Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Social and Educational Sciences
Department of Geography

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Assessment of environmental impacts in the Norwegian licencing process for wind power.

Master's thesis in Natural Resource Management
Supervisor: Jan Ketil Rød
Co-supervisor: Roel May
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Abstract

The development of wind power requires careful consideration of different political goals, environmental impacts, and stakeholder interests. These considerations are taken into account through a procedure called “the licencing process”, which a developer undergo in order to build and operate a wind power facility in Norway. This licence is applied for by sending an application to the Norwegian Water Resource and Energy Directorate (NVE), who reviews the application and decides if a licence is issued or not. A large part of these licencing application is the Environmental Impact Assessments (EIA), which purpose it is to assess and report how the surrounding environmental values are impacted by the proposed development. However, in the literature, very little is known about how these environmental impacts actually affect the wind power licence decisions.

Through an extensive data collection from all wind power project applications in Norway from 2000 – 2020, this study aimed to statistically analyse how these impacts influence the final outcome of the licence process. Focusing on the influences of reported high negative impacts, how the different EIAs are weighed and if high impacts to a single theme is enough to predict the outcome. The findings suggest that high reported impacts to both cultural heritage and natural themes will reduce a developer’s chances of being granted a licence for the project. The results for the other investigated themes were less conclusive, indicating that it is still uncertain how high negative impacts to a majority of the reported themes influences the final licence outcome. It is further found that the EIAs are not weighed equally, and that high negative impact to a single EIA theme is not enough to predict the outcome of the licencing process.

Sammendrag

Utbygging av vindkraft krever nøye vurderinger av ulike politiske mål, miljøpåvirkninger og andre interesser. Disse hensynene ivaretas gjennom en konsesjonsprosess, som en potensiell utbygger må gjennomgå for å kunne bygge og drifte et vindkraftanlegg i Norge. En slik konsesjon søkes ved å sende inn en søknad til Norges vassdrags- og energidirektorat (NVE), som vurderer søknaden og avgjør om konsesjon gis eller ikke. En stor del av disse konsesjonssøknadene er konsekvensutredninger for miljø og samfunn (EIA), som har til formål å vurdere og rapportere hvordan de omkringliggende miljø- og samfunnsverdiene påvirkes av den foreslåtte utbyggingen. I litteraturen er det imidlertid svært lite kjent om hvordan disse rapporterte miljø- og samfunnskonsekvensene faktisk påvirker konsesjonsbeslutningene for vindkraft.

Gjennom en omfattende datainnsamling fra alle konsesjonssøknader for vindkraft i Norge imellom 2000 – 2020, har denne studien hatt som mål å analysere hvordan miljø- og samfunnskonsekvenser påvirket om et vindkraftprosjekt fikk konsesjon eller ikke. Fokuset var på innvirkningen av høye negative konsekvenser for de ulike temaene rapportert i EIA, hvordan de ulike temaene opp mot hverandre og om høye konsekvenser for et enkelt tema er nok til å forutsi utfallet av konsesjonsprosessen. Funnene tyder på at høye rapporterte konsekvenser for både kulturarv og naturtemaer vil redusere en utbyggers sjanser for å få konsesjon. Resultatene for de andre undersøkte temaene var mer usikre, noe som indikerer at det fortsatt er uklart hvordan høye negative konsekvenser på et flertall av de rapporterte temaene påvirker det endelige utfallet av konsesjonsprosessen. Det er videre funnet at EIA-temaene ikke veies likt, og at høy negativ konsekvens på et enkelt EIA-tema ikke er nok til å forutsi utfallet av konsesjonsprosessen.

Acknowledgement

This master's thesis on the assessment of environmental impacts in the wind energy licensing process is the result of a challenging, sometimes uncertain, and intense learning process that lasted from the autumn of 2019 to the winter of 2022. It's a large part of my master's programme in Natural Resource Management at Trondheim University of Science and Technology.

This research, which was initially planned as a project including the mapping toolbox for Consensus-based Siting of Powerlines and Wind power plants (ConSite), was not possible to conduct due to the rapidly changing situation surrounding wind power in Norway. So instead of researching the placements of already developed wind power projects according to the environmental impact assessments, I investigated how these assessments have influenced the licence outcome. Working with the master thesis has been a long and drawn-out process and completing this work would not have been possible without help. As such I would like to thank Roel May (NINA), Mark Gillespie (HVL) and Norunn Hornset (NTNU), who have all been most helpful with my statistical analysis.

Jan Ketil Rød, my supervisor, deserves a special thank you, for his excellent help and advice. Despite the fact that this thesis ended up slightly outside of your field of expertise, you have been a steadfast supporter and have always provided solid inputs! Thank you so much for everything!

I would also like to thank my parents, family, and friends for the support I have received along the way, your support has been invaluable to me! Lastly, I wish to thank my fellow master students at Natural Resource Management, for your company during the pandemic, the nice conversations during my work on the thesis and the long coffee breaks!

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Abbreviations

NVE: The Norwegian Water Resources and Energy Directorate.

OED: The Norwegian Ministry of Petroleum and Energy

EIA: Environmental Impact Assessments.

PBA: Planning and Building Act

MTA: Environmental, transport and construction-plan

MW: Megawatt

KLD: The Ministry of Climate and Environment

TKV: Thematic conflict assessments

GHG: Greenhouse gasses

EU: European Union

EEA: European Economic Area

INON: Non-invasive nature areas

LCOE: Levelized Cost of Energy

CI: Confidence Interval

NA: Not available

ROC: Receiver Operating Characteristic

AUC: Area Under the Curve

1. Introduction

The nations of the world have been called upon to reduce their emissions of greenhouse gases (GHG) and transit towards a low-carbon global economy in order to mitigate the impact of man-made climate change (UN, 1992; 1997; 2015; WCED, 1987; IPCC, 1990). For this transition to take place, the increase in electricity production from renewable sources will be crucial (Thygesen and Agarwal, 2014). Thanks to new policies, the availability of better technology and falling production costs, the share of renewables in the power mix is rising rapidly. Depending on the scenario, its predicted to rise to 40% or even two-thirds renewable energy by 2040 (IEA, 2018).

Norway has the second longest coastline in the world, which offers good conditions for wind power generation. If compared to other European nations however, Norway has been rather slow in developing its wind power capacity. That being said, the development has increased rapidly during the last decade, with several large wind power projects being realised in the last years alone, causing a 79% increase in electricity generated by wind power in 2020, compared to 2019 (NVE, 2020a; 2020c).

While harnessing energy from wind is neither an original or new idea, and technologies utilizing the power of the wind have been available for at least three millennia. This wind energy was nevertheless primarily used to provide mechanical power, for instance, used for sailing ships. However, by the 1990s, wind power had emerged as one of the most important sources of renewable energy (Ackermann and Söder, 2002) and has since become one of Europe's preferred choices for increasing its renewable energy production.

Despite being efficient tool producing energy while avoiding the emission of GHGs, the building and operation of wind power facilities have significant spatial and environmental impacts, causing the development of wind power to occasionally be shadowed by heated local and national debates (Batel and Devine-Wright, 2015; Saglie et al., 2020; Rygg, 2012). The debates usually reflect on these impacts, demonstrating that climate-change policies and the bid to increase the production of renewable energy comes at a price, not least with regards to nature conservation (Warren et al., 2005).

Wind power was first introduced as an environmentally friendly way of producing energy, but Bye and Solli (2007) argued that a shift in opinion have taken place, from that wind power being perceived as environmentally friendly, to representing an unwanted intervention in nature, with proponents seeing value in wind power as a sustainable source of energy, and opponents seeing it as an destruction of the landscape, spoiling of the natural habitats and prioritizing economy before nature (Rygg, 2012).

It is important to note that, as with all large land-use changes, the development of wind power requires careful consideration of different political goals and stakeholder interests, which is usually conducted through a procedure referred to as *licencing* (Inderberg et al., 2019; Petterson et al., 2010). This process is very complicated, and while elements, such as stakeholder perceptions and acceptance requirements, have gotten a lot of coverage from the scientific community (Bailey and Darkal, 2018; Batel and Devine-Wright, 2015; Graham et al., 2008; Jenkins, 2018; Knutsen et al., 2015), other parts of the licensing process have received far less attention, and to my knowledge, there are only a few studies focusing on which elements actually influence the outcome of the licence process (Harper et al., 2019; Petterson et al., 2010; Roddis et al., 2018; Thygesen and Agarwal, 2014; van Rensburg et al., 2015; Inderberg et al., 2019; Inderberg et al., 2020).

It was indicated by both Harper et al. (2019) and Inderberg et al. (2019) that municipalities wield considerable influence in the licencing process. This fact was further investigated by Inderberg et al. (2020) in their paper "What influences windpower decisions? A statistical analysis of licencing in Norway". In this paper they analysed how municipalities stances, together with the added influence of "natural environmental impacts" influenced the final outcome of the licence process. They found that both the municipalities stance and the natural environmental impacts had a strong influence on the final licence outcome. Municipalities with a negative stance towards a wind power project have in practice something very close to veto powers, while high negative impacts to the natural environment substantially reduce the likelihood of project realisation. Meanwhile, it was also observed that the environmental impacts of wind power have received surprisingly little attention from the scientific community, and that their statistical analysis represents one of the first statistical tests on how local resistance and environmental considerations influence the licencing outcome.

This presented a significant research gap into the understanding of the Norwegian licencing process. In this thesis I will try narrowing that gap, by expanding investigation of the influence of the reported impacts for wind power. Using Norway as a case country, as the situation with onshore wind power in Norway and the resistance it has met in the last few years makes this a relevant study for both society and further research.

1.1 Problem statement and thesis specification

The growing levels of tension surrounding the development of wind power, as well as the following debates, drew my attention to the topic of which elements actually influence the licence outcome. The most pronounced event being the rejection of a “national framework for wind power” proposal, intended to improve and streamline the licencing process in Norway. This "framework" was rejected as it was deemed too controversial, making it not able to succeed in its objective of lowering the future conflict levels surrounding the wind power developments. This particular event highlighted the uncertainties surrounding any future development of onshore wind power in Norway (NVE, 2019d), making the grounds for the acceptance of earlier wind power projects particularly interesting to study.

The reason why wind power has become so controversial in the last decade is difficult to pinpoint, but one can hypothesise that there is a conflict of interests between the decision makers, wishing to utilize the available natural resources and the local stakeholders most affected by any negative impacts caused by this utilization. Because the value created by a finalized wind power project can quite accurately be predicted and understood in monetary terms, for instance as potential property tax paid to the host-municipality or by the power produced, it is more difficult to estimate and evaluate negative consequences as they can’t be compared using the same scale. The consequences for the environment, natural resources and society impacted are usually valued as “priceless” or subjective, often with no fixed monetary value, they present a complex challenge when they are supposed to be compared and weighed against the positive impacts. This line of thought led me to an interesting line of questioning:

How can one value something that does not have an inherent price tag, or whose value changes depending on individual opinion? ***&*** *How can these valued be evaluated and compared to each other?*

As I could not find or think of any good answers to these questions above, I became intrigued by the idea of investigating what values licencing authorities use when coming to their conclusions. In this particular case, since we are talking about the production of energy in Norway, the decision makers or authorities on the subject are The Norwegian Water Resources and Energy Directorate (NVE), who are a directorate under The Ministry of Petroleum and Energy (OED).

In order to select which wind power projects that should be developed, they utilize a concession or licencing process. Most often simply called "the licencing process", and it is mainly regulated by two Acts: The Energy Act and The Planning and Building Act. Through the Energy Act of 1990, all wind power projects larger than 1 MW are required to apply for a licence, and those larger than 10 MW[1] are required to do an Environmental Impact Assessment (EIA)[2], which is regulated by the EIA guidelines in Norway's Planning and Building Act (PBA).

The EIA covers a wide range of issues and is a system used to report a project's perceived impact on the surrounding environment in the event of it being built. Some of the impacts often covered are the following: the visual impact on landscape, the direct and indirect impact on cultural heritage, the loss of wild non-invasive nature areas and conservation interests, impact to the natural environment and biodiversity etc. (NVE, n.d-b). As such, the collective assessments of the impacts can be used to quantify a project's "total" environmental impact.

As stated above, the weighing of the different values is an issue, and the EIAs are not without flaws or limitations. It has been argued by several that the impacts assessments are not sufficiently understood, and carries a relatively weak impact on planning decisions (Thygesen and Agarwal, 2014). It was also argued that external actors, have trouble to anticipate and predict how various factors are weighed when the authorities reach their final licencing decision (Inderberg et al., 2019), warranting further research on the topic.

By working along the same lines as Inderberg et al. (2020), while excluding the municipality stance (as this influence is presented as a near certainty) and expanding on the use of EIAs, investigating at all the perceived impacts, and not just the ones reported for natural environment and biodiversity. The goal of this thesis is to gain a better understanding how all the different impacts are evaluated and how they influence the outcome of the licencing process, and it led me to pose my first research question:

Research question 1: *How do perceived societal and ecological impacts influence the likelihood of a wind power licence decisions in Norway?*

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[1] Wind-power projects with sizes less than 10MW are not required to do a full-sized EIA, but lightweight version, making them incomparable with the rest of the dataset.
[2] The environmental impact assessment is an important part of the licencing process in Norway. It will be explained in detail in chapter two.

To answer this question, project information and EIAs from licence applications publicly available in NVE's archives were gathered (NVE, 2021a), ranging from 2000 – 2020. The data was then extracted and coded to perform a multivariate logistic regression analysis, with the «Licence outcome» being the dependent variable and the EIA being the explanatory variables. It is important to note that all the projects had to have a size of 10 MW or larger and needed a usable EIA as smaller projects do not have the same requirements.

The EIA covers a large range of issues, and as the project's locations differ, so will the issues. In anticipation of this, I purposefully made quite broad research questions instead of many small ones, expecting that certain issues are present in some EIAs, but not in others making a detailed investigation of each and every theme present in the EIA challenging. It is also assumed that the different themes are valued differently, adding to the complexity of the study.

That being said, one would find it very surprising if high negative impacts on the EIAs did not influence the process in any way, regardless of the issue, and my subsequent hypothesis being:

Hypothesis 1: *High negative impacts reported by the EIAs will reduce the likelihood of licence being granted.*

There are many other factors than the EIA to be considered when deciding which projects are viable and which projects are not, and as previously discussed, the evaluation of each separate theme is likely to be an issue. Some examples of the many factors for NVE to consider are, project sustainability, local need for electric energy, the availability of power grids, the political push to meet renewable energy goals etc.

While the first research question is designed to answer how the different themes in the EIAs influence the licence outcome, investigating at each type of impact separately, weighing its influence on the process, it does not investigate how the different themes are being weighed. For example, if the visual impact on landscape is equally as important as the impact to the natural environment and biodiversity. Thus, another research question is needed to further enlighten the process.

Research question 2: Are the EIAs weighted differently? Will high impacts to a single EIA be crucial enough for a project to be rejected?

This question should be answerable by using the same dataset and method as for Research Question 1. The importance of this question is to investigate if some themes are more influential than others, and if so, how are they valued and how compare to one another. If the identification of these themes proves to be possible, the knowledge could further help the identification of future conflicting values between the licencing authorities and local stakeholders. As well as making the outcome of an eventual licence application process easier to predict in the event of high negative impacts to any such themes.

This will most likely be a very challenging question to research, as there are many different applications to investigate, and preliminary investigations imply that there are distinct conflicts for each project. It is initially assumed that high negative impacts will lower a project's chance of being granted a licence, and that NVE evaluates these projects individually, at least to the extent of evaluating their environmental and societal impacts.

Hypothesis 2: The EIAs will not be weighed equally. They will however not be influential enough to predict the outcome of the licence process.

Because there are so many distinct EIAs to evaluate, and in some cases, separate EIAs, I expect to discover that the EIAs are not weighed equally, as the alternative would make the license process far too rigid to effectively manage such a complicated subject. I also expect to find that some of the EIAs to have a higher weight than others as some conflicts will be found to be consistent throughout 20 years of the licencing process. I do however not expect to find that high impacts to a single EIA is enough to predict the outcome of the licencing process.

1.2 Readers guide

Chapter 2 explains the theoretical aspect behind the study and how the licencing process works. This chapter starts by explaining the Norwegian licencing process and the laws its guided by, followed by a short introduction what a *licence* is. The licence process is then explained in detail, walking through it in chronological order. In addition to this, additional research on the topic is presented and the political situation and external drivers are accounted for.

Chapter 3 explains the methodical approach of my thesis. The study design, data material, variables and analytical approach is presented. I present the data material used in the analysis, and account for how it was collected. This data collection is a significant part of this study and contains much useful knowledge and observations from the data collection phase. The latter part of the chapter presents the variables and analytical approach used in the analysis.

Chapter 4 presents the results from the analysis. The chapter starts by presenting the results from the investigation of the influence of EIAs on the licencing process, explaining all the models in turn. Then the findings for the weights of EIA are presented in the final part of the chapter.

Chapter 5 discusses the results in light of the literature presented in chapter 2 and the knowledge gathered in the data collection phase in chapter 3. The discussion will not exclude to discuss non-statistically significant findings but will also put emphasis on existing literature and the probability of the relationships. This chapter then discusses the conclusions for my hypothesises. In the end of the chapter potential weaknesses of the study are also discussed.

Chapter 6 is the concluding chapter, where the most important finding is presented. This chapter will also present recommendations for further research.

2. Background

In order to understand how the outcome is influenced by the EIAs, an introduction to Norwegian licencing process is required. In this chapter I will present the laws which form the legal basis of the licencing process, a detailed walkthrough of the licencing process, a comprehensive description of the EIA and how they are made. At the end of the chapter, previous research that are relevant for the thesis will be discussed as well as the political situation regarding wind power in Norway.

2.1 The "Norwegian licencing processes"

The Norwegian licencing process for wind power development is mainly regulated by two sets of laws, also referred to as "Acts". The Energy Act (1990, no. 50), and the Planning and Building Act (2008, no.71). The rules regarding the EIAs have been through significant changes since the concept was established by Norwegian law in 1989, with the first rules regarding impact assessments for projects being included in the Planning and building Act (PBA). In 1990 the first regulations for EIA were adopted, and later several significant changes have been made, as shown in table 1, "Changes in the EIA-regulations". This background explanation does not focus on rules or practices concerning the EIAs done by governmental agencies, as this is mainly used for the development of land-use plans, as this is a separate process, based on the same laws. For more details on this subject, I suggest reading the report submitted by Fauchald (2018).

Table 1: Changes in the EIA-regulations (Fauchald, 2018, pp. 28-29).

Year	Legal basis	EIA – obligations	Implication for EIA
1989	PBL	Decided by the responsible ministry.	General rules implemented.
1990	Regulation	Rules for project notification are first implemented but are not applicable for wind power.	New rules detailing content of the EIA implemented.
1996	PBL & Regulation	Certain types of projects are obliged to provide EIA, not wind power. The need for an EIA would be assessed if a project required an investment larger than 50 mil NOK.	Detailed rules on case processing implemented in both the PBL and regulations, including rules on the EIA program.
1999	Regulation	Clarifying that EIA should be provided for wind power projects and that the previously set investment limit did not apply for "electric installations".	No changes of note.
2005	PBL & Regulation	Wind power projects larger than 10 MW are obligated to provide an EIA, this does not however, apply for projects smaller than 10 MW. EIA is required for specific plans.	More detailed rules on the EIA program.
2009	PBL & Regulation	Wind power projects larger than 10 MW are obligated to perform an EIA, the need for an EIA for projects larger than 5 MW is assessed individually.	No detailed rules about EIA in the PBL, the rules are continued in the 2005 regulations.

2014	Regulation	Wind power projects larger than 10 MW are obligated to perform an EIA, no lower limit for when EIA should be considered in wind power cases.	More detailed rules for the EIA of regulations plans.
2017	Regulation	EIA is obligatory for wind power projects larger than 1 MW.	Wind power projects between 1 and 10 MW are exempt from the rules about notification and EIA-program, new rules on mitigation measures implemented.

