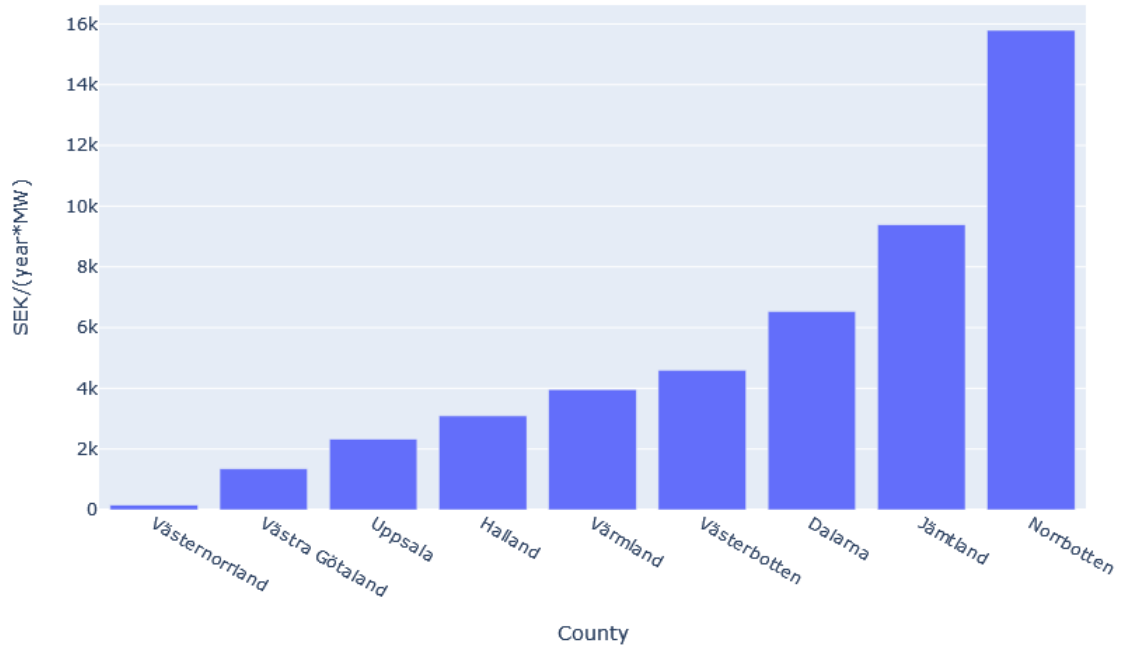

Figure 5.12: Compensation per MW per year for each county

To facilitate a link between the direct compensation and the community indemnity

grants, the scatter plot in figure 5.13 sets the total compensation paid out by the County Administrative Boards in contrast to the total installed capacity within the county. When observing this plot in relation to figures 5.3 and 5.4 it is clear that a correlation between installed capacity and compensation through community indemnity grants exists, whereas this can not be observed for direct compensation. An explanation for this result could be that there is a more robust legal framework in place for determining the value of the community indemnity grant compensations. The compensation is determined according to the specific formula assembled from the legal documents while the court rulings were more ad hoc. The community indemnity payments are explicitly proportional to the average effect of the generator, it is, therefore, reasonable to see such a correlation.

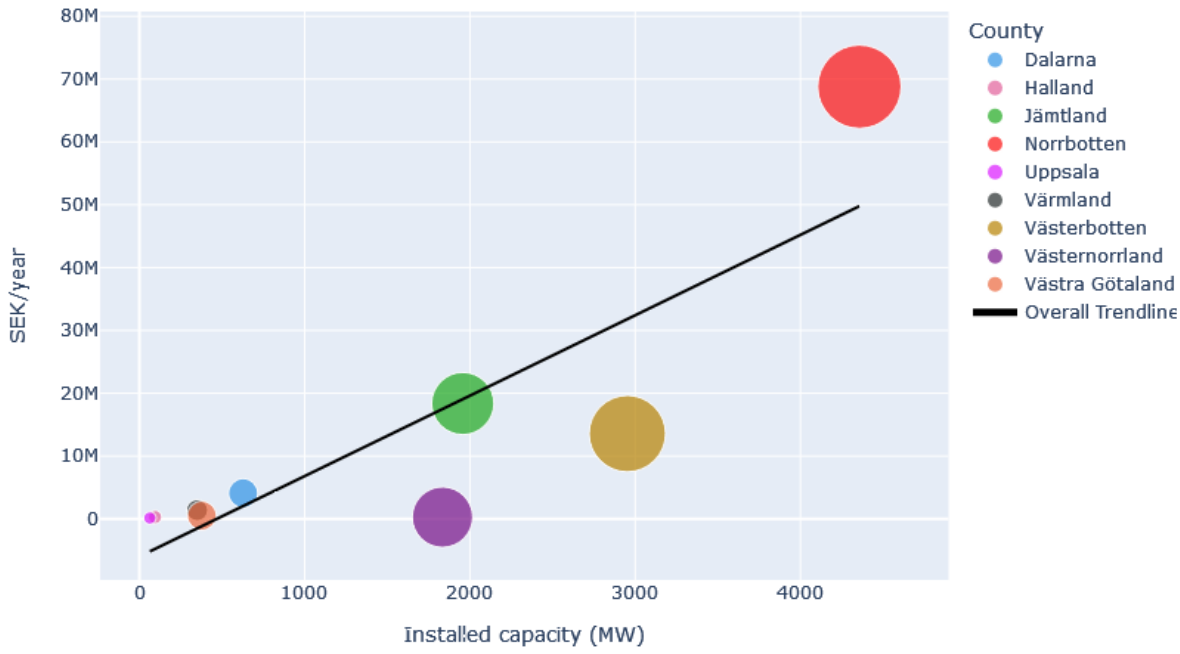

Figure 5.13: SEK per year in relation to total installed capacity in each county. Size corresponds to the normal annual generation (GWh) of each county from hydropower.

As with the direct compensation in figure 5.6, each payment of the community indemnity grants was also categorised to be able to paint a picture of how the compensation was used. The pie chart in figure 5.14 shows the fund distribution with the business sector category dominating with just above 40% followed by other and

culture and leisure. The compensations are therefore in many cases not necessarily directly connected to the correction of physical damage due to hydropower, but rather general payments with the intention of promoting the welfare of the local community. The compensation for impact on land and watercourses and fishing section of the categories are a relatively small proportion of the total compensation. As the data regarding the county indemnity is more recent than the court verdicts, this could indicate a change in attitude towards what types of value are seen as important and worthy of compensation.

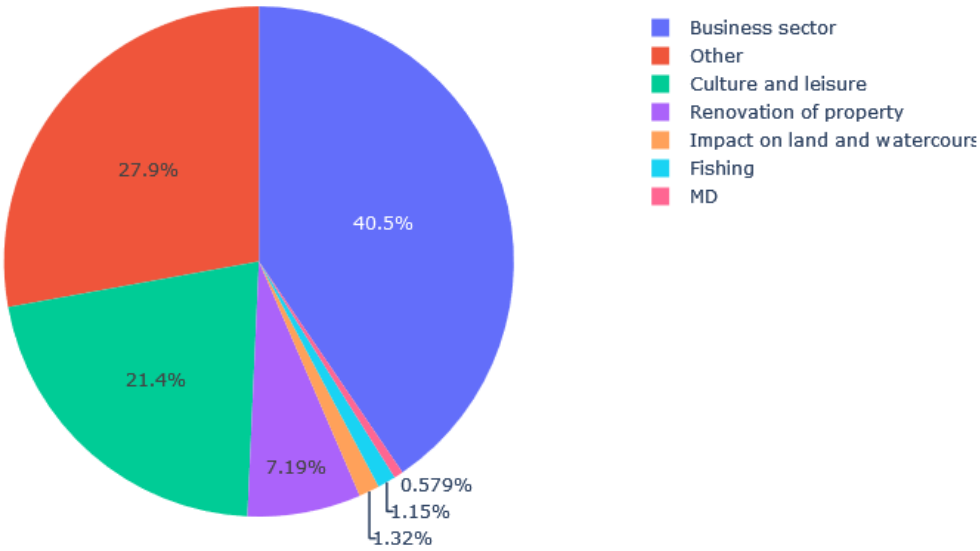

Figure 5.14: Distribution of different categories for community indemnity grants

5.5 Calculations for Compensation Based on the Proposed New Incentives for Wind Power

The Swedish government released a report about how to increase the incentive for wind power development in Sweden. In the report there is a proposal for a compensation scheme to properties nearby wind power plant. The proposal is that each property situated closer than 1000 meters to a wind turbine is entitled an annual grant of 2.5‰ of the wind turbine's revenue (see zone A in figure 5.15). For properties situated on a distance longer than 1000 meters from a wind turbine the grant will decrease linearly with the distance. The formula for calculating the share