The purpose of the Energy Act (§ 1-2) is to "ensure that production, transformation, transfer, turnover, distribution and the use of energy takes place in a way rational for society, taking into account public and private interests that are affected". The Energy Act contains the basic rules for granting permits (which in this thesis is referred to as licences) to establish and operation of wind power plants and acts as the groundwork for the centralized licence application process for wind power projects. The requirement for license processing comes from the Energy Act, and there are different requirements for different sizes of wind energy plants, measured mainly in power capacity using megawatt (MW). The law differentiates between three different categories, with different requirements for each.

1. **Above 10 MW:** The projects with an installed power of above 10 MW are obliged to include an EIA in their applications, and the case process is mainly steered by the Energy Act, with NVE as the responsible authority[3]. It is the projects in this category that is focused upon in this thesis, as most cases in the two other categories follow different procedures and lack the needed information.

2. **Between 1-10 MW:** These projects only need to follow a shorter application process, not requiring a project notice or EIA program, and only a simple EIA. However, these have more municipal involvement.

3. **Less than 1 MW:** Projects with a planned installed power below 1 MW (& fewer than 5 turbines) are not required to apply for a license under the Energy Act, and therefore falls outside the EIA obligation.

The purpose of the Planning and Building Act (§ 1-1) is, among other things, to "promote sustainable development for the benefit of the individual, society and the future generations", "coordinate state, regional and municipal tasks and provide the foundation for decisions on the use and protection of resources", as well as "ensure transparency, predictability and participation for all affected interests and authorities". The law contains the basic rules on the

[3] See regulations on environmental impact assessments (2017 no. 854) appendix I point 28

design of land-use plans, indicating which activities can be established within a given area as well as the investigation of any consequences of establishment of such activities.

PBL provides the legal basis for the regulations on environmental impact assessments (2017 nr. 854). The purpose of these regulations is to "ensure that impacts to the environment and society is taken into consideration during the preparation of any plans or projects, and when deciding whether and on what terms they should be implemented". It regulates the duties of the developer, which plans, or projects requires an EIA, who the responsible authority is and how they are supposed to act, how it should be performed and what it should contain. It is this regulation that stipulates that wind power licence applications above 10 MW are obligated to perform an EIA, that the responsible authority is NVE and that the law connected to the process is the Energy Act (Appendix I, nr 28).

These laws and regulations bestow large amounts of freedom to the NVE/OED's management practices, making any guidelines on how to prepare a licence application and/or an EIA extra important for the quality of the licencing process. The guidelines for wind power currently used by NVE dates back to 2007 (KLD, 2007), and has not been updated since their implementation. There is no specific guideline for what a licence application for a wind power projects larger than 10 MW, but the guideline for ≤ 10 MW is currently used for both. This guide details the subject information a finished licence application should contain (NVE, n.d-b).

1. General information about the applicant (developer).
2. The work done in the planning stage (relations with other actors, alternative plans etc.).
3. A detailed description of the wind power project (containing maps, placements, detailed information on wind conditions, turbine types and height, foundations and placements, detailed description of the roads needed, details on construction work and plans for the future operation of the wind farm).
4. Economy (detailing investments, costs, and yearly production).
5. Rational for the incorporation the additional power to the power grid
6. Impacts on the environment, natural resources, and society.
7. Public and private projects.
8. Impacts on private interests.

The most important information for this thesis is naturally the part detailing the impacts on the environment, natural resources, and society, which will be closer explained in the part about EIA.

2.2 The licence

A licence is given for a period of up to 30 years according to the Energy Act (§2-2), but NVE usually only grants licences for a 25-year periods, starting from the day the project is operational. A series of licence terms usually accompany the licence, detailing among other things, within what timeframe a project is expected to be commissioned, and how and when it should be decommissioned. The timeframe for the completions of a project can be extended, usually leading to an extension of the licence period. A decommissioned wind power project[4] is obliged to "to remove the facility and as far as possible revert the landscape back to its natural state" (§3-5). When the licence period is at its end, the developer can either apply for a renewal[5] of the original licence, and continue operating, or shut down and decommission according to the terms stated in the licence grant. In the next chapter I will explain the licencing process in chronological order. A simplified version of this is displayed by figure 1 below.

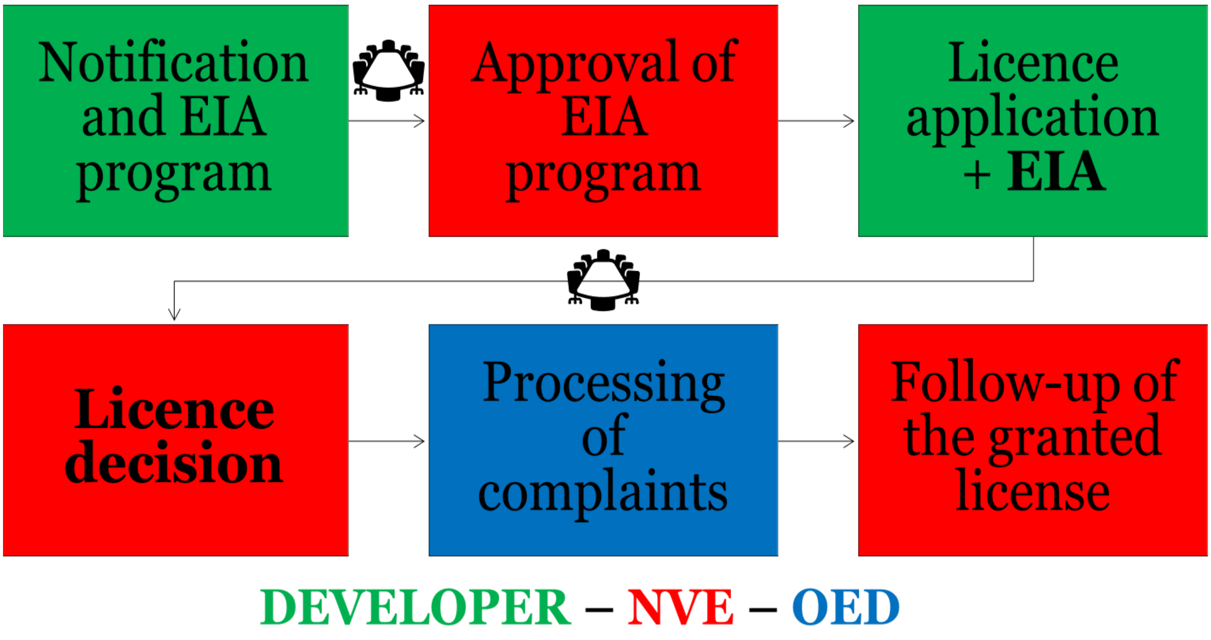

Figure 1: A simplified version of the licencing process in chronological order. The process is color-coded for added simplicity, showing the active party at each specific stage in the process. The table and chairs represent the two public hearings held as part of the process.

[4] Since no licences have yet to be decommissioned, there is no detailed information on this phase yet.
[5] According to NVEs, three projects have applied for a re-establishment (renewal) of their original licence. All these applications were accepted.

2.3 Timeline of the licencing process

Stage 1: Project notification, and preliminary assessment of possible consequences to the surrounding environment: The notification is the first official announcement of the planned project, and its purpose is to share preliminary information about the project with the parties affected by it. The preliminary information includes project location, size, and possible societal and environmental impacts, and as a stage where affected parties can voice their opinions and put forth their feedback to the project. The process starts with the notification being handed in to NVE, and is then sent out to all affected parties, who holds a six-week hearing period where those who wish can provide feedback to the proposed project[6]. In addition, a public meeting is held in the host municipality during the same six-week period.

As a part of the notification, the developer must provide a preliminary assessment of possible consequences for the surroundings. This assessment should contain proposal for a study program indicating which subjects the developer believes that further investigation is needed. This is the formal start of the EIA program.

Stage 2: Determination of the EIA program: After the hearing period, NVE gathers and processes the feedback received, and uses it to determine the EIA program. The developer is in turn responsible for following this program and ensuring that the information gathered is as accurate as possible. The developer is allowed to choose who will carry out the studies, but the people or firms in question must be professionally qualified and have professional integrity.

Stage 3: Licence application and EIA: In this step the developers collect the sub-reports from each of the different required topics (e.g., impacts on landscape, biodiversity, noise, shadow-casting…) The developer then compiles these into the completed EIA for the project, prepares the full licence application and submits it to NVE. This stage forms the basis for the project evaluation and licence decision. After the application is submitted to NVE for evaluation, it goes on another six-week hearing, with the relevant documents being sent to relevant recipients for consultation (Local, regional, and national authorities are included, as well as any other stakeholders who wishes to submit input). As in step two, NVE arranges a

[6] According to PBL §5-4 the affected state and regional body may raise an objection where the development is «of national or significant regional importance, or…of other reasons are of significant importance to the body area of responsibility ». Municipalities also have the right to raise objections when the development is «Of significant importance to the municipality's inhabitants, to the business community or the natural or cultural environment in the municipality, or for the municipality's own business or planning ».

public meeting during the hearing period. After all the feedback is reviewed, an inspection of the intended construction area is carried out.

Stage 4: Licence outcome: NVE makes a holistic assessment of the application based on the application, the results from the environmental impact assessment, feedback received during the hearing period and NVE's professional knowledge of wind power to decide the outcome of the licence process. The answer being “Yes” or “No” (Although NVE can approve parts of a project or approve it with stipulations for changes in the application parameters). The reply is presented in a separate document called “Background for the decision” where NVE presents all the assessments and information used while reaching their decision.

If no one voices complaints within the deadline after a decision have been made, this is where the application process ends (If any party with the right to do so, has objections during the process or disagrees with the outcome and complaints, NVE will pass the case to OED who will review the case and has the final say in the matter.

Stage 5: Processing complaints (if any): The decision can be appealed within three weeks of it being announced, by parties connected to the case in addition to other stakeholders who have a legal right to appeal the decision[7]. This also applies if there still are unsolved objections from the earlier hearing periods of the process. If a complaint or objection is raised, the case is automatically given over to OED, who reviews it and then makes a final decision[8]. There are raised complaints on a majority of the licence decisions made by NVE, but there are only a few cases being overturned, as OED rarely decides in favour of the appealing faction(Fauchald, 2018, p. 17).

Stage 6: Follow-up of the granted license: Before the developer can start construction, NVE and the Norwegian Environmental Agency must approve the environmental, transport and construction-plan (MTA) and a detailed plan specifying the development plans inside the decided framework for the project. For a more detailed explanation visit NVE’s webpage for the licensing of wind power development (NVE, 2015) or read the FNI report by Fauchald (2018).

[7] According to the Energy Act §2-1, the same bodies that are given the right to object in accordance with the Planning and Building Act are also given the right to appeal the licensing decision in accordance with the rules in the Public Administration Act, Chapter VI.

[8] OED is the highest authority in wind power cases and processes any appeals. Their decision is final and can’t be appealed.

2.4 Explaining the EIA for wind power projects < 10 MW

The use of EIA in planning processes ensures that the implications for environment are taken into consideration before any decision is made. The EIA-process always starts with the EIA-program being prepared. This happens according to the rules on "Notification and suggestion for the EIA program" in PBL §4-2 and chapter 4 of the EIA-regulation. For projects and plans that are covered by the requirements for notification, a notification shall be prepared as early as possible, with a proposal for a program for assessing possible impacts of the project or plan. The proposal shall account for the plan, any need for studies and arrange for public participation. The notification with a proposed EIA-program shall be sent for consultation and submitted for public inspection before the program is determined.

This notice, and more importantly the suggestion for an EIA program is supposed to contain the information listed below, according to the EIA regulations §14.

a) The plan or measure, the intended area, and any issues that could in the particular case can be considered important for environment and society
b) The conditions that according to chapter 5 are to be investigated, and which methods are intended to be used to obtain the necessary knowledge
c) Relevant and realistic alternatives and how these are to be assessed in the environmental impact assessment
d) The planning or application process, with deadlines in the process, participants, and a plan for participation from particularly affected groups and others

After the notice has been sent to NVE, the next step is to determine which EIAs are to be made, according to the EIA-program, which then becomes the template for the finished EIA. The suggestion is, as per regulation, made available for public scrutiny during a hearing period, where feedback is also collected and used to steer the future process. The EIA-program should be determined within ten weeks of the hearing periods end, and those who have submitted statements are to be informed on the result of the process. When presenting the finalized EIA-program, NVE has to make an account of all statements given during the hearing period, how these has been assessed and maintained in the EIA program (EIA regulations §16). NVE has the right to stop the further processing of the case, by determining not to decide on an EIA program, but this decision must be accounted for[9] (Fauchald, 2018, p. 39).

[9] There is no separate category for such cases in NVE's archives of wind power licence applications. Some projects are listed as "message withdrawn", "application suspended" or as "application withdrawn". In practice,

Requirements for the content of EIAs appears from the EIA regulations, chapter 5, and partially detailed specifically for wind power projects in NVE's guideline for wind power (NVE, n.d-b). The EIAs content and scope "should be adapted to the relevant plan or project and be relevant to the decisions being made"[10], "should be based on relevant and accessible information", and if the information on important matters is lacking, "the information will have to be obtained" (EIA regulations § 17). The developer is free to choose who gathers the information and makes the reports but are required to follow the specified EIA-program. Relevant information is obtained to a large extent through the hiring of consulting agencies (who are required to have the professional qualifications and integrity to correctly investigate of the impact on that specific theme), on-site inspection, and collecting pre-existing information (E.g., maps of the existence of cultural heritage sites, valuable landscape, important areas for outdoor life or important infrastructure that might come into conflict with the projected wind power plant). It is important to note, that some themes have their own specific guides and acts providing the background for their assessments, an example being that all impacts on nature are to be assessed by the principles of Norway's Nature Diversity Act (OED, 2016, p. 51).

The EIAs are usually submitted in a series of individual technical reports on each theme. How these are assessed, are described closer in the methods. These individual reports are then compiled into a complete EIA detailing all the researched impacts that the wind power project is projected to have. According to §17 of the EIA-regulation, the developer is supposed to make a "non-technical" summary of the EIAs and present it in the project application. The Norwegian Environment Agency was tasked to review how the licensing system for wind power projects have operated in terms of environmental considerations by the Ministry of Climate and Environment. This report found that the summarizing of the results from the EIAs in a standardized and systematic way would have given a better basis for comparison, both within and between projects. Some systemics have been taken from the Norwegian Public Roads Administration (2006) handbook 140 (which is now updated to V712), but that there is not provided a standard layout for the environmental impact summaries for wind power projects.

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it appears that NVE prefers to encourage applicants to apply the project pending or withdrawing the application rather than deciding not to determine the EIA programs. It seems that more than two out of five wind power projects registered with NVE have been terminated on the basis of informal case processing (Fauchald, 2018).
[10] Which indicates that the EIAs are intended to be individual in nature, and that they assess local themes that are of importance in the geographical area of project they are assessing.

This report also did an assessment of the thematic conflict assessment system (TKV) implemented by NVE, which is a system used to assess themes of particular interest in addition to that of the EIAs reports organized by the developer. The following themes were assessed according to the TKV system:

1. Reindeer husbandry, which is assessed by the Reindeer Husbandry Management.
2. Defence purposes – Any conflict assessment of impacts to the Norwegian armed forces are carried out by the Norwegian Defence Estates Agency.
3. Environment and cultural heritage sites - the conflict assessment is carried out by the Norwegian Environment Agency and the Directorate for Cultural Heritage.

The purpose of the TKV system was to make it easier to select projects with low amounts of conflict to these themes and identify the projects with early signs of significant conflicts. This was achieved by involving agencies for specific themes that do their own assessments on the side of the EIA assessments (Norwegian Environment Agency, 2015, p. 28). The TKV system was implemented in 2005, and partially discontinued by the Directorate for Cultural Heritage due to lack of influence in the process (Norwegian Environment Agency, 2015, p. 29) but fully discontinued by 2016 (Fauchald, 2018, p. 42).

How these themes were assessed will be presented in chapter 3.2.2.

2.5 Additional research on the topic

The reasons behind wind power support or opposition was studied by Rygg (2012). She tried to work out if local support and opposition for wind power is associated with economic reasons and environmental concerns and NIMBYism, respectively[11]. She found that most of the arguments made in favour of wind power development addressed local concerns for economy, modernisation, and employment opportunities, not the need for sustainable energy. She also found that the opposition was not based on NIMBYism, but more complex, based on many different arguments, and that the controversies were distinct to each community. The findings indicate that "many different issues" are causing opposition against wind power, and that these are distinct for each community, showcasing the EIAs relevance to the process, as it potentially carries crucial information that needs to be accounted for before making a licence decision.

[11] "Not in my back yard" is a way of identifying resistance to wind power based on local impacts to one's own home area.

Investigating who influences the licencing process, Inderberg et al. (2019) studied formal requirements and informal practices of the licencing process for wind power in Norway. They found that changes in regulations and organisation of the licencing process, along with locating the licencing body (NVE) within a sector authority (OED) instead of generalized planning, have given the NVE considerable room for decisional discretion. This gives rise to the issue of transparency, where the grounds for the licensing outcome and the weighting of various factors are unclear, making it difficult to predict the outcome for similar projects. One of the informal practices found by Inderberg et al. (2019, p. 185), was that through the notification stage that NVE practiced informally recommendations for the developers to withdraw projects they regarded as non-feasible. This might be due to different concerns, such as grid connection problems or due to conflicts with special interests (TKVs) such as the Sami people and reindeer herding, environmental issues, or the Armed forces. While this practice makes sense from practical perspective, it reduces the transparency and predictability of NVE's decisions.

The only study that investigated the EIA in Norway was done by Inderberg et al. (2020), who did a statistical analysis trying to discover what influenced the wind power decisions in Norway. In this study they focused on two factors, the municipalities stance towards the projects, and the impact to the natural environment. The data was collected from publicly available archives at NVE and supplemented by individual inquires for each case. They found that municipalities having a positive stance towards the project was vital, as extremely few projects were granted licence against the host-municipalities wishes. In the more relevant part of their study, they investigated how the impact to the theme "Natural environment and biodiversity" of the EIA would affect a project's likelihood of approval. This theme focuses specifically on a project's consequences for local flora and fauna, representing the projects quantifiable environmental impact. By doing a multivariate logistic regression they found that "high environmental impacts" significantly reduced the projects chance of licence approval.

The study by Inderberg et al. (2020) clearly indicates that the information presented by the EIAs in wind power cases are considered when deciding if the licence will be granted or not. As this study only investigated a single aspect of the reported EIAs and did not assess all the project's reported environmental or societal impacts. As found by Rygg (2012), there are a many different issues that are controversial for wind power projects, often individual to each single case. So, while there is value in presenting proof that the consequences to nature are being considered by the NVE, it does not essentially improve our understanding of the influence of the EIA.

2.6 The Norwegian wind power policy

To better understand the questions posed in this thesis, and their consequent results, certain theoretical and political knowledge background knowledge is required. The purpose of this section is to give an introduction into that information. First, an introduction into the political goals of the Norwegian government regarding wind-power is imperative, as the different political issues might affect the guiding values used by the licencing authorities, who are the ones who select which wind-energy projects are to receive a licence, based on these assessments. For example, as the demand for renewable energy grows, it is reasonable to expect that larger consequences will be acceptable.

Since the first large (>10 MW) wind park was opened in 1998, the Norwegian licencing authority OED has granted licenses to almost 100 different projects, out of which 52 have already started production. Within the last few years onshore wind-power has had a strong growth, and in 2020 onshore wind-power produced approximately 9.9 TWh of electricity, which is a 79 percent increase from 2019 (NVE, 2020c). This growth is expected to continue further, with 14 projects being under construction (NVE, 2020a) and wind-power is expected to exceed 10 percent of annual electrical production by the end 2021.

In February 2017, the OED commissioned NVE to take the lead on a proposal for a national framework for onshore wind-power, which was planned to be a collaborated work between agencies whose areas of responsibility are affected by the building of onshore wind energy. The reasoning behind this commission was that after the introduction of the electricity certificate scheme, there has been an increased influx of wind power developers applying for licences for their projects, more than could be expected to be built, wasting resources for both the developers, grid companies and OED/NVE. Furthermore, in some cases these projects have led to significant local conflicts.