of the revenue that should be paid out as compensation is seen in ??. Properties at a distance that is longer than 10 times the height of the wind turbine will not receive this compensation, i.e. the compensation is zero at the distance of 10 times the height of the wind turbine (the outer line of zone B in figure 5.15). If a property is situated in the range of compensation for more than one wind turbine, for example if the household is located near a wind turbine park, the compensation sum is based on the total revenue from a maximum of two wind turbines. The revenue is calculated by multiplying the yearly electricity generation of a wind turbine with the average electricity price[36](“SOU 2023:18”, 2023).

$$\text{Compensation} = 2.5‰ \cdot (1 - \frac{\text{Distance} - 1000}{(\text{Total Height} \cdot 10) - 1000}) \cdot \text{Share of revenue} \quad (5)$$

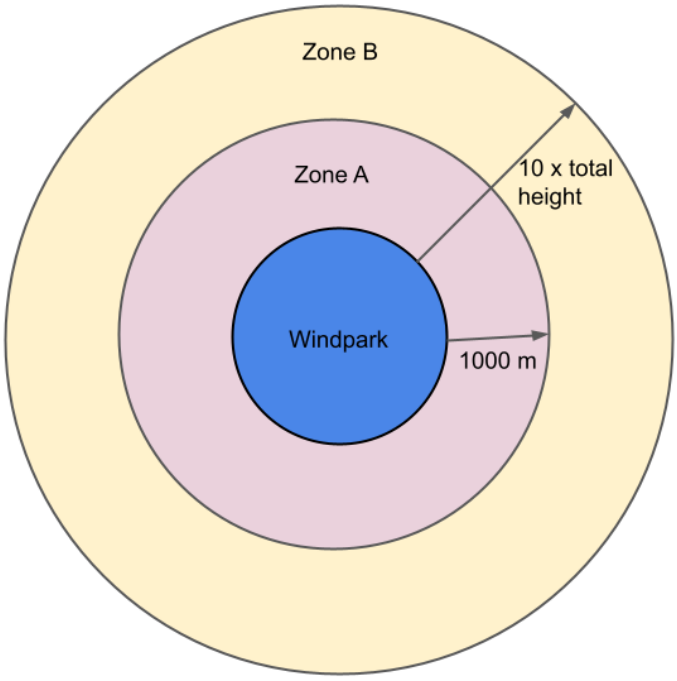

Figure 5.15: Zones around wind turbine park

[36]Swedish: Spotpris

5.5.1 Example Calculations Based on the Proposed New Incentives for Wind Power

This section illustrates the compensation scheme described above with some examples. Cloud Wind Turbine Park[37] is a wind turbine park situated in Ånge municipality in the middle of Sweden. It has been operational since 2020 and has 54 wind power plants at a height of 218 meters. The expected annual generation from the park is 805.5 GWh. The park has an area about 40 km^2 (Arise, n.d.). With this specific wind turbine park as a starting point, calculations have been done to show what the compensation sum would be if a similar wind turbine park (with the same measurements and electricity generation) were to be built in different municipalities with different population densities.

Table F1 shows the population density and average electricity price in three different municipalities. Furthermore, it shows average compensation sums for each municipality. These compensation sums are calculated based on the general information about the wind turbine park and the municipality specific conditions. To do this calculations some assumptions have been made. A first assumption is that the wind turbine park is build in the shape of a circle. To compute the compensation sum per household in the area corresponding zone A in figure 5.15, the revenue for two wind turbines were multiplied with 2.5‰. To compute the compensation sum per household in the area corresponding to zone B in figure 5.15, equation 5 was first used to compute what share of the revenue that was going to be paid as compensation. To simplify these calculations it is assumed that all households, on average, are located in the middle of the zone B, i.e 1590 m from the wind turbine park. The compensation sum per household could then be computed multiplying the computed share with the revenue for two wind turbines.

The compensation sum per household for the two areas was then multiplied with the number of households in zone A and B respectively and then added in order to get total compensation. For this it was assumed that the population of the municipality is evenly distributed over the whole area of the municipality and that there on average lives 2.2 people per household (SCB, 2018). By dividing the total compensation with number of household an average compensation sum per

[37] Swedish: Cloud Vindkraftspark

household was given. By dividing the total compensation with the wind turbine park's electricity generation compensation per GWh was given. For more detailed calculations see appendix E.

Table III: Information and calculations on compensation from a wind turbine park placed in three different municipalities in Sweden

Municipality / Variables	Ånge	Hjo	Sollentuna
Population Density [capita/km^2]	3.0	31.1	1449.1
Bidding Area	2	3	3
Average electricity price [SEK/kWh]	0.663	1.374	1.374
Total SEK/year	642 830	13 629 574	1 079 605 730
SEK/household/year	31 358	64 595	58 250
SEK/GWh/year	798	16 921	1 340 293

5.6 Comparing the Compensation Variants

Figure 5.16 shows a comparison of the range of compensation per GWh for the community indemnity grants, the direct compensation from court rulings and the example calculations made in the previous subsection. Sollentuna was removed for this visual comparison and an average was used between Hjo and Ånge instead. This was done since the value for SEK per GWh per year for Sollentuna made it difficult to visually represent this comparison. Sollentuna is located very close to Stockholm which would result in many households being compensated, thus explaining the significantly higher values resulting from the calculation. This comparison makes it clear that the direct compensation from court rulings is significantly higher in terms of SEK per GWh, unless you take the example value for Sollentuna into consideration.

The calculations performed earlier help to illustrate how possible wind parks built in areas with higher population density (such as Sollentuna) would result in the responsible developer having to pay significantly higher compensation sums to affected individuals as compared to wind parks of similar size being built in low population density areas, even though the amount of compensation each household

would hypothetically receive is comparable between Sollentuna and Hjo (see table III). Following this, it makes more sense for the expansion of wind power to mainly take place in locations which have very low population density, since it not only decreases the necessary compensation but also the amount of locals which would possibly be hesitant.

At first glance it might seem strange that the direct compensation is so much larger than both the community indemnity grants and the example calculations. However, with some added context, it actually makes more sense than what initially meets the eye. Both the community indemnity grants and the hypothetical payments from wind parks represent compensation per annum whereas the compensation from court rulings represent larger one time payments connected to the construction itself. To further elucidate, direct compensation can be thought of as larger compensation payments that cover the impact that the construction of the hydropower plants were predicted to have at the time of construction. In contrast, community indemnity grants are payed out annually and updated based on inflation each year. Similarly, the proposed wind compensation scheme would change annually based on the current situation.