This national framework for wind-power contains two parts:

- Updated knowledge on the socio-ecological effects of onshore wind-power based on relevant studies, impact assessments, literature and already acquired experience from established wind-power plants.
- Maps proposing the most suitable regions for building wind-power in the future. The maps should be based on updated knowledge.

These areas where to be selected based on the local wind resources and existing or already planned access points to the power grid, so that no new large scale grid structure would have to be projected and built, secondarily this would then be assessed towards other important environmental and societal concerns (OED, 2017).

This framework would follow up on the recommendations made by OED on how to facilitate profitable production of renewable energy in Norway (OED, 2016). Through these recommendations the Norwegian government was pointing out the need for more guidance when choosing where it is appropriate to build onshore wind energy. According to the letter of assignment and the energy report, which stated that the main purpose of the national framework was to establish a solid foundation for selecting the best wind-power projects early in the licence application process. Another purpose of this framework was to increase the predictability of the process, contributing to a more efficient licensing process while mitigating any conflicts in the process.

The finished proposal for national framework for wind-power was published the 1st of April 2019 (NVE, 2019b). At the same day, it was also made available for a public hearing and stakeholders were invited to give feedback until the 1st of August. In the same period, there were also held six regional meetings. The public hearing was extended to the 1st of October as several of the stakeholders wanted more time to formulate their replies. At the end of the hearing, the proposal had received about 5000 responses from various agencies, municipalities, and county councils. The majority of replies came from individuals (OED, 2019a).

Most of the feedbacks where critical to the method of highlighting suitable areas for wind-power, fearing that their municipalities and home areas would receive additional interest for wind-power projects. These responses led the sitting government to conclude that they would not implement the national framework for wind-power in its current state, with its 13 areas considered particularly suitable establishing wind-power. The governments reason behind this decision being that in light of the replies the framework did not accomplish its goal of being conflict mitigating (OED, 2019b).

In the period before 2019 everything indicated that onshore wind energy in Norway was a developing industry (OED, 2016, p. 9), which would be facilitated for. In a report by NVE it is indicated that few new projects will be realised after 2021-2022 (NVE, 2019d, p. 15), and that the resistance to wind power makes the future unpredictable. In 2020, the government decided to restrict the licencing process for onshore wind power, and put further emphasis on local and regional anchoring of the projects (OED, 2020). However, as there has been no new projects applying for licence there is no data or information on the effects of this action.

2.7 External drivers for the wind power policy

There are many different drivers causing the increased focus on renewable energy Norway, one of them being: international and national policy regarding climate change. Norway has for a long time been in the forefront in the fight against climate change. It is one of 11 supporting nations for the first assessment report from the Intergovernmental Panel on Climate Change (IPCC, 1990). In this report it was stated with certainty that:

- "There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be."
- "Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it."

Along with many other assessments of the world's climate, the report recommended a program for the development and implementation of a global and comprehensive action towards resolving the issue of global warming (IPCC, 1990). The knowledge provided by the first assessment report laid the foundation for the United Nations Framework Convention on Climate Change (UNFCCC), which was a major step towards global cooperation against global warming and climate change. In the UNFCCC, the signatory nations acknowledged that climate change and its adverse effects was a common concern for humankind, and that human activities have led to increasing atmospheric concentrations of GHGs which have enhanced the effects of the natural greenhouse effect, warming the earth. These nations also acknowledged that the largest share of historical and global emissions of GHGs has originated in developed nations, and that these countries should carry the greater responsibility, and Norway was accounted among these. This convention did not however set any restriction on its participants but allowed for future negotiations in additional protocols (UNFCCC, 1992).

The next step for the UNFCC was the implementation of the Kyoto protocol, which was first adopted in 1997 (UN, 1997), and ratified by Norway in 2002. It is stated in article 2, 1a-iv that: “Each Party included in Annex I in achieving its quantified emission limitation and implement and/or further elaborate policies and measures in accordance with its national circumstances, such as promotion, research, development and increased use of new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies”. The Kyoto Protocol entered into force on 16th of February 2005 with no time limits. However, the emission obligations under the Kyoto Protocol were limited in time, and through this agreement Norway committed to cut their GHG emissions compared to the emissions from 1990, which was used as a base year. Through the Kyoto protocol Norway specifically committed to emitting 10% less GHGs in the first period, from 2008 to 2012, and then recommitting to emit 18% less GHGs in the second period from 2013 – 2020 (Prop. 173 S, 2013).

The third step for the UNFCC was the Paris agreement, which was ratified by Norway in December 2016. Which was the first legally binding international treaty on climate change. The main points of the agreement are the following:

- All countries have obligations to cut greenhouse gas emissions.
- It is agreed to limit global warming to 2°C, preferably no more than 1.5°C.
- Countries must draw up a plan for emission reductions and must report emission reductions and new targets.

Through the Paris-agreement, Norway, in cooperation with the European Union (EU), committed to a goal of achieving at least a 40% reduction of GHGs by 2030 compared to the 1990 level, where five prioritized areas for enhance climate policy efforts were presented, one of them being “renewable energy” (UNFCC, 2016). EU is an important actor on the stage of environmental politics, and an important partner for Norway. This relationship was formalized the 1st of January 1994, when Norway joined the European Economic Area (EEA). Through this agreement, Norway became obliged to follow EU’s environmental rules and policies, which has had a major influence on Norwegian environmental regulations and policies, as it can be assumed that 80% of the Norwegian legislation on environmental issues have their basis in EU legislation through the EEA agreement. The EU set a goal towards reducing their total GHG emissions by 85 – 95% compared to 1990-levels. To do this they set a goal to have 32% renewable in the energy sector, while also achieving 32,5% energy efficiency by 2030, aiming for a 55% cut in their total GHG emissions (KLD, 2020).

In 2009, Norway committed to a goal that within 2020, 67,5% of the energy produced in the Norwegian energy sector should be renewable. A measure to achieve this Norway entered a cooperation with Sweden, creating a support scheme for the increased production of renewable energy, this was called the El-certificate arrangement, or more popularly, the "Green Certificates". This cooperation was to ensure increased production of electrical energy from renewable sources, which in Norway lasts to the end of 2021. The way this arrangement works, is that power producers and other consumers are obliged to purchase green certificates, and new renewable energy producers will gain one green certificate for each MWh of renewable energy produced, making an extra incentive for electricity producers to invest in new renewable energy (OED, 2011; 2014).

3. Method

This chapter gives an account of the methodological approach used to answer the research questions, beginning with a presentation of the study design and data material used in the study, followed by a description of how the data was collected and a general explanation of the EIA and the themes included in the study. Thereafter, a definition of the selection of data used in the analysis, why it was used, and present the variables used in the analysis. Finally, I present the analytic approach and the statistical methods used. I will also present how I assessed the model's ability to explain the variation in the data material.

3.1 Study design

This study's purpose is to examine how a wind power projects reported social and environmental impacts influences its chances of receiving a positive licence outcome. As the licencing process is complex, and the decision possibly being influenced by a large range of different factors, I found it necessary to isolate the EIA scores for each wind power project and investigate whether there is a relationship between highly negative reported impacts and the projects' licence decision. As the aim of this study is to identify relationship between a dichromatic response variable (licence decision) and a series of explanatory variables. As such, the best way to answer my research questions was by performing a logistic regression.

3.2 Data material

The study design is based on the collection of information on all processed wind power projects between 2000 – 2020. For each of these projects I collected two main pieces of information: the licence decision and the projects' reported EIA scores for all available thematic reports. NVE is responsible for making this information publicly available, which is therefore available from NVE's web-archives as a part of each project's case file (NVE, 2021a).

3.2.1 Collection of general project information and licence decision

The licence decision can usually be found in the summary of the case files for each project, as project status or a short summary of the case proceedings, but the information itself usually originates from one of two documents. The first is the reply from NVE, which gives a detailed description of the processing of the specific project and presents the assessments NVE has performed in order to form the basis of their decision. In the event of any complaints or objections to the case proceedings, the decision made by NVE must be re-evaluated, and the final decision can be found in OED's appeal decision. In this document, OED usually summarizes the complaints, objections, and any new information, using this to re-evaluates NVE's decision based on this information. OED might overturn NVE's decision, support it or in some cases changes the terms for the licence given.

The data collection had to be done manually, by systematically going through each wind power project applied for in Norway and the information about the wind power projects are available using NVE's web pages (NVE, 2021a). I simplified the data gathering process using the archive's search bar in order to create a excel sheet listing all processed wind power projects that would potentially be usable in this study. All the projects contained in this list came attached with some preliminary data, mainly: Application ID, name of the project, name of the applicant, geographical area, applied potential power, applied electricity output and project status. This list was then used as the starting point for my data collection.

The resulting list contained 253 projects[12], where 151 had received a licence decision while the rest had stopped somewhere during the licence process[13]. Of the 151 projects, two projects[14] were processed before the year 2000 and as such fell outside the scope of this study. I expanded and corrected the project-list by adding any relevant information found when reading through the applications, replies and EIA reports. This was usually information on already built power plants, the applied number of turbines, the date of application, the date of the licence decision, if the EIA is available etc. The full list is displayed by table 2.

Table 2: Data categories and definitions in the licence datasheet.

No.	Label	Description	Format
1.	**Name of project**	Name of the project, for identification purposes	Text
2.	**Developer**	Name of the project developer.	Text
3.	**County**	Name of the region where the project is applying to build.	Text
4.	**Municipality**	Name of the municipality where the project is applying to build.	Text
5.	**Application ID**	Used as a unique identifier for each project and as a key to link information from other databases (e.g., NVE's map services).	Number
6.	**Applied power output**	Power output in MW that the developer is aiming for.	Number

[12] The 102 projects that stopped before receiving a licence decision were not investigated further.
[13] I will further expand upon this in chapter 3.3.1.
[14] Træna & Sandøy (Harøy), where the Træna project was rejected and Sandøy approved. Neither project would have been usable in any further analysis.

7.	**Applied electricity production**	Total yearly electricity production the developer is applying for.	Number
8.	**Date applied**	Date when the full application with an accompanying EIA was submitted.	Date
9.	**Date rejected**	Date when the project was rejected, either by NVE or OED.	Date
10.	**Date approved**	Date when the project was approved and received a licence to build the wind energy facility.	Date
11.	**Progress**	Progress of each project divided into "Built", "Being built", "Being planned" or "Rejected".	Text
12.	**State of application**	If the application is accepted or rejected	Binary response
13.	**EIA**	Status of EIA in the report divided into "Usable", "Not usable" & "Not available".	Binary response
14.	**Complaints**	If the project has received any formal complaints, involving OED in the decision-making process.	Binary response

3.2.2 Collection of environmental impact assessments (EIA)

There is, as far as I have found, no other way of collecting the EIAs from the wind power licencing process other than through manual extraction from the EIA document. These EIAs are typically divided into sections, also called "thematic reports" or themes, covering a project's potential consequence for the surrounding environment. Most of the thematic reports cover "non-priceable" themes and they are usually assessed according to chapter six of the handbook for impact assessments by the Norwegian Public Roads Administration[15] (Norwegian Public Roads Administration, 2006, pp. 133-228). This handbook uses three central terms to describe, assess and analyse non-priced environmental impacts, and these are *value, scale,* and *impact.* The word *value* representing the assessment of how valuable an area or environment is. *Scale* representing an assessment of the size and degree of change an area is subject to, and the *impact* being the combined assessment of both value and scale.

A typical assessment according to this method is supposed to look something like this:

1. The current status of the investigated theme is to be presented. The status is presented in a value-neutral and fact-based review. This forms the basis of the assessment of the value and scale of the impact.
2. The investigated theme's value is presented, based in its quality and function.

[15] The current version is V712.

3. The scale and effect of the impact is reviewed, explaining how and to what degree the investigated theme is affected by the wind power project development.
4. Grading the consequence according to the scale and effect impact compared to the value of the impacted theme.

The EIA grading system

The grading of the consequences uses a matrix that divides the impacts into a range of nine discrete values from very large negative (-4) to very large positive (+4), with no impact in the middle of the scale (0) (see figure 2). These numbers are then used to signify and simplify the project's impact on that specific theme and are in this thesis used to represent the EIA statistical analysis. As these thematic reports contain large amounts of information and assesses the impacts of a range of different aspects within a single theme, e.g., the impact on a species of bird or how visible the wind turbines will be from a village, the data collected from the EIAs were the final conclusion reported for each theme.

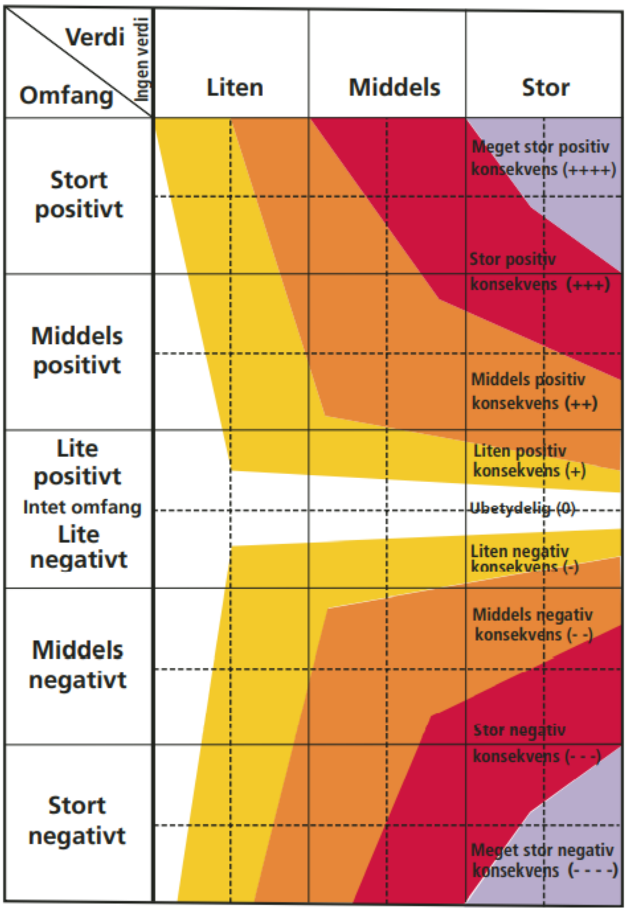

Figure 2: The impact-matrix used when assessing the impact of themes in the EIA (Norwegian Public Roads Administration, 2006, p. 142).

As mentioned in chapter 2.4, NVE has also utilized another system for assessing environmental impacts, the thematic conflict assessments (TKV). While I have not collected the individual assessments made for each themes using this system[16], some EIAs reported the impacts according to the TKV system[17], which use a different scale than the (+4) / (-4) system, and instead uses a A-E system, with the different letters representing different impacts scales (NVE, 2009).

[16] As it is outside the scope of this study.
[17] Impacts to defence was mainly reported according to the TKV system.

- A represents no conflict.
- B represents a small conflict.
- C represents medium conflict where it's possible to mitigate by small changes to the project, like removing or repositioning a small number of wind turbines.
- D represents a significant conflict, which is possible to mitigate with larger changes to the project, like removing or repositioning several wind turbines.
- E represents a very significant conflict, which is impossible to mitigate regardless of the changes made.

The TKV system has been in use since 2005, and several EIAs has been evaluated according to this system, and some themes[18] even utilize this system when reporting the EIAs, it presented a small problem for statistical analysis. To be able to compare the themes assessed with the TKV framework, the assigned TKV scores were converted to the following numbers in accordance with the consequence matrix previously showed in figure 2.

- A was converted to 0 (No conflict)
- B was converted to -1 (Small negative impact)
- C was converted to -2 (Medium negative impact)
- D was converted to -3 (Large negative impact)
- E was converted to -4 (Very large negative impact)

The main difference between the TKV scale and the impact matrix is that the TKV scale only has no impact and negative impacts, while the impact matrix has both sides of the spectrum. As most of the assessments are for negative impacts, the merging of these two types of assessment systems did not cause any troubles in the analysis.

When collecting the EIAs, I used the licence datasheet as a guide, making a list of all the projects where a licence decision was reached. The first place I looked were the licence application itself, as it usually contained a summarized version of these in either the summary of the application itself, the introduction of the application or in the bottom of the application. Although the methods and quality of the reports vary, so in most cases I ended up reading the entire EIA chapter and collected the EIA values directly from the assessments in each chapter and not the summarized versions. In the end, my EIA sheet had 16 different main themes, but

[18] Mainly reported for impacts to defence.

as some of these were assessed differently and many themes were assessed with the use of sub-themes (Norwegian Environment Agency, 2015), the result was a total of 37 EIA themes.

The EIA themes found during the data collection are shown in table 3 below, and afterwards explained in detail in chapter 3.2.3. Note that this table also describes which variables the themes were grouped into, which will be important information for chapter 3.5.

Table 3: EIA themes and variables found during the data collection.

Theme:	Represented by variable:	Description:
Landscape and visual impacts	**Landscape**	The effects of the wind power facility on the landscape (how visible the wind turbines and roads are) are assessed.
Cultural heritage **1.** Direct impact **2.** Indirect impact	**Culture**	The direct and indirect impacts to cultural heritage are assessed.
Outdoor recreation and travels	**Recreation**	The impacts direct and indirect impacts to areas used for outdoor recreation and travel are assessed.
Natural environment and biodiversity **1.** Flora **2.** Fauna **a)** Birds **b)** Other fauna **c)** Wild Reindeer **d)** Marine environment	**Nature**	The impacts to the different types of flora and fauna are assessed, usually for each separate category or species in the area.
Icing	**Physical**	During certain conditions with high air pressure and freezing temperatures or during sub-cooled rain, ice can form on the blades of the wind turbines. This theme assesses the risks of harm and the potential loss of production.
Noise	**Physical**	Assessing the expected sound level produced by the rotating wind turbines and how they affect neighbouring buildings sensitive to noise.
Shadow casting	**Physical**	When the sun is low in the sky, the rotating blades from a wind turbine can create pulsating shadows which can be experienced as annoying for people living close to the wind turbines. The number of hours expected for buildings and areas sensitive to this is assessed.
Reflective flash	**Physical**	The turbines blades can sometimes reflect sunlight, causing reflecting flashes, which can cause disturbance to neighbours and livestock. The potential for this effect causing annoyance for neighbours are assessed.
Pollution and Waste	**Pollution**	Building a wind energy facility requires heavy machinery, using fuel and oils. Accidental spills of these substances can damage the environment. The potential for accidents and spills is assessed together with mitigating factors.

Drinking water	**Pollution**	Water sources could potentially be contaminated by runoffs from the construction-phase, or any accidental spills from the machinery. The value and impact to nearby water sources are assessed.
Non-invasive nature areas and conservation interests **1.** Non-invasive nature areas **2.** Conservation interests **3.** Conserved watercourses **4.** Public plans	**Protection**	Non-invasive natural areas are all areas that are more than one kilometre as the crow flies from the nearest heavy technical encroachments. Conserved areas are often of very high value and therefore any human interventions in these areas must be accounted for, current and planned natural reserves are usually directly avoided, but can sometimes be affected indirectly. The potential loss/conversion of these areas area mapped, evaluated, and assessed.
Land use **1.** Agriculture **2.** Farming **3.** Forestry **4.** Fishery **5.** Boat traffic **6.** Reindeer herding	**Land use**	Potential areas to produce wind energy are sometimes already in use for other purposes, and the building of a wind energy project could impact these in several different ways. The loss of areas used for other purposes are assessed.
Defence interests	**Sector**	The building of a wind energy installation might cause conflicts to existing or planned defence installations. The potential conflict and mitigation measures are assessed. This is most often assessed using the TKV scale.
Aviation /Air safety	**Sector**	Wind turbines are large obstructions that can cause trouble for low-flying air traffic, especially air ambulances and helicopters. The potential for conflict with aviation are assessed.
Telecommunications	**Sector**	The wind turbines can act as obstacles, causing disturbances for telecommunications the potential for conflict with telecommunication is assessed.
Societal effects **1.** Municipality finances **2.** Employment/Value creation **3.** Tourism/Travel	**Society**	Societal effects usually explain how the wind energy facility potentially effects the society around them, other than being a source of power. The potential societal effect of the building and operation of the wind power facility is assessed. Municipality finances and employment/value creation are the only themes that are consequently assessed as "positive".

3.2.3 Definition and commonly used assessment processes of the EIA themes.

To explain how the different EIA themes are being assessed, I used the licence replies from NVE as a basis for these explanations. I acknowledge that there is newer documentation available for these assessments, but reason why I chose not to include them is that they were published in the period 2018-2019 as a part of the framework for wind power (NVE, 2021b) and that they could not have been used as the foundation for the assessments of the EIAs in my dataset, and are therefore they are not considered relevant for this study.

Landscape: In 2004, Norway ratified the Council of Europe's Landscape Convention, which defines landscape as follows; "*Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors* (Council of Europe, 2000, p. 3). An important aspect of this convention is the emphasises it puts on the individual's experience and valuation of the landscape, and the importance of safeguarding landscape values. The individuals experience of the landscape will depend on factors such as attitudes, knowledge, and socio-cultural conditions. The convention is contributing to raising awareness about this aspect of wind power development, and how the individual should be involved in the discussion about landscape changes.

Wind turbines require large areas and are often located exposed in the terrain. When assessing the wind power plant's effect on the character of the landscape, it is usual to use the distance to the wind turbines and the characteristics of the landscape as a starting point. The dimensions and details of the wind turbines can be clearly perceived from a distance of two-three kilometres. Within this distance, the wind turbines will have a clear imprint on the landscape character. At longer distances, so two-three kilometres to about 10-12 kilometres, the wind turbines will be perceived as a clear landscape element and will affect one's perception of the landscape. Within this distance, local topography, elements of vegetation and visibility will influence the visual impression of the turbines. At larger distances than 10-12 kilometres, the visibility of the turbines will depend, among other things, on the visibility (NVE, 2012, pp. 35-36).

The visual impacts to these points of interests are then often explained and assessed with the impacts being compiled in a table, where an overall consequence for landscape will be made. The experience of the wind power plants visual effects in the landscape will depend on several factors; how much of the field of view the wind turbines covers, the number of visible wind turbines, the viewer's position in the landscape, climatic conditions, and any effects of shadow casting. The factors that are important for the individual wind power plant will vary depending on site-specific conditions like the spatial structure of the landscape. Natural direction of view will also be important for the experience of the wind power plant, also for affected buildings in the wind power plants immediate areas.

Cultural heritage: Wind turbines add a modern element to the landscape, which in turn changes its character, influencing the experience of the area and the understanding of its historical dimension. Cultural heritage sites and cultural environments are landscape elements who are vulnerable to changes and interventions in the landscape. Special considerations are therefore required in advance of any decision to build and operate wind turbines in the surrounding area and are protected by the Cultural Heritage Act. These are clearly defined in the Cultural Heritage Act §2 as *The term «archaeological and historical monuments and sites» is defined here as all traces of human activity in our physical environment, including places associated with historical events, beliefs and traditions* and *The term «cultural environment» is defined as any area where a monument or site forms part of a larger entity or context* (KLD, 1978, p. Section II).

A wind power plant with its associated infrastructure can have both direct and indirect impacts on the cultural heritage sites and cultural environments. The direct impacts of a wind power plant on cultural heritage sites and cultural environments are linked to measures taken within the planning area or along routes for power lines and roads. These direct impacts are mainly cultural heritage sites being either physically damaged or removed in such a way that the values related to them are reduced. Such direct interventions can mainly be avoided by changing the building solution in the shape of moving turbine and road placements.

When planning a larger project, the developer is also, according to the Cultural Heritage Act §9, obligated to investigate if there are any protected heritage sites[19] in the area. If there are found protected cultural heritage sites either within the planning area or in close vicinity of the wind turbines, the development can be considered as changing, reducing, or spoiling their values. How the project impacts these sites depend on the type of cultural heritage sites and cultural environments in question, the characteristics of the landscape, distance to the wind turbines and the degree of visibility. These assessments are usually done by collecting information from public databases, oral and written sources and through physical inspections of the area. The evaluation and scale of the impacts are done according to the guide published by The Directorate for Cultural Heritage (2003).

[19] This includes all cultural heritage sites that are dated to the year 1537 and older, including buildings built before 1650 and all Sami cultural sites older than 100 years.

Recreation: Outdoor recreation was in St.meld. nr. 39 (2001) defined as *a stay in the open air in leisure time with the intent to change environments and experience nature*. The goal of the outdoor recreation policy has in recent decades been to promote outdoor recreation for everyone, both in daily life and in harmony with nature. The value of outdoor recreation for health and well-being is fundamental in this recreational policy in the same way the right to public access; the right to roam and reside in the open country constitutes a foundation in the Norwegian outdoor tradition.

Establishment of a wind power plant will affect for the exercise of outdoor recreation as a result of changed land use. The outdoor recreation experience will also be affected by the visual impression, noise, and shadow casting. In addition, the accumulation of ice on the turbine blades can at times mean that access to areas in close vicinity of the wind turbines are restricted due to danger of ice chunks being thrown from the blades. The impacts on outdoor recreation can be connected to, among other things, landscape, cultural heritage sites/cultural environment, and tourism. While the establishment of wind power will most likely affect outdoor recreation in a negative way for many, the establishment of internal roads can increase the accessibility of the area for people with reduced mobility by providing easier access routes recreational areas.

Nature: Wind turbines, like other technical installation electricity production, will affect biodiversity. Roads, power lines, and turbines act as unnatural barriers erected through a natural environment, which causes fragmentation. Experience gathered from earlier projects shows that the building of wind turbines affects biodiversity, including birds, other fauna, and vegetation in many different ways. With regard to flora, it is the change in hydrological conditions resulting from construction work and roads which has the possibility of causing the greatest changes in relation to the original state of vegetation in the area. The effects on direct degradation of biotopes by occupying the area are usually small, depending on if there are any endangered plant species and habitats in the vicinity.

Both nationally and internationally there has been an increased focus on the effects that wind turbines have on birds, both in terms of collision risk, degradation of important biotopes (nesting areas), and disturbances which could cause displacement from the area. The risk of bird collisions will depend on the species living in the area, the function of the area, and how the wind turbines are located in the terrain. Direct intervention in areas with nest sites for red-listed species and species of responsibility can sometime be avoided by adjusting or removing turbine placements. It was stated by NVE that the effects of wind turbines on birds were quite uncertain, but that there were several research projects underway. This theme has been much research in years after this, an example would be the Norwegian Institute for Nature Research (NINA) investigation on the functional habitat loss for migratory soaring birds and their development of a micro siting tool to model thermal updrafts used by soaring raptors (Marques et al., 2019; Hansen et al., 2020).

The effects of wind turbines on other fauna are assumed to be temporary and modest. In Norway, there has been studies on the effects of wind turbines on deer, which showed that deer are negatively affected mainly during construction work. Over time, this species adapts to the physical encroachments (NVE, 2012, p. 45). Effects to wild reindeer are also sometime assessed, with the same assessments as for other fauna being made, with the addition of grazing areas and migratory patterns being evaluated.

In some cases, the wind power project is placed in coastal areas and the construction of this project requires roads between islands or other actions that might affect the marine natural environment. Roads between islands could potentially impact marine species by changing the ocean current, and as such the impacts of these actions needs to be assessed.

The impacts to nature are often assessed in two main parts, the impacts to flora, and the impacts to fauna, with these themes being divided into subgroups based on the flora/fauna found in the area. The species inhabiting the area are usually mapped using databases and reported sightings, the species found are then categorized and the impact to each is calculated, sometimes as the impact to nature as a whole, or sometimes for each affected theme.

Icing: Icing on the turbine blades occurs mainly during periods of high humidity with temperature falling to 0°C or below. The ice is formed when subcooled water droplets collide with the rotor blades and freeze on impact. The accumulation of ice can lead to reduced power production from the wind turbine and dangers in form of chunks of ice being thrown from the rotating blades of the wind turbine. The danger of icing can in most cases be minimized with the wind turbines being stopped in the periods when these conditions occur, and/or that the turbines are placed further away from areas that are trafficked or populated.

Noise: Noise is defined by Ministry of Climate and Environment as unwanted sounds, and what are perceived as such might vary. Wind turbines produce noise in two different ways.

1. Mechanical noise generated by the generator and gears inside the turbine hub.
2. Aerodynamic noise produced from the turbine blades moving in the wind.

The mechanical noise from modern turbines has in recent years been significantly reduced and are in most cases negligible, so the main source of noise from a wind turbine are normally the aerodynamic noise produced by the movement of the air across the turbine blade.

Most wind turbines are in operation at wind speeds between 4 and 25 m/s (see figure 3). The noise from the wind turbines increases with the wind strength, but so does the background noise of the wind itself. At wind speeds above about 8 m/s, the background noise from the wind will begin to become the dominant source of noise. Therefore, at higher wind speeds the noise from the wind turbines will be masked by the background noise from the wind. The noise is most audible at a wind speed of around 8 m/s, and it is common to use this wind strength as a starting point in noise calculations. Factors such as distance, wind direction, weather conditions and topography will be decisive for the actual noise level.

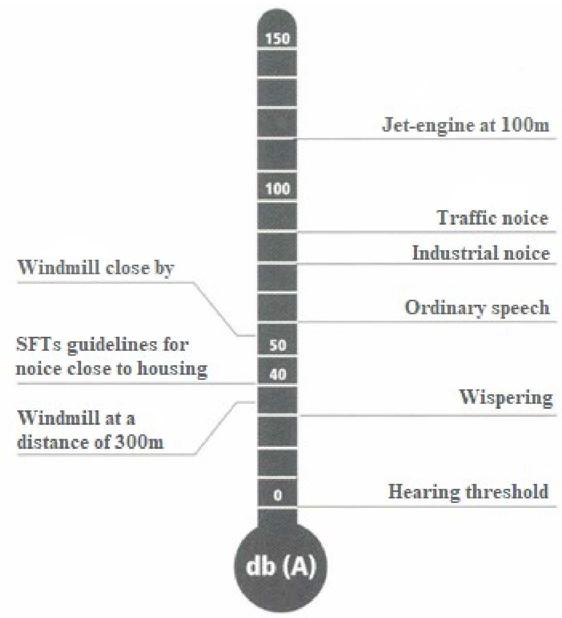

Figure 3: A scale of noise levels from known sound sources in relation to that of a wind turbine, adapted from Selfors and Sannem (1998).

This impact can be assessed by calculating the amount of noise (in dB's) produced by each turbine and the distance and terrain between the turbine and neighbouring houses, calculating the noise being heard from each household in the vicinity of the project. The threshold for noise is 45 dBA for all buildings used for housing (KLD, 2014, pp. 206 - 208).

Shadow casting: At certain circumstances, the wind turbine could be in a position in between the sun and neighbouring house. When the blades rotate, they sweep in front of the sun, throwing a moving shadow that will be projected towards the viewing point in a repetitive pattern. In part, one will experience this as a sweeping shadow over a surface. But in some cases, this is perceived as rapid changes between direct light and short "flashes" of shadow.

If the wind turbines placement, height, and rotor diameter is known, it is possible to do a theoretical calculation of the expected amounts of shadows cast by the wind power facility. Usually, the calculations are done using two different scenarios, worst case, and actual shadow casting. The worst-case scenario does not account for the actual number of solar hours or the angle of the sun, which are factors that are used when calculating the actual hours of shadow casting in addition to statistics on solar data and weather conditions.

The way this theme is usually assessed is by using computer software to calculate the amount of time shadow casting occurs for each household in the project's general vicinity. While there is no set limit for what is acceptable for shadow casting in Norway, NVE recommends that buildings with uses sensitive to shadow casting are not exposed to more than eight hours of actual shadow-casting per year, more than 30 hours of theoretical shadow-casting for per year, and that the calculated shadow casting does not exceed 30 minutes per day (NVE, 2014c).

Reflecting flash: Reflective flashes can occur when sunlight reflects from the turbine blades. The turbine blades are produced with smooth surface to provide optimal production and repel the accumulation of dirt. From experience, reflective flashing from wind turbines is a rare occurrence and that normally, the reflective effect from the wind turbines is halved after the first year of operation.

Pollution and waste: The construction of a wind power facility the requires the use of heavy machinery and other tools. These usually need fuel and other chemicals that could be damaging to the surrounding environment if spilled. The turbines generator uses oils as lubricants, which could potentially spill in an accident, although this is in most cases considered highly unlikely. The bulk of the waste from a wind power facility is produced during the construction period. This theme is assessed by accounting for all possible pollution and any consequences of an eventual accident, the waste produced and how its disposed of. This theme is usually more important topic for the environment-, transport and construction plan (MTA) containing a detailed plan for the waste management that a wind power developer must follow during the construction phase.

Drinking water: Often assessed alongside "Pollution and waste", the wind power facilities possible impact on drinking water sometimes gets special attention, especially if the parts of the planned construction areas is within a watershed of a source of drinking water or hydropower plant. The impacts on this theme are often assessed in the same way as for pollution and waste, with the likelihood of any accidents and its effect on the watershed, locating any water bodies the project where the eventual spills and pollution would accumulate.

Non-invasive nature areas and conservation areas: According to the then Directorate for Nature Management, non-invasive nature areas (INON) in Norway are a collective term for all areas that are more than one kilometre away from heavier technical intrusions. Included in these heavier technical intrusions are wind turbines, construction roads and power lines. Non-invasive nature areas are divided into three zones based on their distance to the nearest intrusion.

- *Wilderness:* more than five kilometres away heavier from technical intrusions in nature.
- *Non-invasive zone 1:* are three to five kilometres away from heavier technical intrusions in nature.
- *Non-invasive zone 2:* are one to three kilometres away from heavier technical intrusions in nature.

Areas that are less than one kilometre from heavier technical intrusions are described as intruded upon and are therefore of lower value.

Conserved areas and watercourses are usually protected from heavier technical intrusions but can still be indirectly affected by the development of wind power as the presence of wind turbines within viewing distance which could still reduce their perceived value.

This theme is usually assessed by collecting data on invasive free nature areas in or around the planning area, using mapping software to construct buffer zones around any planned roads, turbines, and powerlines, and using these to calculate the subsequent loss of non-invasive areas. Conserved interests and waterways also accounted for, evaluated and the perceived impact on these are calculated in turn.

Land use: Agriculture can sometimes be affected by the building of wind energy, not so often by the turbines themselves but the roads. Most often this affects outfields and pastures as these are the very common in the same area's potential for wind energy installations. While roads can negatively impact land use interests by occupying large areas, they can also make the areas more accessible, which can be a positive impact. The same information is also found to be true for impacts to forestry.

In some cases, fishery could potentially be affected by projects built close to the ocean, as wind energy structures often are imposing markers in the landscape, as they often are visible at all hours with lights marking their location.

Wind energy installations can obstruct and lay claim to areas traditionally used for reindeer herding, obstructing their migratory paths, this can cause disturbance for both people and animals (NVE and Reindriftsforvaltningen, 2004). This theme is regarded of special interest by the NVE and as such is a part of the TKV assessment system.

Defence interests: Wind turbines could disturb and dimmish the effectiveness of radars and other defence installations by acting as a constantly moving obstacle. The assessment of this theme is usually done through going into a dialog with The Norwegian Defence Estates Agency, where they assess the projects impact on any current or planned defence installations. This is usually assessed using the TKV system.

Aviation / air safety: Wind turbines are to be regarded as aviation obstacles for low-flying aircraft and helicopters. This theme is often assessed by Avinor through contact with the developer, with them assessing the possible obstructions and dangers a wind power project could pose for air traffic and radar systems in the area.

Telecommunications: This is usually assessed by contacting the broadcasting companies in charge of tele/radio communications in the area, and through dialog with them assessing how a potential project would impact the tele/ radio communications in the area by acting as obstacles.

Societal effects: Wind power development can have effects on society both locally, regionally, and nationally. These effects that are most often associated with economics and activity change, but they can also include effects of a more symbolic nature. An operational wind power facility is usually considered to have a positive effect on the surrounding area and host municipality, directly and indirectly affecting the host municipalities economy through tax revenues, employment or by the purchase of goods and services from the area. More detailed information on this subject can be found in the report "Regional and local effects of wind power development" which NVE has used as a basis for their decisions (Førde et al., 2010).

The assessment is done by evaluating how much value is generated by the project, in form of employment, tax and goods purchased in the local community. The impact on tourism and travel are usually also accounted for.

3.2.3 Weaknesses in the data

The licencing process for wind power is a complicated process. There is a myriad of issues to account for when projecting a wind power plant which is in part reflected in the EIAs. There are hundreds of different issues to investigate, evaluate and assess. All these different issues are assessed in themes and adds to the thematic reports of environmental impacts complexity and depending on the complexity of the issues make them hard to interpret and to understand the values they represent. There are many different ways of presenting an EIA, and some developers have different solutions to doing this than others (as reported by Norwegian Environment Agency (2015)), and some applications are especially complicated to interpret as they offer several alternatives for the same project, with different environmental impacts for each, adding to the complexity of their interpretation.

In a few cases, the licence was approved based on changes in the licence terms or direct changes in the project, which since there is a lack of EIA for this new solution can affect the result in a small way. As such, this analysis, I assume that all projects are either accepted or rejected based their EIAs, as I have found no solution to account for this complex dynamic.

In the start of the data collection phase, the first potential weakness became apparent. There were fewer than 149 usable cases (wind power licence applications) and as many as 37 variables (EIA themes) to consider, not including control variables such as size, year of licence decision or levelized cost of energy (LCOE). The small sample size of the dataset could potentially cause problems in the analysis of the data as the complexity of the model might exceed what the sample size allows, and patterns might be detected that will fail to be reproduced in future samples (Greenland et al., 2016).

Another problem I discovered during the data collection phase was the apparent lack of data in parts of NVE's archives. The quality of this archive varies from case to case, in most cases they contained all the needed information and more, which is the case of for example

“Ånstadblåheia wind power plant” contains both the notice, application, both the replies from NVE and OED, in addition to other project information (NVE, 2014b). In contrast to the Ånstadblåheia casefile, the casefile for “Holmafjellet wind power plant” hold the same standard, only containing a brochure of the licence application, and no additional EIA information (NVE, 2014a). There was a total of 16 cases where there was a lack of usable information, where a majority of the cases are from the early 2000s. Adding to this lack of data, many of the projects were not comparable as they were either extensions of already approved projects, research projects or smaller than 10MW, causing them to be assessed differently. In total there were 38 projects that were not comparable, causing a total loss of 54 projects from the data.

I also discovered that some EIAs were assessed using different methods than the consequence matrix or TKV scale that I use as my key to compare the process for the different projects. These assessments were made usually made with a written a text instead, explaining the consequences. A good example of this is the application and EIA for “Svåheia wind power facility” which contains very few precise assessments and uses an entirely different scale than normally used (Dalande Vind, 2007). This caused problems in the data collection phase, as it made the assessments impossible to compare to the ones using the matrix or TKV scale. Rendering the datapoint useless as it is not clear how NVE interpreted these assessments in the end. When encountering this type of problem, I first marked the assessment with a (?), I then investigated the matter further in search for any usable assessment in the text or summary, but if no clarifying information was found I marked the assessment as “Not available” (NA).

When collecting the EIA values, it becomes clear that some themes were related or overlapping. These thematic impacts are sometimes assessed together, and sometimes as a part of a “whole”. An example of this is the thematic impact assessment of cultural heritage sites and cultural environments, which are usually affected directly and indirectly by the construction of wind power facilities. In some cases the themes are assessed with one value for the direct impact and one value for the indirect impact (Norsk Miljø Energi Sør, 2005, p. 46), in some cases with only a summary value for both (Norsk Hydro Energi, 2003, p. 39) and in some cases they assess all three (Norsk Vind Energi, 2007). The problem this poses is that it presents several different ways the themes can be assessed on and must be addressed in a statistical analysis. When reviewing the applications, a pattern emerges which can be used to link the different data together into overarching themes as seen in table 3. How this was done will be further explained in the statistical analysis.

To analyse the data, consistent numbers are needed. In many cases there are inherent uncertainties in the EIAs, meaning that the assessment made consists of two values instead of one. An example being "Overall, the consequences are assessed as Large to medium negative (-3 / -2)" (Nordkraft Vind, 2011, pp. 31-32). These types of assessments were made in many EIAs, and for the theme "Landscape" this happened in 38 of the 105 available assessments, roughly in one-third of the assessments. As a statistical analysis cannot deal with two variable values for one unit, the mean value of the two assessments were used to represent the assessment of the EIA.