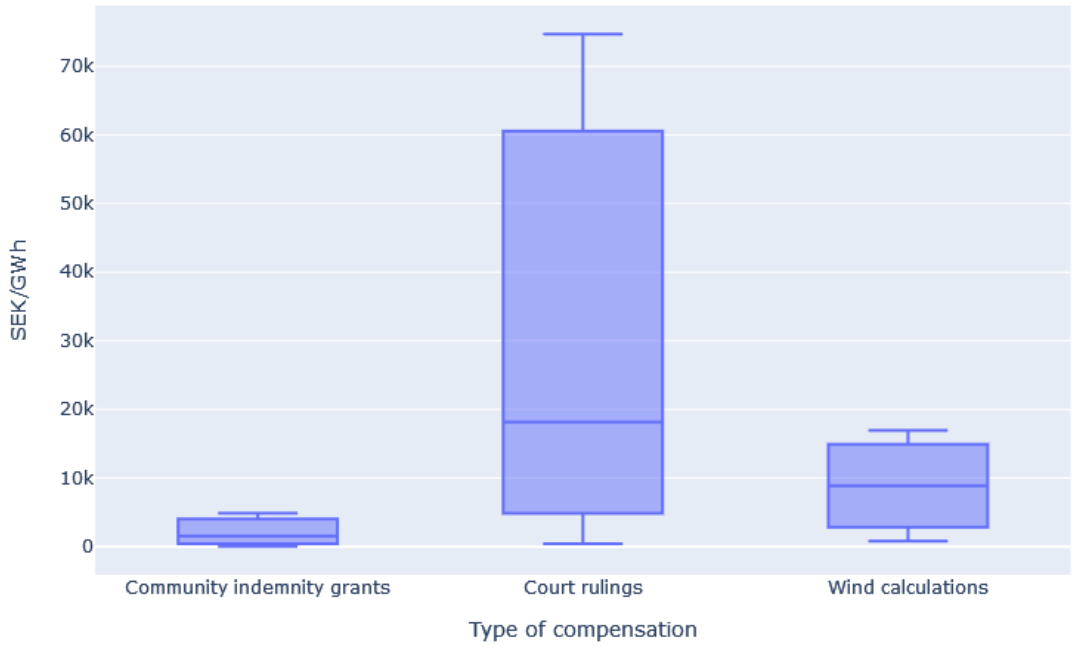

Figure 5.16: Amount of compensation per GWh of normal annual generation for the court rulings, the county administrative boards and for the hypothetical wind power compensation per year.

6 Discussion

6.1 Why Compensation?

As described in the previous sections, compensation has been used historically, is used today, and is planned to be used in the future. But why is compensation used? In the government report The Value of the Wind[38], it is clear that compensation is used to increase the acceptance of wind power. But why is the acceptance low in the first place? Compensation is used in order to repay for something that is experienced to be lost. In the context of wind power development, people might be disturbed by the noise of the wind turbines, or perceive the wind turbines to be ugly and result in the loss of a beautiful view.

Another perspective of compensation is that people do not want to feel fooled. If a company wants to develop energy production close to someone's property, they will also earn money on that production. Even in a case where one is in general positive towards the development of renewable energy, if a company is going to earn money while disturbing people living close by, these people may also want a share of that revenue. That could be in the form of compensation. After the compensation is established, it is important that the compensation feels fair. If the recipient of the compensation experience the compensation to be insufficient, their trust in the system for compensation, the responsible governmental agency as well as the company will decrease. Decreased trust in institutions can lead to decreased acceptance of renewable energy projects earned by compensation schemes.

If a compensating mechanism can develop both acceptance and a feeling of fairness it fulfills its purpose. However, one can think about the question of whether compensation always can be used. On the one hand, compensation has been used historically. On the other hand, one can question if the compensation has always been fair and developed acceptance. In the early 20th century, when the development of hydropower in Sweden accelerated and people were compensated for e.g. loss of properties, one can say that it was fair because the people affected

[38]Swedish: Värdet av Vinden

got monetary compensation for the losses they had. On the other hand, all values that were lost were probably not compensated for. For example, the existence value of the Porjus River was probably not compensated for. One could argue that the continuation of paying out community indemnity grants will in the longer term cover all different values. Nevertheless, it is questionable if there is a valid compensation for everything. The history of how the development of hydropower in Sweden came to a halt with protests and opinions of the importance of having untouched rivers could be an argument that everything cannot be compensated for if it would be lost.

To be able to create this compensating mechanism that is both fair and creates an acceptance, one approach is to make an assessment that tries to cover different types of values which brings us to the different perspectives of environmental assessment.

6.2 How and Why Environmental Assessment Has Developed

Historically, compensation made as a result of constructing hydropower stations often regarded loss of property. In the early days, many environmental factors, such as biodiversity, were not included in the calculations and therefore not compensated for. The reason for this not being a priority during the fast expansion of hydropower in Sweden in the mid 1900's is not clear. It could be because of the lack of knowledge on how the hydropower plants affected the water bodies and the life in and around them. The first hydropower station in Sweden was built only a few years prior to the great hydroelectric expansion which made it a rather new technique where all consequences had not yet been explored and defined. On the other hand, it could have been known but the benefits of the hydroelectric dams during a period of heavy industrialisation in Sweden weighed heavier than the impact on nature. Regardless of the reason, a change in how the environment has been evaluated has been seen since this large expansion of hydropower.

In the 1970s, these environmental values received more consideration in the discussion on whether or not to construct hydropower plants in the rivers. This was almost 80 years after the first hydropower plant was built in Sweden. Arguably, more knowledge on how these constructions affected the areas they were located in was

known by this point. Generally, the 1970s was the peak of multiple environmental movements which might be a reason for the pressure on the Swedish government to seriously consider environmental values when using water bodies, especially when constructing or expanding hydropower stations. This led to a analysis and categorisation of water bodies, where certain categories were deemed more important to preserve than others.

Moving even closer to the present day, more regulations have been implemented both on a national level and a European level. The water law was replaced by the Swedish Environmental Code including more environmental interests in conservation, and the European water directive made it clear that more interests than just user values and economic values are considered today. From this, one conclusion is that the context of today's development of energy resources looks completely different compared to the beginning of the twentieth century. More knowledge about biodiversity, climate change, and justice has given another complexity to how to evaluate the consequences of a project. In today's context, more values are considered which commonly lead to a conflict of interests where trade-offs need to be done. Another aspect is that there are more actors that have a say in today's context leading to more people involved in the negotiation. Increased knowledge about what to evaluate and how anthropogenic activity affects the systems of Earth will hopefully lead to better decision-making. Nevertheless, it slows down the administrative processes and the development of renewables needed today.

6.3 Incentives for Wind Power Development

The development of wind power is heavily debated today and is a key element in conducting a just expansion of fossil free energy production. The recently published government report regarding incentives for wind power attempts to propose solutions to the complex situation ("SOU 2023:18", 2023).

When comparing the historical development of hydropower to the expansion of wind power today in Sweden, some differences become clear. The discourse today surrounding wind power is one of overcoming the resistance towards wind development in communities. This stands in stark contrast to how hydroelectric dams were seen by communities during the twentieth century. At the time of the

Sarek agreement, some local populations wanted hydroelectric expansion near their communities to the extent that they collected signatures in support of building hydroelectric dams. This naturally poses the question: what are the reasons for this disparity?

One of the major reasons for the signature collection during the hydropower developments was that a local hydropower station was seen as an opportunity for cheaper electricity and new opportunities for work due to industrial expansion. The connection between increased prosperity and wind power seems to be absent today, with the municipalities vetoing a majority of new wind power projects. It seems like the local population does not see a clear connection between economic prosperity and the wind turbines.

In contrast to the wind power projects, the green industrialisation projects that the wind turbines are intended to power are highly popular among municipalities. Projects such as the Northvolt battery factories, H2 Green Steel, and Hybrit are all highly requested among municipalities as they would bring a large number of work opportunities and economic prosperity to the municipality (Bye, 2023). The infrastructure needed to supply the industry with power - the wind turbines - is not wanted, which ironically risks the future of the projects. A mechanism to clarify the link between wind power and the green industry leading to economic prosperity could increase acceptance among municipalities.

A similar issue also arises in the context of community indemnity grants. Although another governmental report[39] highlights the relative support among municipalities for community indemnity grants, one major drawback of the system is that the link between hydroelectric companies and funded projects is unclear. It seems to be unclear to the community that the projects funded by the community indemnity grants are actually funded by the hydropower companies ("SOU 2022:56", 2022). To avoid this confusion, one could imagine a system where the payments are not made by a fund set up and managed by the County Administrative Board, but rather payments directly from power companies to the projects. Despite this, according to a government directive from 2022[40] ("DIR 2022:27", 2022), the system

[39]SOU 2022:56 - A Resilient Provision of Metals and Minerals that are Critical to Innovation
[40]DIR 2022:27 - Strengthened Incentives for Expanded Wind Power

of community indemnity grants has received broad support among municipalities. This support could be a reason for the unofficial, voluntary compensation from wind power companies sometimes being referred to as community money[41]. However, the name could be seen as somewhat deceptive, as it seems to be clearly associated with community indemnity grants, despite not being codified as part of the community indemnity system.

An incentive system that is perceived by the public as generally fair is likely to enjoy public support and therefore possibly result in a decrease in the use of the municipal veto. The lack of such a codified structure is a contributing factor to the difficulty in expanding wind power today and this problem is intended to be remedied by establishing a clear legal framework for wind power compensation, as already exists for hydropower ("DIR 2022:27", 2022). The non-codified system of voluntary bargaining currently in place seems to be insufficient for an expansion of wind power needed to satiate the increasing need for electricity for the rapid electrification of the Swedish industry ("SOU 2023:18", 2023).

The current unofficial system for wind power compensation creates ambiguity in what is allowed or not regarding compensation ("DIR 2022:27", 2022). This could be a factor in reducing the confidence in the system, and therefore also the will to accept wind power development projects. A vital component in the expansion of the Swedish wind power system is the aspect of social acceptance and involvement of the public in the decision-making process (Gustavsson, 2022). Bearing this in mind, compensation should not be regarded as the sole tool to facilitate the acceptance of wind power, but rather it should be supplemented with a range of other approaches.

Energy transitions should not be looked at through a lens of purely reducing emissions, socioeconomic factors should ideally be taken into consideration as well. Due to the way the proposed incentive mechanisms are shaped, the compensation will be high in areas with high population density. In practice, this will likely lead to rural communities being disproportionately affected by wind power developments. Therefore suggested incentive mechanisms may lead to a disproportionate amount of wind power being placed in northern Sweden, which could be perceived as unfair.

[41] Swedish name: Bygdepeng

It may seem reasonable to put wind turbines in rural areas, where one would expect few people to be disturbed by the turbines. However, this could by some be seen as unjust as the rural areas in northern Sweden already produce a large surplus of electricity relative to its small population ("SOU 2023:18", 2023).

In addition to the rural/urban divide, there may be other socioeconomic factors at play, as the socioeconomic status of an individual may affect how receptive an individual is to the construction of a nearby wind park in exchange for compensation. The marginal utility for increased prosperity decreases as the wealth of the population increased. It may therefore be the case that a richer population would require more compensation to accept the degradation of the environment, while a poor population may welcome a hydroelectric dam or wind park, which leads to work opportunities at the cost of local environmental quality. If such a pattern becomes apparent and certain communities perceive themselves to bear a disproportionate part of the burden of the energy transition, it could in the long term undermine the faith in the governmental institutions.

The idea that socioeconomic status has implications on the willingness to accept nearby energy developments may be a part of the reason that there seems to be a difference in the acceptance of hydropower historically and wind power today. One could argue that the increased prosperity of the Swedish population today compared with the mid-20th century may be a factor in the seemingly shifted priorities. The attitude that permeated the hydroelectric expansion in Sweden was one of pragmatism, where the needs of the growing industry outweighed the potential damage to nature. The existence of natural phenomena was mostly not included in the calculation, as compensation was mostly due to concrete damage, such as loss of property and income from fishing. Despite the seeming lack of compensation for existence values, the acceptance was comparatively high.

The perceived damages caused by wind power are of a different nature; the government report lists the main complaints regarding wind power as: noise pollution, light pollution, a destroyed view and that the large turbines are seen as "towering" by some. ("SOU 2023:18", 2023) Despite the fact that several of these complaints are relatively subjective, the acceptance of wind power is low. At first glance, this may seem counter-intuitive, but it is important to keep in

mind that it is the subjective experience of lost value that is measured when evaluating environmental damage. The acceptance of the energy developments should reasonably be a function of perceived damage, benefit, and compensation. It seems like all three variables have varied significantly during the 20th- and 21st- centuries. While certain aspects of the community indemnity system are still relevant and have clearly inspired the proposed incentive structure for wind, the new incentive mechanisms also have to be adapted to their new societal context.

Another aspect of the compensation system that the report suggests is that at most, one can be compensated for two wind turbines. This could be seen as the report in some sense advocates for large wind turbine parks. Since larger wind turbine parks will have more wind turbines that are not close to any properties (under the assumption that no one lives in the park), there will be more wind turbines that the company does not need to pay compensation for because of the simple fact that the area of the wind turbine park grows faster than its circumference. One can contradict this statement by saying that there will probably be more people living close by the larger the wind farms, and therefore more people will be compensated. However, there will still be less compensation the company needs to pay for each wind turbine since there will be a larger amount of wind turbines in the middle that the company has to compensate for. Therefore the company will make a greater revenue per wind turbine the larger the farm is.

The new government report on incentives for wind power presents several proposals for new compensation schemes that would be calculated using the price of electricity ("SOU 2023:18", 2023). For hydropower, the community indemnity fees are calculated using the price base amount, and the direct compensation is based on the damages to land and the surroundings. This means that the local residents will receive compensation regardless of the success of the hydropower project and the energy market. In practice, the wind power proposal would in a sense make the local residents involuntary investors of the wind turbines as their compensation is directly related to the price of electricity. For hydropower stations, all the risk has been on the developers as the compensation is a fixed amount. The sum of the compensation can be seen as a measure of the damages society assumes someone has experienced. Regarding the new proposal in the government report, the "damages" would then

fluctuate over the years even though it is the same wind turbine with the same impact. This indicates a fundamental difference in the meaning of compensation. The ”damages” would then fluctuate over the years even though it is the same wind turbine with the same impact. At the same time, the developers need a certain income to be able to continue to run the wind turbines. Using the proposed model, it would possibly be easier to avoid bankruptcy during periods of low energy prices as the compensation would be lower. The proposal is, however, unclear regarding what would happen in such a scenario as it mentions both that compensation needs to be at least 1000 SEK and that the total of all compensation can not be more than 2% of the income from the wind turbine without specifying what takes priority.

In essence, all the compensation schemes discussed above have the fundamental purpose of establishing trust and creating a framework designed to facilitate a realistic path towards further expansion of the Swedish energy system. In this process, it is important to do so through not only a monetary perspective, but also place emphasis on sustainability, equity, and justice.

6.4 Further Research

This report has mainly focused on two kinds of compensation, (1) direct compensation through court rulings, and (2) community indemnity grants. Both of these appear to be commonly used ever since 1918 to this day. However, there seems to be little scientific research evaluating these methods in a greater quantitative manner to determine how cost-effective and goal-fulfilling they have been. A few governmental reports question the effectiveness and current design of community indemnity fees (“SOU 2022:56”, 2022 page 480, “SOU 2021:53”, 2021 page 121-124). Scientific papers often take a case-study approach that often covers a certain aspect of the history of hydropower, such as Vedung and Brandel (2001), Hansson (1994) or Jakobsson (1996). A comprehensive evaluation is essential to determine if and to what extent these methods might be applied to the expansion of wind power. This study tries to inspire to further research with a qualitative data-driven research approach by mapping what data might be available and by providing the foundation of a data set regarding compensation.

Another government report, questions the effectiveness of community indemnity

fees based on a survey ("SOU 2022:56", 2022). It concludes that it is a model that should be avoided when implementing compensation to improve the acceptance of mining operations as no clear improvement in the general opinion can be observed as a result of community indemnity grants ("SOU 2022:56", 2022). This report also raises the possibility of creating a joint system for compensation for hydropower and other water operations, mining operations, and wind power ("SOU 2022:56", 2022). A combined framework is of course beneficial in several regards as it might, for example, reduce administrative costs and the overall complexity of the compensation system. To be able to even consider such a system, a clear understanding of the impact, benefits, and effectiveness of the current community indemnity grants system is needed. This would require the collection of data on the local populations' perception of hydropower in affected areas as well as their knowledge about, and opinion on, for example, community indemnity grants, much like the survey made in the other report ("SOU 2022:56", 2022).