3.4 Variables used in the analysis

In this section the variables used in the statistical analysis is presented, starting with the dependent variable *Licence decision*, the independent variables representing the *EIAs* and the three control variables, *year of licence decision*, *installation size*, and *Levelized cost of energy*. At the end of this chapter the descriptive statistics are presented in table 12.

3.4.1 Dependent variable

The dependent variable used in this analysis is the outcome of the licence process, or "licence decision" as it will be referred to from now on. As previously stated, in order to build, operate and own a wind power plant larger than 10 MW in Norway, a developer is required by the Energy Act to apply to NVE for a licence and follow any terms and conditions given by them. This makes the licence decision an ideal indicator for investigating NVE's values, as we can assume that projects that have receive licence approval (1) are in accordance with these values, and the projects that were rejected (0) are in conflict with them.

In practice, the licence decision is more complicated than just a binary "Yes" or "No", as the decision itself may involve the project being approved with the requirement that certain conditions are met, like changes to the project size, placement of roads, turbines, or other prerequisites. Including this as a factor in the analysis would complicate it beyond that which is reasonable and needed. In this study, I assume that each project is approved according to the project information presented in the licence applications and EIAs.

Status on applications and licences

According to the archives of NVE, there has been a total of 245 licencing cases for wind power plants during the period investigated for this study. However, this number is not totally accurate as some older projects are missing and some projects are merged, making the actual number of projects 253. The two projects approved before the year 2000 are removed, making the final number 251.

Out of the 251 projects, 149 reached the stage of a formal licence decision. Out of these 97 received a licence, while 47 projects were rejected, and five projects were withdrawn after being accepted (listed separately). The remaining 102 projects were either stalled during the notification stage, application stage, the notification or application being withdrawn. These numbers are presented in table 4 below.

Table 4: Licence status.

Status	Frequency	Percentage
Licence granted	97	38,6
Licence rejected	47	18,7
Licence withdrawn	5	2,0
Notification halted	20	8,0
Notification withdrawn	60	23,9
Application halted	5	2,0
Application withdrawn	17	6,8
Total	251	100,0

As I am using the licence decision as my dependent variable, the only three categories I can use are “licence granted”, “licence rejected”, and “licence withdrawn”. I can include this last category since it fulfils the criterion that a licence decision has been made. That the licence has been withdrawn by the developer at a later moment can be considered irrelevant for this study, as these projects passed through the exact same process as the other licence applications making them comparable in the analysis, and there is no guarantee that any of the other accepted projects won’t be withdrawn by the developers in the future. The category “licence withdrawn” is beyond this point merged with the licence granted category. The remaining 102 projects is not considered in the further study and is not accounted for in analysis as they lack the aforementioned “licence decision”.

Of the 149 processed applications, over 70% of were appealed to OED, and went through the additional “appeal” stage. By breaking down the application process into pieces and showing where the different projects by application stage presents a better image on how the licence process works. This is presented in table 5, 6, 7 and 8.

Table 5: The notification stage.

Status	Frequency	Percentage
Notification withdrawn	60	23,90
Notification halted	20	7,97
Applications removed during notification stage	80	31,87

In the notification stage it can be seen that a total of 60 projects were withdrawn, and 20 projects were halted. This accounts for a total loss of 80 applications during the notification stage, which leaves a total of 171 projects. The difference between withdrawn projects is no longer being planned while halted projects might restart the process at a later date. These projects could have been stopped by NVE using informal practices as suggested by Inderberg et al. (2019, p. 187), decreasing the predictability of NVE's decision. After the notification stage and the public hearing period, the application stage is the next part of the application process which is showed in table 6.

Table 6: The loss of application during the application stage.

Status	Frequency	Percentage
Application withdrawn	17	9,94
Application halted	5	2,92
Applications removed during application stage	22	12,87

There are fewer projects are stopped or withdrawn during the application stage, but with the same results as in the notification stage. With a total of 22 projects being removed from the dataset, and a total loss of 102 projects which is roughly 40% of the wind power projects in NVE's archives, leaving a total of 149 projects that went through the decision and appeal stage. The next stage is the licence decision stage, which is presented in table 7.

Table 7: The total amount of projects receiving licences during the decision stage.

Status	Frequency	Percentage
Application accepted by NVE with no appeals	28	18,79
Application accepted by NVE; decision appealed	86	57,72
Application rejected by NVE with no appeals	14	9,40
Application rejected by NVE; decision appealed	21	14,09
Applications not appealed	42	28,19
Applications appealed	107	71,81

There are only a few projects that actually receive a definite "Yes" or "No" during the decision stage. Only 42 cases are decided by NVE alone, which is roughly one in every third case. All the rest have either received complaints, objections to a favourable decision or have contested the unfavourable decision given by NVE. The remaining 107 cases were reviewed by OED, who as stated have the final say in the licensing process. OED's decision can be seen in table 8.

Table 8: The outcomes of the appeal stage.

Status	Frequency	Percentage
Application accepted by NVE; decision upheld by OED	71	66,36
Application accepted by NVE; decision changed by OED	15	14,02
Application rejected by NVE; decision changed by OED	3	2,80
Application rejected by NVE; decision upheld OED	18	16,82
Applications appealed	107	100,0

By inspecting this table, it can be seen that OED upheld NVE's original decision in 89 cases, while the decision was changed in total of 18 cases. The impacts of appeals on the process will not be investigated further in this thesis, and all decisions will be merged into accepted and rejected applications. However, this indicates that OED places trust in NVE's decisions, and that the decision is likely to be upheld.

The remaining 149 projects and their distribution are listed below in table 9. This concludes the number of projects that have a final licence decision and are usable from the perspective of the dependent variable. For the list of applications, check Appendix B.

Table 9: Licence decision for processed wind power cases.

Status of processed cases	Frequency	Percentage
Licence accepted	102	68,5
Licence rejected	47	31,5
Total	149	100,0

3.4.2 Independent variables

As independent variables I use different socio-ecological impacts that are reported in the EIAs of the licencing process. All wind power projects larger than 10 MW are required to undertake a thorough investigation of the project's impact to its surroundings. It is the conclusion of these that will be used as this analysis's independent variables, and by using these I investigated the impact of any reported consequence of a wind power plant chances of receiving a favourable licence decision.

Status on applications and EIA

Among the projects that received a licence decision, only 95 projects contained usable EIAs, while 38 of the EIAs were unusable, due in most cases to the projects was found to either be smaller than 10 MW, experimental or an expansion of an already existing project. The reason why these projects should not be used for the analysis is that they often contain less information, but mainly that they could have received a licence on different grounds than the remaining 95 projects. 16 projects did not contain the application or EIA document, and therefore could not be used in the analysis, with no information that could be found doing additional searches from additional online sources[20]. Table 10 shows the distribution of the remaining projects EIA status.

Table 10: EIA status for processed cases.

Status of EIA in processed cases	Frequency	Percentage
Usable	95	63,8
Unusable	38	25,5
Unavailable	16	10,7

Table 11 shows the remaining 95 cases that are usable for a logistic regression. The percentage of accepted projects versus rejected projects has not changed after the removal of the projects with no or unusable EIA data, and there is still a roughly two-thirds accepted vs one-third rejected.

Table 11: Licence status of usable projects.

Status of EIA usable cases	Frequency	Percentage
Accepted	66	69,5
Rejected	29	30,5
Total	95	100,0

[20] In these cases, I inspected webpages of the host municipality and project developers for additional information.

3.4.3 Control variables – "Possible cofounders"

Looking aside from the environmental impacts a wind energy facility would have on its surrounding, it is also important to consider the economy and viability behind the wind power projects in question, as their positive impacts should outweigh the negative impacts. The argument being that it would make little to no sense building a wind energy facility in a location where the negative socio-ecological impacts are large while the positive socio-economic impacts remain minimal. These control variables are however expected not to have too much sway over the EIA variables, as reported by Inderberg et al. (2020, p. 7).

There are several factors other than the EIAs that may influence the licence decision. In this thesis I have chosen to focus on how economy affects the NVE's opinion of a wind power project. It is stated in most NVE replies that project economy is an important factor, and NVE normally evaluates four main factors in their project economy appraisal. Wind resources, icing on the installations, length and number of roads and the topography of the landscape. According to NVE these factors are complex and not always very precisely estimated in the application stage of the licencing process (Inderberg et al., 2020).

I rely on two proxies for the evaluation of economy, project *installation size* and *levelized cost of energy* (LCOE) for the projected locations. The first proxy is consistently reliable information found in all the licence applications (although this is sometimes changed though applications to change project installations size) and it's measured in megawatts (MW). The project's installation size can influence the EIA and licence decision directly as it reflects potential income for the local municipality but also the environmental impact – as a higher MW means more tax incomes, but most likely also higher environmental impacts. For the second proxy, LCOE, I used NVE's own LCOE map which were published alongside the national framework for wind power (NVE, 2019b). This map is explained in notes published alongside the data (Weir, 2018) and I explain LCOE closer and how the data was collected in chapter 3.4.3.1.

In addition to focusing on economy, I am also interested to investigate if learning effects, policy change, changes in capacity or other factors in additions to potential changes in licensing practices over time have statistical significance on the licence outcome. The effect of time might be direct or work through other factors like changes in EIA procedures or assessment methods, local, regional, or national attitude towards wind power. To measure this, I used the year of the application decision, obtained through the NVE archive.

There are many other factors that might influence my results that I have not included as I wished to keep my main focus on the EIAs. One of these possible controls are for example municipality stance, which were investigated by Inderberg et al. (2020) who found that only two projects was granted a licence against the hosting municipality's wishes while 43 projects where rejected, giving the municipality *de facto* veto rights (Inderberg et al., 2019).

3.4.3.1 Levelized Cost of Energy

A potentially useful element to consider when calculating the viability of a project is the "Levelized cost of energy". LCOE is a term used to explain the total costs of a powerplant divided by all the energy the plant can produce over its lifespan, the result being, the lowest electricity price the powerplant can operate with, without losing money. LCOE is stated in øre/kWh and represents the long-term electricity prices that the wind power plant must have, to be profitable at a given rate of return + operating and maintenance costs. The calculation is mainly based on quality of the wind resources and the cost of network connection is not included in the calculation.

When NVE published their suggestion for the national framework for windpower, they also publish a set of GIS map layers (NVE, 2019c). Among these where a LCOE layer covering all of mainland Norway, as shown in figure 4. My idea for the usage of this mapped data was join the table containing my data with the positioning data for each project found in NVE's map service shown in figure 5 below.

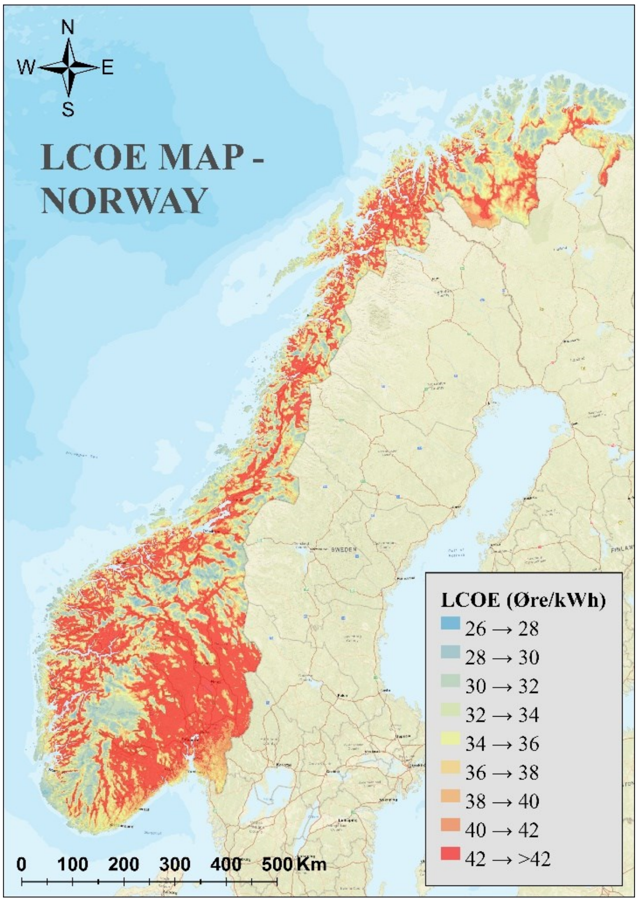

Figure 4: Levelized cost of energy (LCOE) map of Norway

The intended use for the LCOE map was to provide an overall picture of which larger areas are most suitable for future wind power development based on available knowledge on wind conditions, forest cover and terrain complexity, but it was never intended for use as a detailed planning tool (Weir, 2018).

However, if this was used as a way of selecting areas suitable for future wind power facilities placements it is interesting if the LCOE value have anything to say for the approval rating of a wind power project.

In addition to having a downloadable LCOE maps, NVE has maps over every wind energy project, which is available in their online web services (NVE, n.d-a). I downloaded the GIS point file *vindkraftanlegg* from NVE's map database. This file contained the coordinates of all wind power projects in NVE's archives, containing a total of 267 project locations. It also contained more information in its attribute table, including "Application ID" of each project. This is important, as I have already collected this kind of information during my general project information collection process, which makes me able to "join" the data I have already collected and the point file I downloaded from NVE's map database using this information.

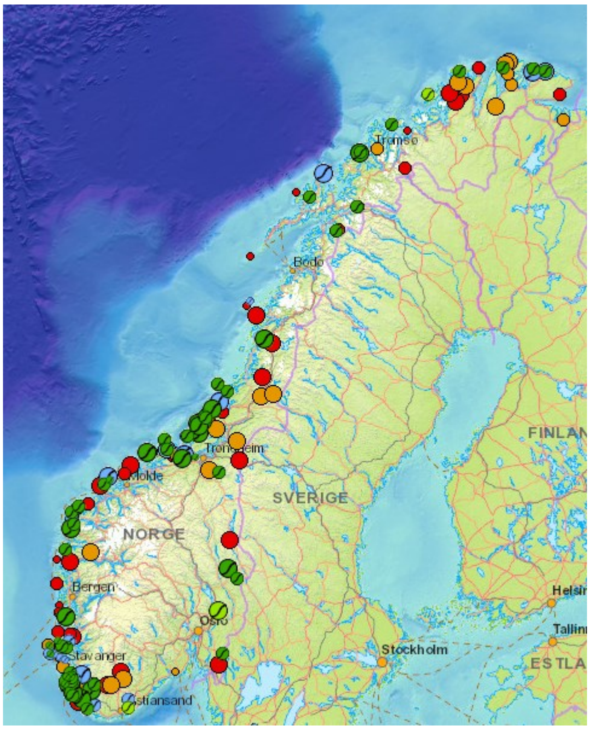

Figure 5: A cut out from NVEs map service showing all the processed wind power projects in Norway. The *dark green* points represent operational wind farms, the *light green* represent wind farms under construction, the *red* points show rejected projects, *blue* points accepted projects while the *orange* points where the licence process is still ongoing. The size of the dots represents the size of the projects in MW. (NVE, n.d-a)

I loaded a simplified version of my general information datasheet containing the "project status" and "Application ID" into Arc GIS[21] together with the *vindkraftanlegg* feature class. I joined my table together with the feature class with a simple join, using the application ID to couple the two together. The join found 135 matching records. A quick inspection of the joined projects shows that 14 projects were missing from the join, but that they all shared position or application IDs with another project. The next step was to load in the LCOE data and extracted the values from the LCOE layer into the point feature containing the wind power projects locations. The values given to the projects in this analysis were found to be between 27.7 and 40.7 Øre/kWh. The map in figure 6 shows the overall geographical distribution of the projects in my dataset, overlayed on the LCOE map the values were extracted from.

[21] I used ArcGIS PRO version 2.9.0 to extract LCOE data and produce figure 4 & 5.

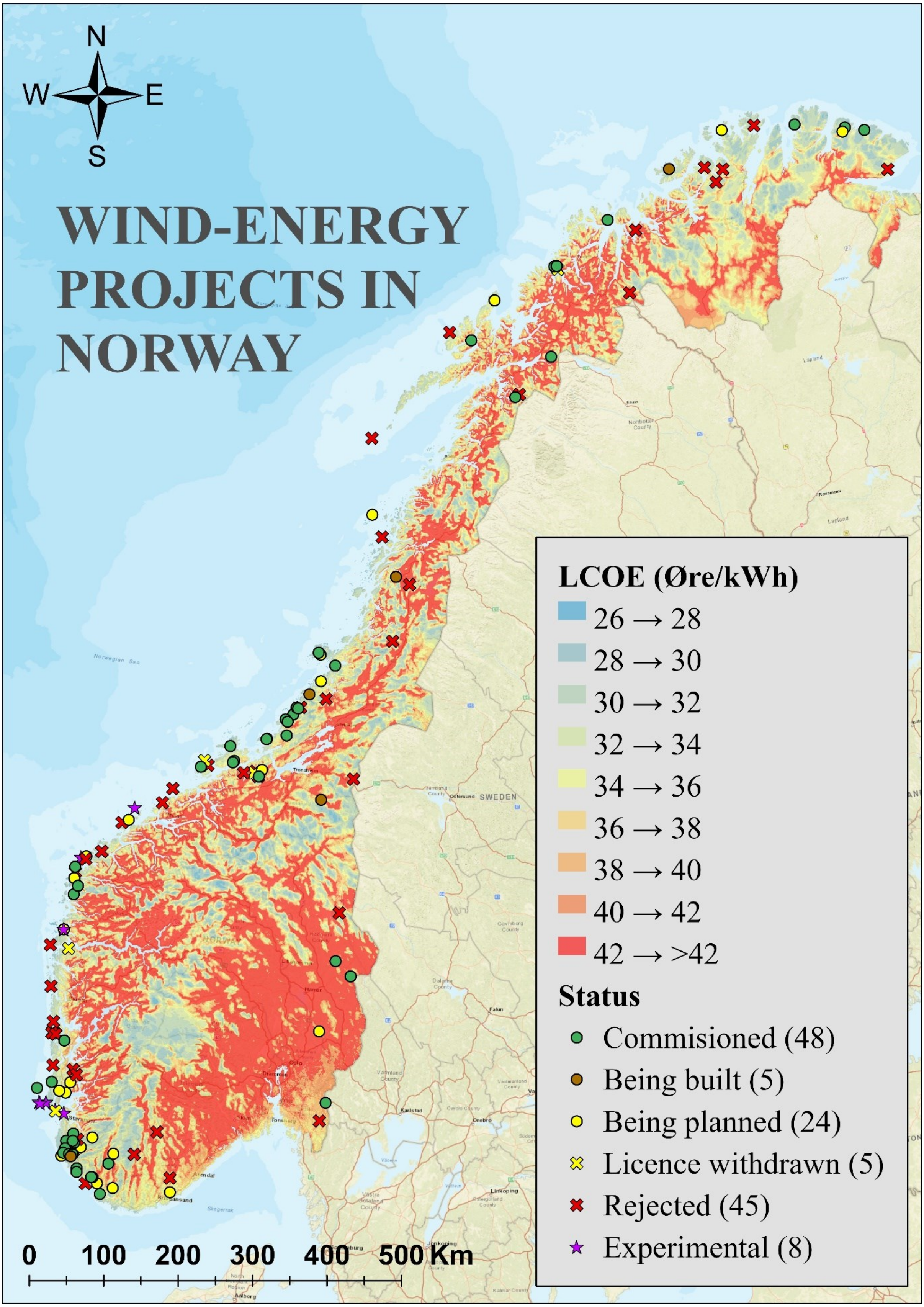

Figure 6: The levelized cost of energy for Wind power in Norway, with locations of all the projects in this study pinned

3.4.4 Descriptive statistics

Table 12: Descriptive statistics of all variables before grouping.