There is possibly a gap between the legal understanding of the law regarding compensation in relation to hydropower and the scientific research on energy transitions and compensation. A better scientific understanding and mathematical formulation of compensation schemes currently in use would make it possible to both more accurately understand the effectiveness of current compensation and aid in creating frameworks for future compensation schemes. An understanding of how the law has been implemented regarding, for example, the classes relating to community indemnity fees [see section 5.4.1] could allow for a better mapping of how specific damages have been valued and compensated. This could then possibly be linked to how the compensation impacts the public acceptance of wind power.

In addition to further research regarding hydropower, the latest governmental report regarding wind power development demands research to be made concerning possible ways of monetary compensation to municipalities ("SOU 2023:18", 2023). This seems to be a clear knowledge gap as well as a critical step in the development of wind power.

6.5 Limitations

For community indemnity grants, there are multiple limitations to the data. Each County Administration Board has its own method for handling applications and its own criteria for when a grant should be approved. There is also no standardised way of compiling the data for approved and denied grants and it seems like it comes down to if an employee of the County Administration Board has taken the initiative to do so. It is therefore not possible to guarantee that the presented payments for each year and county are the entire sum paid that year and there are uncertainties regarding exactly what is included. It is, for example, possible that grants pending approval are not included. There are also considerable gaps in which County Administration Boards have been able to provide data as well as in which years that are provided.

There are around 200 hydropower stations with a capacity of over 10 MW (Lindholm, 2018). As almost all processed court rulings contain compensation, it is reasonable to assume that at least most of them contain records of compensation. Having covered just one court ruling each for 12 of these hydropower stations with a few more being excluded (see appendix A), it is reasonable to assume that this study has covered only a tiny fraction of the total compensation paid through the courts. The reason for limited coverage of court rulings is mainly because of a lack of time. This project has, however, been able to cover both smaller and larger hydropower stations from both the northern and southern rivers. Results of for example compensation in SEK per MW have therefore been presented, but they should be read with caution. The current limited number of court rulings covered limits the possibility for, for example, clustering of the hydropower stations with reliable results. Which is something that could possibly provide relevant insights and patterns of hydropower-related compensation.

As concluded in the scope [3.2], each hydropower station can have anywhere between just a few and sometimes around 100 court rulings connected to it. Having received and read around 50 of these Water Books, the conclusion is that even though it is reasonable to assume that for most hydropower stations a majority of the compensation was paid in connection to the construction. However, there are a considerable number of rulings that mention compensation, fishing impact fees, and

community indemnity fees. This study has not been able to cover these due to the vast number of rulings in combination with limited time and resources.

Only direct compensation is covered by the court rulings. Both the law and several of the processed court rulings mention compensation for consequences and losses related to fishing. These have not been covered as it is less structured and unique for most cases. It is also spread across several court rulings because the consequences on the fish populations usually could not be determined until a few years after construction.

7 Conclusion

The increasing impact of climate change makes it clear that a transition towards a sustainable society is needed. This includes a change in the energy sector to more renewable energy sources that at the same time can meet the increasing demand for energy. In Sweden, the conditions for the transition are already quite good because of the rapid extensive expansion of hydropower during the 20th century. In 1918 a new water law was introduced, which enabled this expansion in several ways. This law established five new Water Courts with the task of giving permission for construction affecting water streams. During the early development of hydropower, environmental values were not taken into account when deciding whether or not to build a hydropower station. In 1983 a new water law was introduced that replaced the law from 1918. The new law was in many ways the same as the previous one but introduced a new focus on environmental protection when evaluating if and where to construct or further develop hydropower in Sweden. Later on, in 1998, this law was replaced by the Swedish Environmental Code, which had an even broader focus on environmental protection. Since the end of the 20th century, no major hydropower plants have been put into operation in Sweden and the expansion of hydropower has thus stopped. Nevertheless, hydropower today accounts for about 43% of the total energy produced in Sweden.

During the expansion of hydropower, compensation schemes were implemented which meant that local communities as well as individuals affected by the hydropower expansion received monetary compensation. There are mainly two types of compensation schemes that are used in connection to hydropower operations in Sweden. One is direct compensation to property owners that are affected by the construction of a hydropower station. The other type of compensation is a so called community indemnity grant. Individuals and associations located in areas affected by hydropower development can apply for the community indemnity grant, and the grants should mainly be used to promote the local community in some way and are paid out annually by the County Administrative Boards.

Despite the large production of electricity from hydropower in Sweden today, there is still a need for further expansion of renewables. Therefore, in the beginning of

2023 a report was conducted by the Swedish government which investigates if and how compensation could give municipalities incentives to allow for expansion of wind power. It highlights the lack of a framework regarding wind power compensation today and brings up some suggestions for compensation.

This report analyses the expansion of renewables in Sweden with the start in 1918. One aim of this project has been to identify and quantify different aspects of hydropower and the related compensation schemes in Sweden. Furthermore, this project has also aimed to compare the historical compensation regarding hydropower with the current plans for the development of wind power.

The starting point of this project was to collect data on hydropower stations in Sweden from energy companies directly, either through their websites or by direct contact. Moreover, data was collected for both the compensation schemes, including when compensation was paid out, what amount, and for what reason. Data on direct compensation was collected from court rulings and data on community indemnity grants were collected by contacting County Administrative Boards. The data was gathered in a data set, which played an integral part in this project, and was later analysed and visualised in several plots.

The analysis of the data provides several insights. One of the most interesting ones is that when it comes to the direct compensation there is no clear correlation between installed capacity or annual generation and the amount of compensation. Contrary to the results for the direct compensation, there does seem to be a correlation between the annual payout of community indemnity grants and the installed capacity. The data shows that most of the hydropower stations are located in the north of Sweden and the amount of compensation allocated through the community indemnity grants are distributed accordingly.

The reason for compensation differs between the two types of compensation schemes. For direct compensation, the most commonly mentioned reason is some kind of physical damage on land or water in connection with the hydropower plant followed by compensation due to loss of property. On the other hand, for the community indemnity grants the compensation is not as clearly connected to the physical damage caused by the construction of the hydropower station. In this case, people receive grants to improve local communities affected by hydropower, for instance,

improving local businesses or culture and leisure activities.

The proposed framework for compensation schemes regarding wind power seems to differ from that which has been historically used for hydropower in Sweden. This is reasonable in an ever evolving society. A differing framework is partly due to the evolution of environmental assessment, placing emphasis on different values in the present day compared to that of the early- to mid-20th century. In conclusion, further expansion of renewable energy sources requires a re-imagining of compensation schemes to facilitate wind power development in Sweden.

A Appendices

A Table of water court rulings

Below, a table (split onto three pages) with a short description of the processed court ruling is included.

Name and Court ruling number	Applicant	Status	Description
Bergefors		Excluded	The first application in 1949. The application was denied and appealed in a higher court before the government approved the application. Construction finished in 1953. Excluded as we didn't have access to those documents.
Forsmo (AnsD 15-1953)	Vattenfall	Included	
Hjälta	Hjälta Aktiebolag	Excluded	The court ruling is concerning a permit to build the hydro power station dated 1946. It mostly contains references to agreements made outside of the court with no sums mentioned in the ruling. It is therefore excluded. There might, however, be mentions of compensation in later rulings.
Hylte	NIKAB owned by Sydkraft AB	Included	
Hölje (A 66/1957 AM 30/1997)	Uddeholms AB, Mölnbacka-Trysil AB, Sångkällforsen AB	Included	
Kilforsen (AnsD 14b-1948 deldom 1949-06-30)	Vattenfall	Included	

Name and Court ruling number	Applicant	Status	Description
Kymmen (DVA 48 VA31/75)	Vänerenergi AB	Included	
Lasele (AnsD 29/1952)	Vattenfall	Included	
Letten (A.M. 45/1952 deldom A 69/1952)	Uddeholms AB, Sulfitaktiebolaget Göta	Included	
Lilla Edet (Västerbygdens vattendomstol AM 16/1923)	Vattenfall	Excluded	There are mentions of compensation but mostly in the form of free electricity. It is therefore excluded.
Messaure	Vattenfall	Excluded	Ruling partly changed in a higher court and was finally approved by the government. Excluded as we didn't have access to those documents.
Röjdåfors (AM 59/1952, 88/1955 och 35/1955)	Röjdåfors kraftverk	Included	
Spjutmo (AD 49/1967)	Spjutmo Kraft AB	Excluded	The court ruling is unclear regarding how much compensation was paid and to whom. It is excluded to not risk introducing uncertain data to the data set.