Variable	Observations	Mean	Min	Max	Prop 0/1
Dependent variable					
Licencing outcome	95	NA	0	1	29 / 66
Control variables					
Licencing decision year	95	2013	2003	2018	
Installation size (MW)	95	106.0	13.5	330.0	
Levelized cost of energy (ø/kWh)	95	31.9	27.7	40.7	
Independent variables					
Landscape	95	-2.18	-3.5	-0.5	
Cultural heritage	90	-1.56	-3.0	0.0	
Cultural heritage (Direct impact)	12	-0.54	-2.0	0.0	
Cultural heritage (Indirect impact)	10	-1.55	-2.5	0.0	
Recreation & travel	93	-1.73	-3.0	1.0	
Natural environment & biodiversity	47	-1.89	-3.0	-1.0	
Flora	65	-1.36	-4.0	0.0	
Fauna	14	-1.89	-3.5	0.0	
Birds	63	-1.95	-3.5	0.0	
Other fauna	56	-1.16	-3.5	0.0	
Wild reindeer	4	-1.00	-2.0	-0.5	
Marine environment	3	-1.33	-2.0	-1.0	
Icing	17	-0.15	-1.0	0.0	
Noise	72	-1.05	-4.0	0.0	
Shadow casting	71	-0.93	-4.0	0.0	
Reflective flash	50	-0.50	-3.0	0.0	
Pollution & waste	61	-0.31	-1.0	0.0	
Drinking water	42	-0.32	-2.0	0.0	
INON & Conservation	23	-1.11	-2.5	0.0	
INON	45	-1.53	-3.0	0.0	
Conservation interests	48	-0.21	-2.0	0.0	
Conserved watercourses	19	-0.13	-1.0	0.0	
Public plans	1	-2.00	-2.0	-2.0	
Defence	51	-0.43	-2.5	0.0	
Aviation	79	-0.27	-2.0	0.0	
Telecommunications	62	-0.19	-1.5	0.0	
Agriculture	76	0.08	-1.5	2.0	
Farming	19	-0.08	-1.5	1.0	
Forestry	18	0.11	-1.5	2.0	
Fishery	2	-1.00	-2.0	0.0	
Boat traffic	1	-4.00	-4.0	-4.0	
Reindeer herding	30	-1.92	-3.5	0.0	
Other land use	14	-0.96	-2.0	0.5	
Societal effects	28	1.82	1.0	3.0	
Municipality finances	34	1.79	0.0	4.0	
Employment & value creation	39	1.60	0.0	4.0	
Tourism & Travel	62	-0.15	-2.0	3.0	

3.5 Prerequisites for logistic regression

Before any type of logistical regression could be attempted, I needed to prepare my dataset in order for it to satisfy the prerequisites for logistical regression. The first problem I would have to deal with when using my data for logistical regression was the large number of NAs present. NA is an abbreviation of *Not available* and represents no data for the specified variable. This is as earlier explained due to projects being assessed differently[22].

Missing data is very important to be aware of, as statistical software will automatically remove the projects containing NAs from any analysis where they are modelled together with other variables if one of the variables contains NAs. If the variable is removed from the analysis during a model simplification, then the projects removed earlier might be taken back into the model, if the variable containing the NA was removed. This will lead to inconsistencies in the results between the models if I were to compare them and is therefore unacceptable.

In order to have usable data, there are several courses of action I could pursue. The first and easiest option would be to omit the projects that have NAs in their variables. Had there been just a few units containing NAs this would have been the best and simplest action to take, but since there are many, other more complicated measures were needed.

In the case of my data, the effects of there being several different methods of producing and presenting an EIA report coupled with the individual nature[23] of the licencing process was clear. The number of NAs in the unprocessed dataset is displayed by figure 7. This data, as it was, could not be reliably used for any kind of statistical analysis and doing a simple omitting of the units with missing data would not be a good solution as there were some themes only assessed once or twice, and would in effect remove the entire dataset.

Column	Nr.NA
TOTAL	95
Project	0
Approved	0
Year	0
LCOE	0
Capacity	0
Output	0
Landscape	0
Cultural_heritage	5
Direct	83
Indirect	85
Recreation_travel	2
Natural_environment_biodiversity	48
Flora	30
Fauna	81
Birds	32
Other_fauna	39
Wild_reindeer	91
Marine_environment	92
Icing	78
Noice	23
Shadowcasting	24
Reflecting_flash	45
Pollution_Waste	34
Drinking_water	53
INON&Conservation	72
INON	50
Conservation_interests	47
Conserved_watercourses	76
Public_plans	94
Defence	44
Aviation	16
Telecommunications	33
Agriculture	19
Farming	76
Forestry	77
Fishery	93
Boat_traffic	94
Reindeer_herding	65
Other_landuse	81
Societal_effects	67
Municipality_finances	61
Employment_Value_creation	56
Tourism_Travel	33

Figure 7: Displaying the number of NAs per variable before grouping

[22] Explained in chapter 3.2.3
[23] The initial notification, the first hearing and the reply to the initial notification determines which themes should be investigated in the EIA, opening up for the possibility of different themes to be investigated and assessed for each project.

In addition to performing a simple omission, I could also have removed variables from the dataset, but this would lead to a loss of data while still not fixing the issues caused by different assessment methods being used in the EIAs and only leave me with a small part of the EIA variables.

The solution I came up with to counter the problems mentioned above were grouping themes together, assigning the different themes into categorical themes which assessed the impact to the same type of EIAs, which is a method to avoid overfitting proposed by Babyak (2004, p. 419). In order to group these themes together, I needed a method of generating data values to replace the NA values, and I investigated four different alternatives to how I could achieve this.

1. Account for *maximum* impact and remove the remaining values.
2. Account for the *minimum* impact and remove the remaining values.
3. Use the *median* of the values.
4. Use the *mean* of the values.

There were positive and negative traits connected to all the solutions, but in the end, I ended up with grouping the variables together using the *mean* values of the grouped variables. The main weakness of using mean value is that any larger impacts that would be most likely considered more important are mitigated by themes that was assessed as not important or that there were no impacts. The positive aspect, and the reason mean was chosen was that it considers all the different impacts (which is not the case for max or min) and is not subject to the randomness of the median (while the median would be better at eliminating outliers, it would also be randomly affected by the type of theme being grouped together). The themes and how they were grouped together can be seen in table 3.

The grouped data was featured several improvements, with the reduction of 37 variables down to a total of nine EIA variables. As displayed in figure 8, there were still many NAs in the variables, and 56 projects still had variables that contain NAs. These NAs are mainly contained in the themes *physical*, *pollution*, *protection*, and *society*, all of which had a tendency to be assessed using other methods than the consequence matrix (Norwegian Public Roads Administration, 2006) or TKV.

Column	Nr.NA
TOTAL	56
Project	0
Approved	0
Year	0
LCOE	0
Capacity	0
Output	0
Nr.themes	0
Landscape	0
Heritage	0
Recreation	2
Nature	1
Physical	17
Pollution	24
Protection	21
Sector	8
LandUse	2
Society	13

Figure 8: The table of NAs after the grouping.

The problems with these four variables forced me to omit them from the analysis[24], as keeping any one of them would make me remove too many projects from the dataset. After removing the variables, the projects still containing NAs where omitted, totalling in 12 projects being removed from the dataset, and leaving me with a dataset of a total of 83 projects and six usable EIA's variables, but with 0 NAs!

Following the grouping process, I investigated correlation between all the remaining variables, investigating if any of them explain the same variation on the data. If the data correlate (change together at a constant rate) they should not be put in a statistical model together as they explain the same thing. If any themes are more than 70 % correlated, they should be removed. For my data, none of the variables I intended to use was correlated.

One problem caused by the grouping was that the EIA variables are no longer categorical according to the consequence matrix (+4 /-4) but numerical according to the mean of the grouped categorical variables, making the results harder to interpret[25]. In order to rectify this and for added robustness I followed the example set by Inderberg et al. (2020) and dichotomized the EIA variables, assigning them into two groups, "High" and "Low" impacts. High impacts reflected moderate to highly negative EIA scores, while low impacts reflected every value above the high impacts, including positive values.

I decided to use a different a cut-off value for the different variables, order to adjust for the effect of the variables being grouped according to the mean, lowering the value of some of the higher impacts. Landscape, Heritage[26] and Recreation were not grouped, while, Nature, LandUse and Sector were grouped. For the non-grouped variables, I assigned values of -2 or lower as "High impact", while I assigned values lower than -1.5 as "high" impacts for grouped values. All values above the cut-off were assigned as low impact.[27]

As the control variable's *year of licence decision* and *project size* were highly non-normally distributed. I investigated if data transformation would improve the distribution, which it did in the case of *project size*, for whose values I converted into square roots, while I left both the distribution of both *year of licence decision* and *LCOE* as they were[28]. By using the values

[24] The dropping of these themes will be more closely discussed in chapter 5.1.
[25] For the models using continuous variables, see appendix C.
[26] As there were only five projects that reported the impacts to heritage using only «direct» and «indirect» impacts to heritage I decided this did not warrant the lowering of the cut-off point.
[27] Positive values were only observed a few times in the in the final dataset, for the two themes recreation and land-use. Instead of acting as potential outliers or an additional category, I assigned them as "low" impacts.
[28] Normal distribution is not a requirement for logistic regression.

for *year of licence decision* and *LCOE* as they were collected generated huge confidence intervals (CI) however, which was due to relatively large numbers in both variables. For ease of interpretation, I subtracted all the values in the year variable with 2020, which lowered the values, while the lowest numbers still represent the earliest years. I repeated this process for the LCOE values as well, subtracting all values with 38.

Of the 83 remaining projects that were comparable, 54 were accepted (codes as '1') and 29 rejected (coded as '0'), yielding an effective sample[29] of 29. This is already in the lower end where a logistic regression is feasible, since the complexity of a model can exceed what the sample size allows, as using small sample sizes can cause the model to detect patterns which can't be reproduced in the future, as an overfitted model will yield and overly optimistic result (Greenland et al., 2016; Babyak, 2004).Overfitting model can be explained in non-technical terms as asking too much of the data, as there is an upper limit to the complexity of the model given the number of observations.

The rule of thumb being that logistic regression should be used with a minimum of 10 outcome events per independent variable (Green, 1991; Peduzzi et al., 1996; Babyak, 2004) which would only allow me to use two variables in each model. However, in situations where only one or a few variables are in focus Vittinghoff and McCulloch (2006) states that five to nine outcome events per independent variable could be acceptable. This means that in order to make an accurate model containing all EIA variables as a model with a total of nine variables would require a minimum effective sample size of between 45 and 63. Any lower and it would result in an overfitted model. In order to avoid this problem, I will only fit simple multivariate models, containing a single EIA variable each, as these models will only have a maximum of four variables, requiring only an effective sample between 20 and 36, which is within the range of my effective sample of 29. This means that this analysis capability to check for relationships between the EIAs are reduced and that the results will only reports the effects of each single EIA variable.

All the variables can be seen in table 13 below displaying the descriptive statistics after the grouping.

[29] The lowest amount of the two outcomes.

Table 13*:* Descriptive statistics after grouping.

Variable	Observations	Mean	Std.dev	Min	Max	Prop 0/1
Dependent variable						
Licencing outcome	83			0	1	29 / 54
Control variables						
Licencing decision year	83	-6.241	2.998	-15	-2	
Installation size (MW, Square root)	83	9.849	3.549	3.674	18.166	
Levelized cost of energy (ø/KWh)	83	-6.141	2.766	-10.270	-0.150	
Independent variables						
Landscape	83					11/72
Heritage	83					50/30
Recreation	83					39/44
Nature	83					24/59
LandUse	83					71/12
Sector	83					81/2

Note: For the independent variables, Prop 0 equals "Low impact" while Prop 1 equals "High impact".

3.6 Analytical approach

For this analysis I used logistic regression, which is a type of generalized linear modelling. The goal of using logistic regression is to predict the outcome using a dichotomous (binary) dependent variable. My dependent variable "Approval" has only two possible outcomes: as the wind power project application is either "Accepted" or "Rejected".

In order to prove or disprove hypothesis one, investigating of projects with a high socio-ecological impacts have a lower chance of receive a licence, and how these are weighed, I ran a series of simple multivariate models (Hosmer et al., 2013), which were expressed as:

$$\frac{p}{1-p} = exp(\alpha + \beta_i Landscape_i + \sigma * Controls) \quad (1)$$

$$\frac{p}{1-p} = exp(\alpha + \beta_i Heritage_i + \sigma * Controls) \quad (2)$$

$$\frac{p}{1-p} = exp(\alpha + \beta_i Recreation_i + \sigma * Controls) \quad (3)$$

$$\frac{p}{1-p} = exp(\alpha + \beta_i Nature_i + \sigma * Controls) \quad (4)$$

$$\frac{p}{1-p} = exp(\alpha + \beta_i Landuse_i + \sigma * Controls) \quad (5)$$

$$\frac{p}{1-p} = exp(\alpha + \beta_i Sector_i + \sigma * Controls) \quad (6)$$

The equations (1 – 6) models the probability of application being granted, where $\frac{p}{1-p}$ is the odds ratio for a project's licence outcome, β represents the coefficients for the EIA variable. While σ represents the coefficient for my controls. α is the constant term across all cases. These models are utilizing the grouped EIA variables, as the EIA variables as collected for the Licence applications and EIA reports were not usable in their original state. This is showed by the descriptive statistics in table 13 above, and is also explained in chapter 3.2.2, 3.2.3 and 3.2.4.

In the analysis, every model's ability to explain the change in the data is compared to a null model, which is a model only contains the constant term α. Every model is started containing the single EIA variable focused upon in that particular model and then the controls are added one by one in order to investigate if the relationship between the independent EIA variable and the dependent licence outcome variable changes.

3.6.1 Measuring the model's ability to explain the variation in the data.

For normal linear regression it is common practice to state the R^2 value in order to assess how well the model describes the variation in the data material. However, there is no established equivalent for logistic regression, although some studies report a series of pseudo R^2, like Mcfadden- or Tjurs- R^2 (Tjur, 2012). These measures are based on various comparisons between the predicted values of the fitted model and those from the null model (the no data or intercept only model). As a result, these pseudo R^2 does not assess a goodness of fit (Hosmer et al., 2013, p. 182).

As a possible answer to this, I used the Receiver Operating Characteristic (ROC) Curve, an example of which is displayed in figure 9.

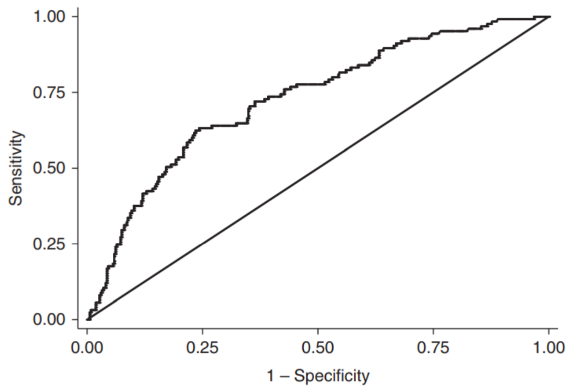

Figure 9: An example of the ROC curve (Hosmer et al., 2013, p. 177)

The ROC is explained by Hosmer et al. (2013, p. 174) as a better and more complete description of classification accuracy than the pseudo R^2. It plots the probability of detecting true positives (sensitivity) and false positives (1–specificity) for an entire range of possible cut-points[30].

The area under the ROC curve (AUC), provides a measure of the model's ability to discriminate between those subjects who experience the outcome of interest versus those who do not. The AUC ranges, theoretically from 0.5 which is depicted by a straight 45° line from the bottom-left to the top right corner, which happens when the model's prediction is no better than a random guess, to 1, which indicates perfect predictions. In the case of the latter, the curve would go vertically straight up to the top left, then run horizontally at the very top of the graph. In the case of a perfect prediction, all outcomes would be perfectly predicted, making all the area of the curve under it.

There are only general guidelines for which AUC number describes good discrimination, but it according to Hosmer et al. (2013, p. 177) the general rule of thumb is that an AUC value = 0.5 suggests no discrimination, indicating the model is as good a predictor as flipping a coin. A value between 0.5 and 0.7 still indicates poor discrimination, and values above 0.7 represents acceptable discrimination. AUC values close to or equal to 1 indicate a model's prefect or close to perfect ability to predict the outcome.

3.6.2 Statistical software used in the analysis

All analysis work was performed in RStudio (version 1.4.1103) with R version 4.0.3. The script which runs the analysis is reproduced in Appendix A.

[30] The different cut-points represent the threshold values for the binary outcome.

4. Results

In this chapter, I report the findings of my study. The results from this investigation are presented as a series of six logistic models, one for each of the six EIA variables: 1) landscape, 2) heritage, 3) recreation, 4) nature, 5) land-use and 6) sector. As only two of the variables in my analysis were statistically significant, I will have to present and later discuss models containing only non-statistically significant variables, as they are part of the results. The main focus of this chapter will be on the EIA variables, how they influence the licencing process and what weight they carry.

4.1 The influence of reported societal and ecological impacts

For my first research question I had the hypothesis that*: High negative impacts reported by the EIAs will reduce the likelihood of licence being granted.* I began my investigation by testing the relationship between the six EIA variables and the licence outcome, respectively. For these models I will report the odds ratio, explaining how the relationship is either positive, negative, or uncertain. Together with the odds ratio I will explain their confidence intervals (CI) and p-value (traditionally set to 0.05) which can be used to explain the statistical significance of the relationship between the dependent variable (licence outcome) and the independent (EIA) variable (Hosmer et al., 2013).

When building the models, I added the control variables one at the time while inspecting their effect on the EIA variables or the licence outcome. As no significant effect on the relationship between the EIA variable and the addition of control variables where found, these effects will be presented in chapter 4.1.7, while the EIA models that did not include the control variables can be inspected in Appendix C.

4.1.1 Landscape

Model 1, as presented below, investigates how high reported impacts to landscape influence a wind power project probability of a favourable licence outcome. As can be seen in the table, there are no significant p-values, and large confidence intervals which stretches to both sides of 1, indicating that there are large insecurities connected to how reported impacts landscape influenced the project licence outcome.

Model 1: Landscape model, including the three control variables.

Model 1	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	5.31	0.65 – 55.40	0.135
Landscape [High Impact]	0.79	0.16 – 3.18	0.748
Year of licence decision	1.03	0.88 – 1.21	0.698
LCOE	0.97	0.81 – 1.15	0.713
Project size	0.92	0.80 – 1.05	0.222
Observations	83		
R^2 Tjur	0.022		
AIC	115.454		
log-Likelihood	-52.727		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 1 estimates that when the impact of landscape is moderate to highly negative, the odds of being granted a license is 0.79 (95% CI [0.16, 3.18]). This estimation, however, is very uncertain and can't be relied upon as indicated by the high p-value of the Landscape variable. More information can be found by inspecting the confidence intervals, which include the possibility of no effect, as the odds ratio of 1 is between the lower and upper tail of the CI value, implying the possibility of high negative impacts to landscape potentially having absolutely no influence on licence outcome. The result stayed the same with or without the control variables and made no significant difference.

The ROC curve for model 1 is shown in figure 10. This graph tells us that impacts to landscape is a poor predictor for licence outcome. This is displayed by the black jagged line, which represents the performance of the model. The jagged line rises slightly, but then travels close to parallel to the straight line going from the bottom left corner to the top right corner, indicating weak predictive capabilities.

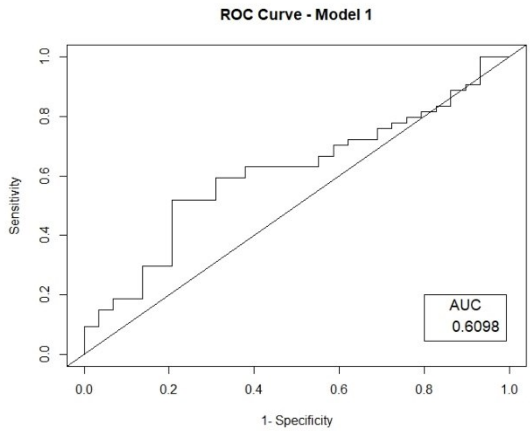

Figure 10: The ROC curve of Model 1.

The AUC value in the bottom right corner reports the same, as the value is barely above 0.6, which according to Hosmer et al. (2013) indicates that the models predictive abilities are barely better than flipping a coin.

Model 1 indicated that there are considerable uncertainties related to how the likelihood of a developer receiving a license is influenced if the EIA for the project report high negative impacts for landscape.

4.1.2 Heritage

In the second model, the influence of high impacts to heritage are investigated, and the findings are showed below in Model 2.

Model 2: Heritage model, including the three control variables.

Model 2	**Dependent variable**		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	5.49	0.84 – 43.23	0.087
Heritage [High Impact]	0.32	0.12 – 0.82	**0.019**
Year of licence decision	1.04	0.87 – 1.22	0.669
LCOE	0.96	0.80 – 1.15	0.675
Project size	0.94	0.82 – 1.08	0.409
Observations	83		
R^2 Tjur	0.091		
AIC	109.955		
log-Likelihood	-49.977		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 2 estimates that the odds of a project being granted a license when the EIA reports high to moderately negative impacts for heritage are 0.32 (95% CI [0.12, 0.82]). As the distance in the confidence interval is so large, there are large insecurities connected to the estimate, but due to the p-value being below 0.05, I accept that there is an effect and that high impacts to heritage will lower a developer's likelihood of being granted a licence if the EIA reports high negative impacts for heritage. This result stayed the same with or without the control variables and made no significant difference, as displayed by model C2, reporting an odds ratio of 0.3 (95% CI [0.11, 0.75]). This model is attached in Appendix C.

The ROC graph in figure 11 tells us about the performeance of model 2. It indicates that the model's predictive abilities are not too good, although better than model 1. This can be observed by inspecting the black jagged line which rises slightly in the lower left and converges closer on the straight line before rising again.

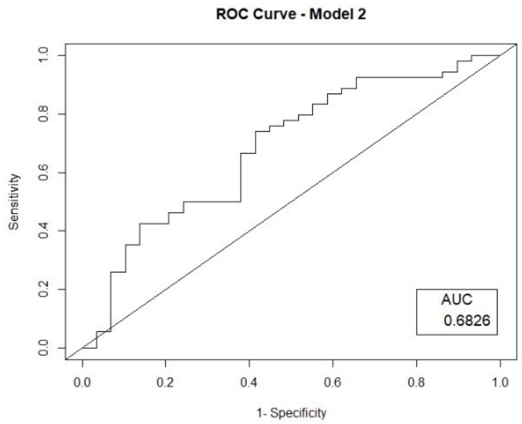

Figure 11: The ROC curve of Model 2

The AUC value for model 2 is, 0.682, which is close to the acceptable value of 0.7, but as its at does not exceed this threshold, the model's predictions are still only slightly better than flipping a coin.

Model 2 indicates that negative impacts to heritage decreases the probability of the developer being granted a licence if the project reports high impacts to cultural heritage, as showed in figure 12.

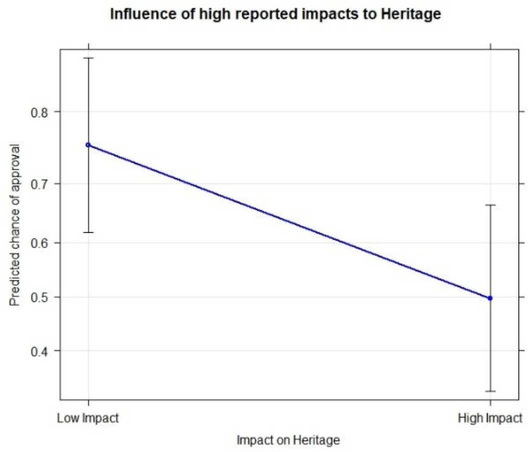

Figure 12: Visualization of the negative relationship between licence outcome and high reported impacts to heritage.

4.1.3 Recreation

For the third model, which models the influence of high impacts to recreation are investigated. These results are shown by model 3 below.

Model 3: Recreation model, including the three control variables.

	Dependent variable		
Model 3	**Project licence approval**		
	OR	*CI*	*p*
(Intercept)	9.03	1.21 – 83.91	**0.04**
Recreation [High Impact]	0.43	0.16 – 1.10	0.084
Year of licence decision	1.05	0.88 – 1.24	0.602
LCOE	0.98	0.82 – 1.17	0.815
Project size	0.91	0.79 – 1.04	0.169
Observations	83		
R^2 Tjur	0.054		
AIC	112.468		
log-Likelihood	-51.234		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 3 estimates that the odds of a project being granted a license when the EIA reports high to moderately negative impacts for recreation are 0.43 (95 percent CI [0.16, 1.10]). This estimation, however, is uncertain as indicated by the p-value for the recreation variable being above 0.05. Adding or removing the control variables did not significantly change this result.

The ROC curve for model 3 is shown in figure 13. The graph supports the findings that the effects of high impacts to recreation are uncertain, as the jagged line goes straight up in the lower left corner, but then starts following the straight line, before joining it and even going below the 45° the top right corner.

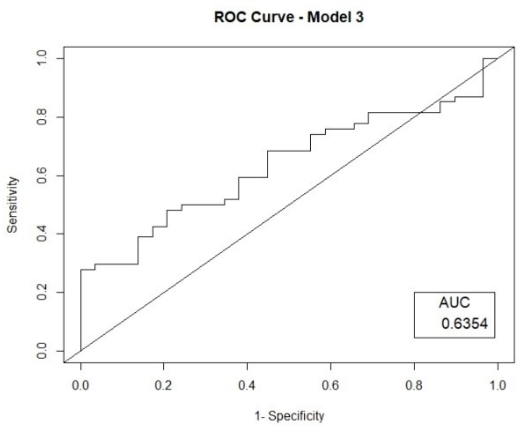

Figure 13: The ROC curve of Model 3.

The AUC value in the bottom right corner indicates the same, as the AUC value is 6.354, indicating the models' poor predictive abilities.

According to model 3, it is uncertain how the likelihood of a developer receiving a license is influenced if the project's EIA reports high negative impacts for recreation.

4.1.4 Nature

For the fourth model, modelling the influence of high impacts to nature. The result of this model is shown by model 4 below.

Model 4: Nature model, including the three control variables.

Model 4	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	11.85	1.53 – 113.81	**0.023**
Nature [High Impact]	0.28	0.07 – 0.88	**0.041**
Year of licence decision	1.05	0.89 – 1.25	0.544
LCOE	0.98	0.82 – 1.18	0.838
Capacity	0.93	0.81 – 1.07	0.335
Observations	83		
R^2 Tjur	0.077		
AIC	110.715		
log-Likelihood	-50.357		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 4 estimates that the odds of a project being granted a license when its EIA reports high to moderately negative impacts for nature are 0.28 (95% CI [0.07, 0.88]). This means that if a project's EIA reports high negative impacts to nature, it will be less likely that the developer will be granted a licence. As the distance in the confidence interval is large, it is clear indications of large insecurities connected to the estimate, however, due to the p-value being below 0.05 I will accept that there is an effect. The effect remained constant with or without the controls as model C4 (See Appendix C), reported the odds ratio value of 0.27 (95% CI [0.07 – 0.83]).

The ROC curve for model 4 is shown in figure 14. This graph tells us that model 4 is not a good predictor of licence outcome, as displayed by the black jagged line that rises towards the middle before coming closer to the 45° line.

The AUC value for model 4 is, 0.6686, which is close to 0.7 which is an acceptable value, but since its close but not exceeding 0.7, the model's predictions are only slightly better than flipping a coin.

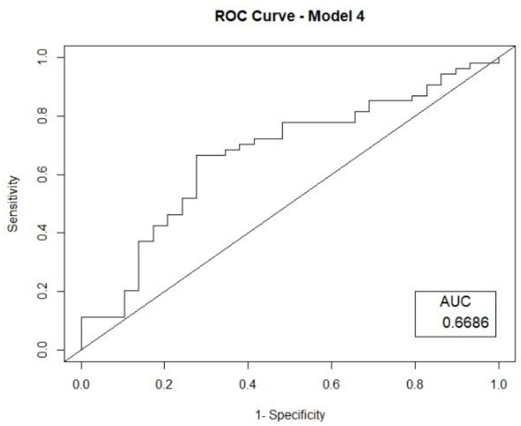

Figure 14: The ROC curve of Model 4

As displayed in figure 15, model 4 indicates that if a project's EIA reports high negative impacts to nature, it will decrease the likelihood of that the project's developer is granted a project licence. The figures also show the large insecurities in the models estimate.

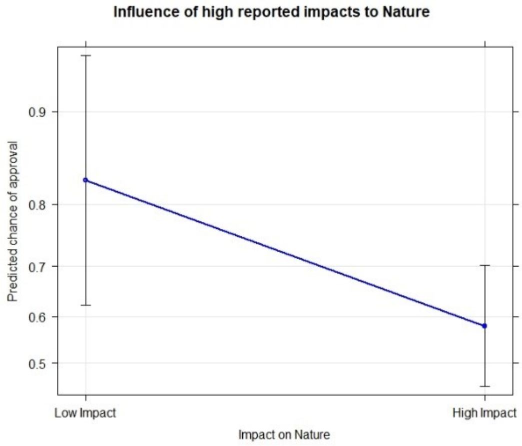

Figure 15: Visualisation of the negative relationship between licence outcome and high reported impacts to nature themes.

4.1.5 Land-use

In the fifth model, the influence of high impacts to land-use are investigated. These results are shown by table 18 below.

Model 5: Land-use model, including the three control variables.

Model 5	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	3.74	0.60 – 26.01	0.165
LandUse [High Impact]	0.35	0.09 – 1.31	0.121
Year	1.04	0.88 – 1.22	0.655
LCOE	0.95	0.80 – 1.14	0.572
Capacity	0.94	0.82 – 1.08	0.382
Observations	83		
R^2 Tjur	0.053		
AIC	113.126		
log-Likelihood	-51.563		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = P-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 5 estimates that the odds of a project being granted a license when the EIA reports high to moderately negative impacts for land-use are 0.35 (95% CI [0.09, 1.31]). This estimation, however, is too uncertain and should not be relied upon as indicated by the p-value of the recreation variable being above 0.05. Adding or removing the control variables did not significantly change this result.

The ROC curve for model 5 is shown by figure 16. This figure tells us that model 5 has generally bad predictive capabilities, as displayed by the black jagged line, with slightly lifts up from the straight line, and then travels almost parallel with it, closing in in the top right corner.

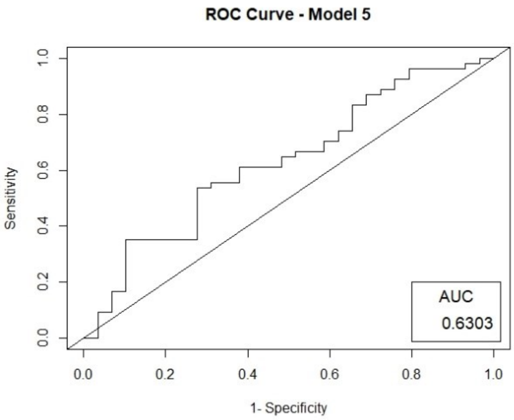

Figure 16: The ROC curve of Model 5

The AUC value in the bottom right corner indicates the same, as the value 6.3, is lower than 0.7, indicating the model's predictions are barely better than flipping a coin. According to model 5, it is uncertain how the likelihood of a developer receiving a license is influenced if the project's EIA reports high negative impacts for land-use.

4.1.6 Sector

Model 6 is presented in table 19, which investigates the influence of high reported impacts to sector for a wind power project licence outcome.

Model 6: Sector model, including the three control variables.

Model 6	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	4.23	0.69 – 29.22	0.127
Sector [High Impact]	0.64	0.02 – 17.42	0.764
Year	1.03	0.88 – 1.21	0.706
LCOE	0.96	0.81 – 1.15	0.658
Capacity	0.92	0.80 – 1.05	0.208
Observations	83		
R^2 Tjur	0.023		
AIC	115.47		
log-Likelihood	-52.735		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Holding all other variables constant, model 1 estimates that when the impact of sector is moderate to highly negative, the odds of being granted a license is 0.64 (95% CI [0.02, 17.42]). This estimation is highly uncertain however, which can be interpreted by the high p-value and the 95% confidence interval, which has a very large span, from almost 0 to 17.66. Adding or removing the control variable from the model made no significant difference to the result.

The ROC curve for model 6 is shown in figure 17. This graph tells us that model 6 is a poor predictor for licence outcome, as displayed by the black jagged line. The line rises upwards quite early, but across the middle it moves toward the 45° line following it closely to the top right corner.

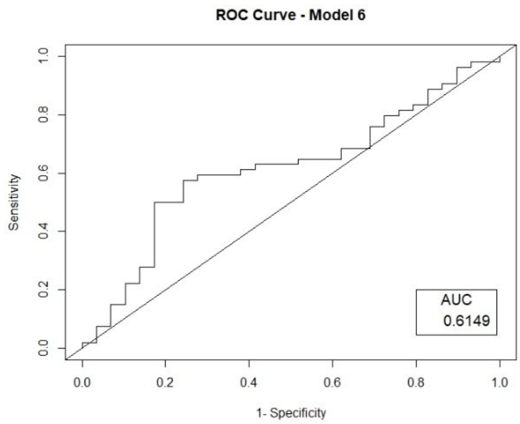

Figure 17: The ROC curve of Model 6

The AUC value in the bottom right corner indicates the same, as the value is barely above 0.6, indicating that the model has only slightly better predictive abilities than a coin toss.

Model 6 indicated that there are considerable uncertainties related to how the likelihood of a developer receiving a license is influenced if the EIA for the project report high negative impacts for sector.

4.1.7 Control variables

For the control variables, I have found that none of the three influenced the effect of the main explanatory variable (EIA), which support the previous findings as the EIA score are supposed to be quite independent from other factors in the licensing process (Inderberg et al., 2020, p. 7). The only variable close to being significant in some cases were the project size, which in all cases yielded a negative correlation with licence outcome. The controls for year of licence decision and LCOE were substantially weaker and far from any statistical significance. As no significant effects for these were found I will not consider them further when discussing my results.

4.2 The individual weight of the Environmental Impact Assessments

By investigating the findings in chapter 4.1, it is clear that the EIAs are not equally weighted. It was found that if a project's EIA reports high to medium negative impacts to both heritage and nature that the project's developer will have a lower likelihood of being granted a licence, but due to uncertainties in the result, the effect of this relationship is unclear for both variables. It was further found that the impacts to recreation and land-use were uncertain, with no clear effect showing found. Finally, the influence of high impacts to landscape or sector were found to be most uncertain, with high uncertainties connected to the results. It was also discovered that no models had AUC above 0.7, implying that none of the high impacts reported by EIAs carry enough weight in order to be an accurate predictor of licence outcome.

The results indicates that high negative impacts to heritage and nature carry a higher weight in the decision-making process while the weights of the other EIAs used in this analysis are more uncertain and that high impacts to none of the themes are enough to accurately predict the licence outcome. There are various possible reasons for this, and they will be discussed in chapter 5.

5. Discussion

By investigating how EIAs influences the wind power projects licence process, it is possible to gain valuable insight in how impacts to the society and environment have been assessed by NVE, and by extension OED. In this chapter I will discuss the results from chapter 4 in the light of theory presented in chapter 2 and the findings from the data collection in chapter 3.

I will begin with a brief discussion about the data collection phase, and the problems encountered during this phase in chapter 5.1 and 5.2, as these are important for how the results are interpreted. Next, I will briefly discuss the significance testing and my approach to analysing and evaluated my findings in chapter 5.3 and 5.4. Following that, I will go over my findings and confirm or disprove the hypotheses presented in chapter 1.1. In chapter 5.5, I will discuss how EIAs influence the conclusion of the licensing process, and then in chapter 5.6, I will discuss how the various EIAs are weighed. Finally, in chapter 5.7, I will review the thesis's limitations and shortcomings.

5.1 Data collection

When collecting the data for the analysis, I encountered a series of obstacles that needed to be sorted out in order for the data to be collected in a systematic and orderly way. The first issue with the collection of data was the complexity of the licence process, and the somewhat chaotic state of NVE's licence archives (NVE, 2021a), which could potentially cause loss of data if not interpreted correctly.

My initial method of using the archive's own list as my initial database worked well in most of the cases, but some project information needed more management as the first issue to be encountered was the complexity surrounding the licence decisions. This first became apparent when I observed that some developers applied for two or three independent projects in the same area, but that these could be aggregated at a later stage and accepted as one. This was for example the case for the Bjerkreim wind power project, which previously consisted of the two wind power projects Eikeland and Steinsland (NVE, 2016). There were two other similar examples with both Marker (NVE, 2017) and Odal (NVE, 2020b) wind power projects, both of which originally consisted of three projects, and in both cases two of the three projects got accepted while one of the three got rejected, adding to the complexity of the assessment.

The case of Storhei, Oddeheia, and Bjelkeberget (NVE, 2019a) could be described especially complicated. These projects were applied for as three independent pieces of the same project, with the intention of the projects being built in stages. Storhei was the first project to be accepted, while Oddeheia and Bjelkeberget applications were halted until further notice. Storhei was later rejected by OED in the appeal stage, with Oddeheia & Bjelkeberget wind power project being restarted and accepted at a later stage. Additionally, the existence of the Storhei project only becomes apparent while reading the attached application and answer, as this is not even hinted in NVE's summary or the name of the files.

These different situations were at times challenging to interpret and demanding in terms of understanding how they were assessed, and which factors were involved in the decision. It could be questioned whether it would be more accurate to account for the individual projects or the aggregated ones, however, for this thesis I chose to interpret every case independently, as this would be the most correct method in accordance with NVE's observed individual case processing, while also retaining a larger sample of projects. When interpreting my findings, understanding NVE's complex system of wind power licenses will be critical, as it's clear that the system used to review wind power projects more independent and complex than I had originally anticipated.

The second issue I encountered was during the collection of the EIA scores. I observed that there were significant differences in how EIAs were reported, and I found that several of the EIAs used different reporting procedures and that impacts on different themes were documented using a variety of methods. Some reported summarized impacts for the theme, while others reported the impacts in a series of sub-reports, reporting a series of different impacts within the confines of each theme, which obviously created issues when comparing how different projects were evaluated. This is the same discovery that was reported by the Norwegian Environment Agency (2015). While this individual nature is not necessarily a bad thing in terms of how the outcome of licence process is reached, as the impact for each wind power project is individual for its geographical location, it does cause problems when trying to compare how the different projects are assessed!

Impacts to Landscape was found to be the most consistently reported theme in all of the EIAs examined in this study, with all the impacts being reported using a summarized method. In addition to this, all were reported according to the methodology of the consequence matrix (+4 /-4) used by the Norwegian Public Roads Administration (2006). An observation that was also true for the theme cultural heritage, as the EIAs were also mostly reported using summarised impacts for both the direct and indirect impacts on cultural heritage, but in very few cases[31], only the direct and indirect impacts were reported, with no report of summarized impacts. The effect of this was negligible, and all the findings from heritage were treated as non-grouped. The last theme that was consistently reported using the same methods were recreation and travel. It is worth to note, however, that in certain EIAs the theme recreation was connected to and reported together with tourism[32]. This could potentially cause some problems for interpretation, as in most other cases tourism was reported as a part of societal impacts.

The impacts to nature were reported using a series of different methods. Often as a summarized impact, but sometimes also by dividing the impacts into the theme's flora and fauna and reporting the impacts to these, respectively. It was also observed that the impacts to fauna would in many cases be further divided up into the theme's "birds", "other fauna", "wild reindeer" and "marine ecosystems". When collecting data on this theme it was observed that the impacts to nature was consequently reported for either one of the three methods, with around half of EIAs reporting summarized impacts to nature[33], while the other half reporting the impacts to nature by dividing it into sub-reports[34] within the confines of the theme nature, but not as a summarized result. A problem that was further complicated with projects reporting both[35]. This created complications when combining all these values together as one value that represented the impact the project would have on nature and would most likely have an effect on the results.

The EIA for icing, noise, shadow casting, and reflecting flash was attempted to be grouped together as physical impacts, however as the reports contained too many inconsistencies to be used in the final analysis. This was due to the diverse methodologies employed when reporting the impacts. Icing was usually reported using the consequence matrix, or the period or percentage of time the icing could occur with estimations on how much loss of production these conditions could cause. Noise, shadow casting and reflective flash was usually reported as an area affected, or number of houses where the appointed threshold values set for that specific theme were crossed. Due to these problems I decided to not to investigate these themes any further in my thesis as they would be very challenging to compare to the rest.