Name and Court ruling number	Applicant	Status	Description
Stornorrfors (AnsD 40/1953 1956-07-17)	Vattenfall	Included	
Sällsjö (21/1 1952 nr 2)		Excluded	A lot was changed in a higher court. Excluded as we didn't have access to those documents.
Trängslet (AnsD 60/1953)	Stora Kopparbergs Bergslag Aktiebolag	Included	There is probably some compensation from this ruling not added to the data set as there is a mention of state owned land being lost as a result of the dam. Compensation for this was handled in a separate agreement which wasn't included in the ruling.
Vargön (1925-27_AM_1937-06-19)	Vattenfall	Excluded	There is an extreme amount of plaintiffs in this court rulings with roughly 300 pages dedicated to a table of compensation. Excluded as this would take a huge amount of hours to process.
Åsens (AnsD 65-1960 (1961-01-25)	Stora Kopparbergs Bergslags Aktiebolag	Included	

Table A1: List of the processed court ruligns in alphabetical order including if they were included in the court rulings dataset.

B In Depth Description of Dataset Sheets

B.1 Sheet 1: Hydropower Stations

Sheet number one in the dataset consists of a compilation of Swedish hydropower stations owned by 12 different companies where each column gives different information about the specific hydropower station.

Column 1: Name of Hydropower Station
Column one gives the name of the hydropower station. This name is used to identify the hydropower station and is used when requesting court rulings regarding the specific station. All information in the following columns are found using the name as an identifier.

Column 2: Court District
The court district is connected to the hydropower stations are decided by the current division of counties connected to each court district.

Column 3: County
Column three shows which county the hydropower station is located in. A county is a geographical area in Sweden and today, Sweden consists och 21 counties (SCB, 2023d). Which county the station is located in gives a general location of the station and is also used to identify which court district it belongs to.

Column 4: Municipality
Through the hydropower companies' websites, the municipalities where the hydropower station was located could sometimes be found. Otherwise, this was found through the name of the station. A municipality is a geographical area that can include both cities and the countryside. Sweden consists of 290 municipalities (Regeringskansliet, 2023a). Subsequently, the municipalities were used to identify which county the station was located in.

Column 5: Water Body
Which water course the hydropower station is located in is showed in this column. This is important since the Community indemnity grant is sometimes connected with a specific water course.

Column 6: Owner

There are multiple companies that own hydropower stations across Sweden. Some of them, including the largest ones, were used as a starting point to find hydropower stations. Which company that owns the hydropower station is represented in this column.

Column 7: Construction Year

The year seen in this column is the year construction of the hydropower station was completed.

Column 8: Installed Capacity (MW)

Column eight shows the installed maximum capacity of the hydropower station. This is presented in MW and is used to exclude stations with a capacity lower than 10 MW later on in the project.

Column 9: Normal Annual Generation (GWh)

This column represents the normal annual generation by a hydropower station in GWh. It is important since the installed power (capacity) or normal yearly production alone does not give a valid picture of the hydropower station. The yearly production depends on both the installed capacity as well as other factors such as water flow.

Column 10: Operational (Yes,No)

If data was available on if the specific powerplant currently is in operation it was represented in this column. Most rows are marked with MD because most companies did not specifically give this information.

Column 11 and 12: Latitude and Longitude

To be able to use the specific geographical location of the hydropower plant, its latitude, and longitude was documented in these two columns. This is used later on to give a visual representation of in what parts of Sweden the hydropower stations are located.

Column 13: Sources

Where the information in each row has been found is referenced here. This column can include multiple sources per row.

B.2 Sheet 2: Direct Compensation

Sheet number two in the data set consists of information regarding direct compensation that property owners received in connection to the construction of the hydropower station. Each row contains information about one compensation and each column gives different information about the specific compensation. The rows are in alphabetical order based on the name of the hydropower station the compensation is connected to.

Column 1: Name of Hydropower Station
The first column contains the name of the hydropower station for which the compensation is connected to.

Column 2: Court District
The court district determines in what Land and Environment Court[42] the rulings regarding the hydropower station are archived. Before the introduction of Land and Environment Courts, there were Water Courts. Since this change occurred, there may be rulings from certain hydropower stations archived in what now is another jurisdiction.

Column 3: County
Column 3 shows which county the hydropower station is located in. A county is a geographical area in Sweden and today, Sweden consists och 21 counties (SCB, 2023d). Which county the station is located in gives a general location of the station and is also used to identify which court district it belongs to.

Column 4: Court Ruling ID
Each court ruling has its own ID. Column 2 gives the ID for the specific court ruling that contains information about the compensation.

Column 5: Year of Court Ruling
The third column give the year of the court ruling and with that the year that the compensation was determined.

Column 6: Property Name
The direct compensation is decided separately for different properties. This column

[42]Swedish: Mark- och miljödomstol

contains information about which property the compensation connects to. Often, the same property can be named in several row and that is if the same property has been given compensation for several different reasons

Column 7: Reason for Compensation
This column states the reason for the compensation as it is mentioned in the court ruling. Several court rulings did not contain any information about the specific reason for the compensation, other than that a property was in someway affected by the construction of the hydropower station, and in those cases it is marked with MD.

Column 8: Category
The reasons for compensation stated in the court rulings are, as described in the method section, divided into more generalized categories. This column contains those categories and in the case where no specific reason is mentioned in the court ruling this is marked with MD just as in the previous column.

Column 9: Number of People
This column gives information about how many people that own the property and hence how many people that is sharing the compensation. In cases when the property is owned by a company or an association it is marked with NA.

Column 10: Compensation Recipient
This column contains information about who has received the compensation. When a company has received compensation the companies name is given. In the case where individuals have been compensated personal identification numbers have been used. Each person has been allocated an unique number, so if a number appear twice it is the same person that has received compensation several times. If the same name occurs in in connection to multiple court rulings in the same county, it is assumed to be the same person with just one identifier.

Column 11: Compensation Sum (SEK)
This column gives the compensation sum in SEK the year of the court ruling.

Column 12: Consumer Price Index [43](from SCB)
The consumer price index is a comparative number that measures how the consumer

[43]Swedish: Konsumentprisindex

prices on average develop for all private domestic consumption. With reference point in 1949, where the consumer price index is equal to 100, it is then calculated monthly. In this column it is the yearly average for the year of the court ruling that is given.

Column 13: Current Worth of Compensation (SEK, January 2023)
In this column the value of the compensation in 2023 is given. This was calculated using equation 1 presented in method section.

B.3 Sheet 3: Community Indemnity Grants

Sheet number three in the data set consists of information regarding the community indemnity grants. Each row represent one payment from the county which have gone through a application process through a case manager at the county.

Column 1: Application ID
All applications have an ID number for processing matters, this column states that ID.

Column 2: Year of Application
Column two gives the year of which the application was handled in to the county for processing by a case manager.

Column 3: Year of Payment
Column two gives the year of when the money where payed out, for many payments, the application was send in at the end of a certain year, and then processed and payed out the year after.

Column 4: Court District
Since counties and court districts have not completely overlapped borders it is stated in which court district the county lies within.

Column 5: County
This column gives the county from which the payment was payed out as well as the county from the data was received. In Sweden there are 21 counties which represent a certain geographical area. Counties, regions and court districts does not always overlap in Sweden.

Column 6: Municipality

Within a county there are a number of municipalities. This column shows which municipality the application came from.

Column 7: Water Body

In some counties, it is specified which waterbody or hydropower station the application connects to. If this data was received it is stated in this column.

Column 8: Compensation Recipient

This column state who received the grant. Most commonly, the recipient is an organisation, municipality or association.

Column 9: Project

This column gives the name of the specific project that the grant funded.

Column 10: Purpose

This column states the purpose behind the project that the grant funded.

Column 11: Category

The reasons for compensation stated in the court rulings are, as described in the method section, divided into more generalised categories. This column contains those categories. Primarily, the categories have been decided based on the project and purpose. In cases where project and purpose are not given the categories have been decided based on compensation recipient. For instance, if a sports association has received the money the payment has been categories has culture and leisure.

Column 12: Compensation Sum (SEK)

This column gives the sum of the community indemnity grant in SEK that is paid out.

Column 13: Current Worth of Compensation (SEK. January 2023)

In this column, the value of the compensation in 2023 is given. This was calculated using equation 1 presented in method section.

C Societal and Ethical Aspects

The main challenge regarding ethical aspects related to this project was that we handled personal information when conducting interviews and during the data collection on compensation. We have adhered to the principles of the GDPR legislation, mainly that information should only be saved as long as it is needed and only the necessary information should be saved. We have attempted to anonymise any potentially sensitive information and have in general limited the amount of such sensitive information we handled. Only members of this group, along with supervisors have had access to this information. Information from public records (such as court documents) have been considered to be less sensitive than information obtained from other sources.

D Additional Visualisation

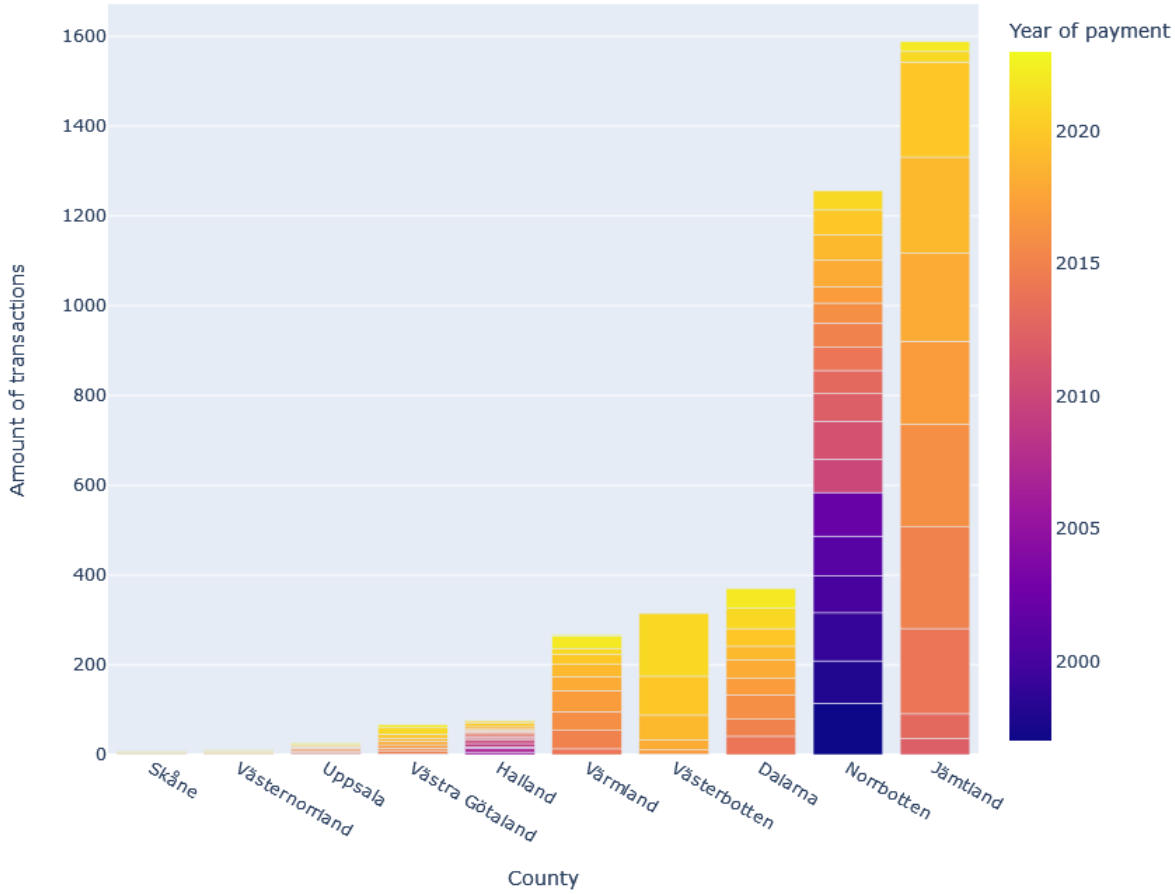

Figure D.1: Number of transactions per county where each color represent a specific year

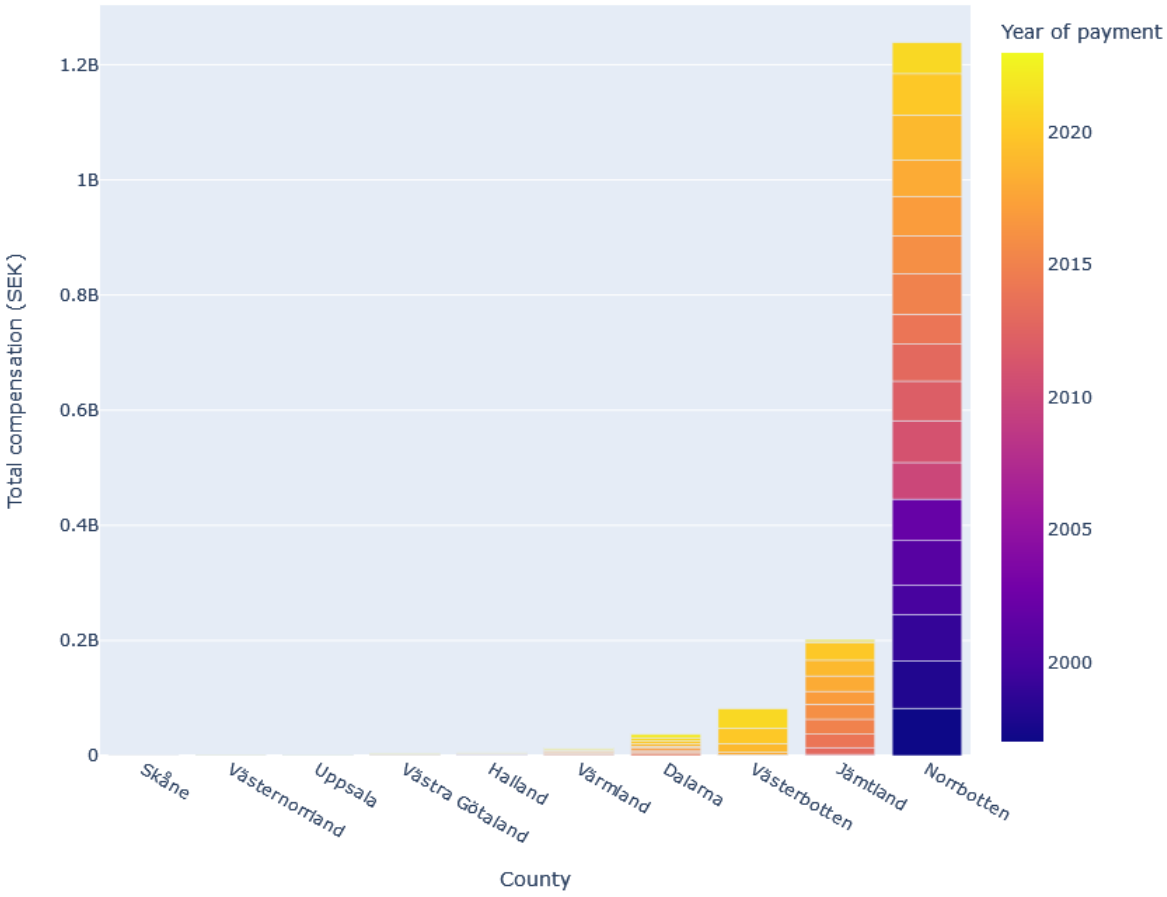

Figure D.2: Total payment amount in SEK per year and county

E Example Calculations for a Wind Turbine Park in Three Municipalities

The following values for the total height, area of the wind turbine park and area of the wind turbine park are the same in all three cases when assuming that the park is circular:

Total height of wind turbine: 218 m

Area of wind turbine park: 40 km^2

Radius of the wind turbine park: 112.8 m

Area zone A: $(1000+112.8)^2 \cdot \pi - 112.8^2 \cdot \pi \approx 3.85 km^2$

Area zone B: $2180^2 \cdot \pi - 112.8^2 \cdot \pi \approx 11.04 km^2$

E.1 Ånge Municipality

The population density in Ånge municipality is 3 people/km^2 SCB, 2023b. Ånge is situated in the energy price range 2 (SE2) which 2022 had an average spot price of 0.663 SEK/kWh.

Estimation of the revenue from all wind turbines in the park:

$$0.663 \cdot 805500000 \approx 534046500 \text{ SEK} \tag{6}$$

Estimation of the revenue from two wind turbines:

$$\frac{534046500}{54} \cdot 2 \approx 19779500 \text{ SEK} \tag{7}$$

Divide the nearby area into two zones. As in figure 5.15, zone A starts at the outer line of the wind turbine park and extends 1000 meters out. Where zone A ends zone B starts and extends to 10 times the height of a wind turbine, which in this example is an additional 1180 meters. Now let's estimate how many households there are in each zone using the population density for the municipality and that there on average live 2.2 people in one household (SCB, 2018): (Assuming no one lives in the park)

Calculations regarding each zone
Zone A:
Amount of people living in zone A: $3.85 \cdot 3 \approx 12$ people

Amount of households in zone A: $\frac{12}{2.2} \approx 5.5$ households

Share of revenue: 0.0025
Yearly compensation per household: $0.0025 \cdot 19779500 \approx 49449$ SEK

Zone B:
Amount of people living in zone B: $11.04 \cdot 3 \approx 33$ people

Amount of households in zone B: $\frac{33}{2.2} = 15$households

Using equation 5 and making the simplification that everyone lives, on average, in the middle of the zone B, i.e 1590 m from the wind turbine park.
Share of revenue: $0.0025 \cdot (1 - \frac{1590-1000}{218 \cdot 10-1000}) \approx 0.00125$
Yearly compensation per household: $0.00125 \cdot 19779500 \approx 24724$ SEK

The estimation tells us that about 5.5 households are located within a radius of 1000 m from the wind turbine park and additional 15 households are located within a radius of 2180 m from the wind turbine park i.e. a distance ten times the height of a wind turbine.

Total compensatiob in both zones

Total compensation annually:
$5.5 \cdot 49449 + 15 \cdot 24724 \approx 642830$ SEK

Average compensation per household per year:
$\frac{642830}{5.5+15} \approx 31358$ SEK

Average compensation per GWh:
$\frac{642830}{805.5} \approx 798$ SEK/GWh

E.2 Hjo Minicipality

Hjo municipality has a population density of 30.1 people/km^2 according to table F1 and is located in bidding area 3 with an average electricity price of 1.374 SEK/kWh.

Estimation of the revenue from all wind turbines in the park:

$$1.374 \cdot 805500000 \approx 1106757000 \text{ SEK} \tag{8}$$

Estimation of the revenue from two wind turbines:

$$\frac{1106757000}{54} \cdot 2 \approx 40991000 \text{ SEK} \tag{9}$$

Calculations regarding each zone Zone A:
Amount of people living in zone A: $3.85 \cdot 31.1 \approx 120$ people

Amount of households in zone A: $\frac{120}{2.2} \approx 55$ households

Share of revenue: 0.0025
Yearly compensation per household: $0.0025 \cdot 40991000 \approx 102478$ SEK

Zone B:
Amount of people living in zone B: $11.04 \cdot 31.1 \approx 343$ people

Amount of households in zone B: $\frac{343}{2.2} = 156$ households

Using equation 5 and making the simplification that everyone lives, on average, in the middle of the zone B, i.e 1590 m from the wind turbine park the total compensation is:
Share of revenue: $0.0025 \cdot (1 - \frac{1590-1000}{218 \cdot 10-1000}) \approx 0.00125$
Yearly compensation per household: $0.00125 \cdot 40991000 \approx 51239$ SEK

The estimation tells us that about 55 households is located within a radius of 1000 m from the wind turbine park and additional 156 households is located within a radius of 2180 m from the wind turbine park i.e a distance ten times the height of a wind turbine.

Total compensation in both zones

Total compensation annually:
$55 \cdot 102478 + 156 \cdot 51239 \approx 13629574$ SEK

Compensation per household per year:

$\frac{13629574}{55+156} \approx 64595$ SEK

Compensation per GWh:
$\frac{13629574}{805.5} \approx 16921$ SEK/GWh

E.3 Sollentuna Municipality

Table F1 gives that the population density in Sollentuna municipality is about 1449.1 persons/km^2. Further, it gives that Sollentuna is situated in the bidding area 3 which for 2022 had an average energy price of 1.374 SEK/kWh.

Estimation of the revenue from all wind turbines in the park:

$$1.374 \cdot 805500000 \approx 1106757000SEK \tag{10}$$

Estimation of the revenue from two wind turbines:

$$\frac{1106757000}{54} \cdot 2 \approx 40991000SEK \tag{11}$$

Calculations regarding each zone
Zone A:
Amount of people living in zone A: $3.85 \cdot 1449.1 \approx 5579$ people

Amount of households in zone A: $\frac{5579}{2.2} \approx 2536$ households

Share of revenue: 0.0025 Compensation: $0.0025 \cdot 40991000 \approx 102478$ SEK

Zone B:
Amount of people living in zone B: $11.04 \cdot 1449.1 \approx 15998$ people

Amount of households in zone B: $\frac{15998}{2.2} = 7272$households

Using equation 5 and making the simplification that everyone lives, on average, in the middle of the zone B, i.e 1590 m from the wind turbine park.
Share of revenue: $0.0025 \cdot (1 - \frac{1590-1000}{218 \cdot 10-1000}) \approx 0.00125$
Compensation: $0.00125 \cdot 40991000 \approx 51239$ SEK

The estimation tells us that about 2536 households is located within a radius of 1000 m from the wind turbine park and additional 15 998 households is located within a radius of 2180 m from the wind turbine park i.e a distance ten times the height of a wind turbine.

Total Compensation in both zones
Total compensation annually:
$2536 \cdot 102478 + 15998 \cdot 51239 \approx 1079605730$ SEK

Compensation per household per year:
$\frac{1079605730}{2536+15998} \approx 58250$ SEK

Compensation per GWh:
$\frac{1079605730}{805.5} \approx 1340293$ SEK/GWh

The combined results are showed in table III.

F Interviewees

Table F1: Information of expert interviews

Name	Occupation	Date of interview
Elisabeth Klintebäck	Case manager at the County Administrative Board of Västerbotten	23-03-14
Nils Ryrberg	Senior Advisor at Åberg Law Firm	23-03-28
Erik Cardell	Technical Advisor at the Land and Environment Court in Vänersborg	23-04-24

G Categories explained

During the processing of data each compensation, both for the community indemnity grant and the direct compensation, was put into a certain category. Inductive thematic analysis was used to categories a wide range of data. Below, some examples of what was included in the different categories are presented.

- Renovation of property: Maintenance of building, renovation of building, extension of building, building energy efficiency, movement of building, replacement of facade, windows etc.
- Culture and leisure: Upgrading hiking trails, upgrading windshield, outdoor gym, grilling area, athletic association etc.
- Business sector: business development, Investment digital information signs, developing tourism sector, business association etc.
- Fishing: Damage to fishing during the construction period, fish farming association, fishing project, fish conservation etc.
- Loss in potential growth: loss of growth, Premature felling of forest, logging etc.
- Impact on land and watercourses: damming, building of dam, building of road, removal of road, damage on road, damage on stream etc.
- Loss of property: purchase of property, island being claimed, loss of boathouse etc.
- Encroachment during construction period: in this category, Encroachment during construction period was the only item that was put in the category.
- Other: marketing, broadband, maintenance of machines, general grants etc.

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