[31] The five projects, Lista, Sørmarkfjellet, Brusali – Karten, Faurefjellet and Langevåg.
[32] For an example of this can be seen by reading the application for the Tellenes project.
[33] Example of projects reporting only summarized impacts for nature: Blåheia, Roan, Geitfjellet, Andmyran etc.
[34] Example of projects reporting several impacts for nature: Midtfjellet, Storheia, Storhei, Elgåsen (Marker) etc.
[35] Example of projects reporting both: Tonstad, Bremangerlandet, Høgås (Marker), Joraknatten (Marker) etc.

For EIAs regarding the impacts of pollution and waste or impacts to drinking water, were mostly reported as small to negligible. These impacts were also observed to be more closely connected to the follow up of an approved project's MTA plan, reporting on possible mitigation measures and the possible worst-case scenarios. As many applications failed to report these impacts, I decided to drop them from the analysis due the inconsistency and subsequent lack of data[36].

The EIAs for INON, conserved areas and waterways was also inconsistently reported, with some reporting the impacts and loss of protected areas according to the consequence matrix, while in many cases the loss or conversion of protected areas were reported in km^2. Due to the same inconsistencies in the reporting as mentioned above, these themes were also dropped from the study[37].

The EIAs for land-use, usually discussed and presented the different impacts to land usage in the area surrounding the projected wind power development. As the types of land usage was different based on the geographical area of where the wind power project was planned, it is not surprising that this theme was the most diverse investigated in this study. It was observed that for impacts to this theme that the types of reported impacts differed depending on the type, and that most cases it was only reported when the other types of land uses were present in the area. This individual reporting of the different themes is a potential weakness of the grouping method, as the different land uses reported would be of different scales and values. However, by reporting impacts according to the consequence matrix, the reports should account for this, and the impacts reported according to this scale should be more or less equal. It should be noted that a TKV theme is reported as part of land use, which is reindeer herding. This theme has been observed of being of particular value and will be discussed in detail later.

There were also inconsistencies observed for the reporting of impacts to defence, aviation, and telecommunication, as some EIA reported the impacts or the absence of impacts to themes[38], while these themes were not even mentioned in some reports[39]. The reported impacts to these themes were usually low or negligible, which could indicate projects with

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[36] Of the original 95 project EIAs, only 42 projects reported on the impacts to drinking water, while 61 reported impacts to pollution.
[37] For more details on how often impacts to INON and conservation interests were reported, see table 12.
[38] For examples of this type of reporting, see the applications of the projects: Faurefjellet, Egersund, Remmafjellet or Tonstad.
[39] For examples of the project EIAs that did not mention one or all themes included in sector, see the applications of Storheia, Hammerfest, Bjerkreim (Steinsland & Eikeland).

potential for large negative impacts to these themes were either not projected at all or halted or withdrawn earlier in the licencing process, as found by Inderberg et al. (2019, p. 185), which could be the effect of the screening process employed by NVE (Norwegian Environment Agency, 2015). The theme defence was also found to be the only theme in my study that systematically reported by the EIAs using the TKV assessment system.

Societal impact where the only themes to typically report positive impacts, with the exception of the theme tourism and travel, which were usually reported as a negative impact or something in between. These impacts were however, in many cases reported using monetary terms, such as potential economic gain for the municipality, value gained by the surrounding community in the form of goods and available jobs etc. Due to this inconsistency with the consequence matrix, these themes were also dropped from the study.

Many of the issues encountered in the collection of the EIAs could have been avoided by simply attributing the instances where a common theme was not reported the value “0”. However, this action was avoided, as it would smooth over the inconsistencies in the process and the reporting of no consequence would be inaccurate when the theme was not mentioned, producing inaccurate results.

The third issue with the data collection I encountered were all the obscure and often poorly explained processes that have been used in addition to that of the EIAs. The first system, the thematic conflict assessments (TKV) were obscure in the fact that their influence on the reports of the EIAs are unknown. As explained in chapter 2.4, this system has been used to screen the selection process, halting, or withdrawing projects with high impacts to themes of special interest. The effects of the screening process is further expanded upon by Inderberg et al. (2019), who found that NVE has developed a practice to advice developers to withdraw projects they regard as unfeasible. While the TKV system can be used to indicate which themes are of special interest to NVE, the effects would be clouded by possibility of projects with high impacts to these themes are removed early in the licence process, and that these impacts are therefore not reported by the EIA. The effects of the usage of the TKV system are hard to scale, or prove, but as found in my data collection phase, 102 projects were either halted or withdrawn before reaching the licence decision stage, proving the existence of an early screening process. While this practice is mutually beneficial for both the NVE, OED and the developers, conserving both time and resources (Inderberg et al., 2019, p. 187) it can be assumed to cause a loss of data on the impacts that influential in terms of reducing a project's chance at being granted a licence, due to its informal nature.

Another point of uncertainty for the reporting of the EIAs are the usage and reporting of "mitigation measures" and alternative development solutions. These further complicated the gathering of EIAs, as they added another layer of insecurity around the actual environmental impacts that were assessed. These measures are usually tailored to the project as a set of terms and mitigation measures the developer are required to follow in the construction and operation phase (Inderberg et al., 2019, p. 184). These are usually detailed in an accepted project's Environmental, transport and construction plan (MTA). To minimize any uncertainty connected to these findings, I have consistently collected the impacts of mitigating measures when available. However, as the mitigation measures were also inconsistently reported in the EIAs, they should be discussed as a weakness of the study adding to the uncertainty of the results.

5.2 Grouping the EIA variables

With a data table with 95 usable EIAs and 37 different EIA themes to investigate, the original dataset was not ideal for logistic regression, which requires between five and fifteen outcomes[40] per variable[41] (Green, 1991; Peduzzi et al., 1996; Babyak, 2004; Vittinghoff and McCulloch, 2006). The added uncertainties I noted during the data collection phase also made the EIA variables very challenging to use. The solution I came up with was grouping the EIA themes according to the groups they were reported by, and in this way, I was able to aggregate the data using both the summarized impact and the individual impacts, while at the same time reducing the potential variables in the logistic regression. This was a method proposed as an strategy in order to avoid overfitting regression type models (Babyak, 2004).

It can be argued the different reporting methods utilized, weakens the reliability of my grouping method, which could be used to explain the weaknesses of models 5 and model 6. It should be noted that the impacts reported for each grouped variable naturally change based on the method used to aggregate the variables into groups. However, the weakness of any grouped variable should not be wholly attributed to this fact, as it has been found by previous studies that impact assessments have a generally weak impact on decision processes

[40] My dependent variable has only two different outcomes, accepted and rejected. As can be seen in table 13, only 29 projects were rejected, making this my "effective sample".
[41] In my models I use four variables, one independent variable representing the EIA theme, and three for the controls. Giving my models a maximum of seven outcomes per variable (also called "predictors").

(Thygesen and Agarwal, 2014). I found that the best method for grouping the variables together was by taking the mean of the reported variables, as this accounted for all reported impacts. The problem with this method however is that it mitigates high reported impacts if there are other low or negligible impacts in the same theme.

In an attempt to further decrease any uncertainties, I simplified the EIA variables by dichotomizing them into two groups, high and low impact[42], using different cut-offs for grouped and non-grouped variables. The dichotomizing of the EIA variable would make the statistical test more conservative, while still answering my research questions. This is the same method utilized by Inderberg et al. (2020, p. 4), which is the only other study, to my knowledge, that investigates the EIAs impacts on the Norwegian licence outcome for wind power.

Using different cut-off values for what are considered 'high impacts' and 'low impacts' could seriously affect the outcome of the results. I therefore use similar cut-offs as Inderberg et al. (2020, p. 4), which also makes sense in terms of the consequence matrix that has been in wide use throughout the licence process for wind-power. As an answer to using both grouped and non-grouped variables, I decided to use a slightly lower cut-off for the grouped variables in order to compensate for grouping the variables according to the mean, lowering the cut-off to -1.5 instead of -2.

In order to mitigate any uncertainties presented by the utilization of dichotomized variables, I will also inspect the univariate models using continuous variables to either support or disprove my hypothesis. These are presented in the lower half of appendix C.

5.3 Significance testing of the relationships

The most difficult part of researching the impacts of EIAs are making conclusions in the face of uncertainty and distinguishing between noise[43] and actual relationships between EIAs reporting high impacts to the themes focused upon in this study and a lower chance of receiving a licence. When interpreting the results of a logistical regression, the common measurements used to establish whether or not the independent variable has an effect on the dependent variable, are the p-value and confidence intervals. As this method of statistical

[42] Treating reported positive impacts for land-use and recreation as "Low to neutral impacts"
[43] Noise in this context are other factors that would influence the licence outcome.

significance testing is the most commonly taught in Norwegian higher education it is an important aspect of this study.

As the paradigm is based on that one formulates a null hypothesis[44] before the analysis is carried out. The null hypothesis assumes that an effect does not exist. If, on the other hand, the result shows that the estimate is not equal to zero with a p-value smaller than a set limit (traditionally $p < 0.05$). If this is the case, the null hypothesis is rejected, and it can be assumed that an effect exists. It has, however been advocated that this paradigm be abandoned due to concerns of reproducibility for both biomedical and social science literature (McShane et al., 2019). It is further proposed an alternative to using p-value in a screening role, to treat the p-value as just one of many pieces of evidence when interpreting the findings, basing the interpretation on scientific inference instead of statistical inference (McShane et al., 2019, p. 241).

Taking the concerns raised by McShane et al. (2019) seriously, I will endeavour to follow their recommendations in this discussion, taking a more holistic approach when interpreting the results from chapter 4. Rather than blindly assuming between "effect" and "no effect" solely based on the p-value, I will consider the data in light of any previous research, the likelihood of a relationship, the quality of the data collected, external evidence and my research design. To assess if there are any relationships in the data, I will strive to include scientific inference into my conclusions instead of leaning on statistical inference alone. Making scientific inferences based on statistics is a major challenge, but it is important to me to be open about any uncertainties that may exist in the conclusions of this study.

5.4 The logistic model’s ability to predict licence outcome

For logistic model 1-6, I decided to use the receiver operated characteristic (ROC) curve with the accompanying area under the curve (AUC) value to interpret the model’s predictive abilities. As seen from the results, none of the models had very good scores for this measure, with all models scoring very close to 0.6, except the models for heritage and nature who scored somewhat closer to 0.7, while all the others scored closer to 0.6.

As stated by Hosmer et al. (2013), a AUC score of between 0.5 and 0.7 is barely better than flipping a coin, implying that all my models are poor predictors of licence outcome. This is to be expected however, as the EIA investigated in each model only being a single factor in

[44] Assumes the opposite of the hypothesis.

NVE's assessment. A way of investigating the impacts from all the EIAs, would be utilizing a method where all the different EIAs could be reliably modelled together, investigating the relationships between each of the EIAs.

5.5 Do highly negative reported values influence the outcome of the Norwegian licence process for wind power.

For my first research question I asked: *How do perceived societal and ecological impacts influence the likelihood of a wind power licence decisions in Norway?* and as a hypothesis to this question I assumed that: *High negative impacts reported by the EIAs will reduce the likelihood of licence being granted.*

Interpreting findings from the logistic regression, I find partial support for my first hypothesis as high impacts to both heritage and nature substantially lowers the chances for a wind power project to be granted a granted a licence. While the impacts to landscape, recreation, land-use, and sector are more uncertain, as displayed by the high p-values and the 95% CI including the odds ratio of 1. Due to uncertainties during data collection, and as there are issues related to the validity of the method, these results require further discussion before any conclusions can be made.

Building on the foundations laid by Inderberg et al. (2020), I expanded the research in order to investigate more of the EIAs influence on the licence outcome, as the EIA covers a larger scope than the impacts to natural environment. By a broad data collection approach, I collected all the EIAs publicly available in NVE's archives in the effort to investigate the themes reported by the EIA. These EIAs are carried out, as required by NVE , by independent consultants and are frequently carried out by multiple separate consultancies, as different expertise is necessary for the various sub-reports, making the EIAs fairly independent but not above criticism, as there has been no standardized way for the reporting for EIAs, resulting in many different methods of reporting (Norwegian Environment Agency, 2015).

In my study I found that physical problems such as noise, shadow casting, reflective flash, and ice, as well as effects on protected areas such as loss of 'wilderness-like-nature' (as defined by the INON dataset) were difficult to evaluate. The same was true regarding the ramifications for conserved regions and watercourses, in addition to societal impacts. I observed that there were many that reported the scope of the impacts using other measures than the consequence matrix (Norwegian Public Roads Administration, 2006, p. 142), which made it difficult to compare and utilize the themes in the logistic regression. Due to the various reporting systems, and subsequent lack of data, I opted not to pursue further investigation of the EIAs for "physical", "pollution", "protection", and "social", although I still believe my investigation is still extensive enough to cover what could be called a significant portion of the environmental consequences produced by the development of wind power. The loss of these themes should be considered as a weakness of the study, and further research is suggested.

5.5.1 Landscape

For the theme landscape, which is the most consequent theme found during my data collection, the findings were very uncertain. Model 1 estimated that high impacts to landscape had a slightly negative influence on the licence outcome, however as indicated by the high p-value and broad 95% CI values, high negative values reported for landscape does not have any significant impact on the outcome of the licencing process and these results are weak and highly uncertain. There could be a variety of explanations for this weak result. One explanation for this is the skewed distribution of the impacts to landscape after the variable was dichotomized, as can be observed by inspecting table 13. Only 11 projects out of the 83 that were used in the analysis reported impacts that were lower than moderately negative (-2), while all the remaining 72 projects all reported impacts higher that were moderately negative or higher. This is supported by the fact that the reported impacts for landscape are generally high, as can be seen from the pre-grouping descriptive statistics in table 12. The mean impact reported for landscape for the 95 initial projects were the overall lowest of all the reported themes[45], with a mean value at -2.18, indicating that the majority of the projects report impacts that I classify in this thesis as “high impacts”. The landscapes variable poor performance should not be wholly attributed to the method however, as shown by model C7. As this model uses the continuous EIA variables, it is not as affected by the high reported impacts. As the results are still very unclear in this model, it gives a strong indication that impacts to landscape does not carry a large influence on the outcome of the licensing process.

A possible explanation for this finding is that the high reported impacts is the fact that the placement of wind turbines that are visible in the landscape is essentially unavoidable, as they require broad open spaces to operate efficiently. Another reason is that the landscape and its values are based on perception, and the impacts are often shaped by local acceptance. The

[45] If you exclude the single use theme «Boat Traffic».

true impact to landscape is likely to be perceived subjectively. A person or community with negative opinions of wind power would perceive the effect from a visible wind farm in the terrain more negatively than a person or community having a positive opinion of wind power (NVE, 2012, p. 34).

Due to the problems discussed above, and as showed by the findings of model 1, I am unable to conclude how high impacts to landscape influences the outcome of the licencing process. Consequently, I conclude that there are too many uncertainties connected the investigation of this theme.

5.5.2 Heritage

The theme Heritage was a theme reported in all the EIAs used in this study. Its only significant difference in methods of reporting in comparison to landscape is that it was sometimes reported as direct and indirect impacts. Projects with high negative impacts to this theme was found by my model to have a lower chance of being granted a licence. Why this result is significant can be explained by a number of reasons. First, the developer is required by Cultural Heritage Act §9 to investigate if there are any cultural heritage sites in the area projected for development (KLD, 1978). As the investigation of cultural heritage sites is done by physical inspection while developing the project and preparing the EIA, its less likely that the scope and value of the consequences can be predicted, which minimize the chances of project rejection by NVE due to large perceived consequences (Inderberg et al., 2019) or not projecting in the given area due to predicted conflicts. Secondly, the destruction or devaluation of the cultural heritage sites cannot be undone when the wind power plant has outlived its licence and the landscape is being reverted to "its original state" as stated by the Energy act §3-5. Thirdly, the importance of this theme is further stressed by being considered by NVE as a theme of special interested, being assessed by the Directorate for Cultural Heritage using the "thematic conflict assessment" (TKV) system.

There are however some aspects of this result that merit further consideration in its disfavour, as the TKV system for cultural heritage was discontinued by the Directorate for Cultural Heritage, as it was discovered that the TKV system did not have any influence on the screening process or prioritization of the projects (Norwegian Environment Agency, 2015, p. 26). Another aspect is that direct and indirect impacts to heritage sites can in most cases be mitigated. By changing the placement of roads, turbines, and power lines to account for any cultural heritage sites found in an area. By inspecting the model C8 in Appendix C, which uses the continuous variable for heritage, it can be seen that it is not statistically significant, although very close, reporting a p-value of 0.057. As this model still reports (with uncertainty) that higher impacts to heritage will lower the chances of a project being accepted I still feel confident in the results presented by model 2.

Taking all these factors into consideration, I conclude that, according to these methods, if the EIA reports high impacts to heritage, it does in fact, reduce the wind power projects chances of receiving a licence. This partially supports my first hypothesis.

5.5.3 Recreation

Recreation is the third theme in my study of the EIAs impacts on the licencing outcome and was present in 93 out of the 95 projects found with a usable EIA. The impact of recreation was found to be somewhat uncertain, as the model estimated that high negative impacts to recreation would lower a project's chance of receiving a licence, although not statistically significant, warranting further discussion on the results. It can be observed in the descriptive statistics in table 12 that the reported impacts to recreation are generally high, as showed by the relatively low mean of -1.73.

As this theme can be connected to landscape, nature, and cultural heritage (NVE, 2012, p. 40), two of which has been found to have a clear significant effect on the licence outcome, it can be assumed that the projects with high impacts to these themes also have a high impact to recreation, which would cloud the results. This connection can be assumed due to the constructions of wind power projects having been often located in remote and pristine areas because of their attractive wind resources, but the same areas where nature and the environment are still relatively untouched (Inderberg et al., 2020, p. 9), giving them a high value for recreation. As the areas are occupied by the wind turbines, the areas value for recreational use is naturally lowered, while in some cases it was actually reported to increase the areas recreational value as the developed infrastructure allowed easier access to the areas. Recreation was as such one of the few themes where positive impacts were reported, were in one hand it could be interpreted as negative for recreation as it decreases the value for the people wishing to stay out in the open air in leisure time, and who has the intent to change environments and experience nature (St.meld. nr. 39, 2001), while on the other hand increasing the areas recreational value for people with reduced mobility as it provides easier access routes to recreational areas.

As I have focused upon how high negative impacts influences the licence outcome, I have not performed a thorough analysis of these positive impacts and have considered them as low or neutral impacts in my main method, although it should be assumed that they too, influence the outcome. I have however modelled the recreation variable as a continuous variable in model C10, attached in Appendix C, which shows that recreation is the most significant of all six continuous variables.

Due to this theme's close connection to both nature and heritage (who were both found to have significant effects), it seems unlikely that there would be no effect from impacts to recreation. However, according to the method I used, I conclude that the uncertainties connected to the assessment of high negative impacts and a lower chance of project acceptance are too great, and that there are too many uncertainties connected to the investigations of the effects of this theme.

5.5.4 Nature

The impacts to nature, were found in this study to carry significant importance in the outcome of the licencing process. The results indicate that projects with high impacts to nature will have reduced chances to receive a licence. This result, however, also needs further discussion before a conclusion can be made. Although the impacts to nature was found consistently in all the investigated EIAs, the methods used to report the impacts varies, making this the first "grouped" variable in my study to be investigated. The problem encountered when trying to compare the impacts for the different projects were that the impacts to nature was reported in series of different ways, with no single preferred method of reporting emerging. This could be explained by the diverse themes investigated, when determining the scope and value of the impact to natural environment. These themes or sub-reports includes impacts to flora and fauna. The reported impacts to fauna were especially diverse, sometimes dividing the reported impacts by species. These diverse methods of reporting sew some doubts about the results as the method used made the different project impacts harder to compare (Norwegian Environment Agency, 2015). But, on the other hand the findings of Inderberg et al. (2020) are reassuring for the result, as this study reported that there was a strong relationship between having high environmental impacts and a lower chance of being granted a licence. This was also supported by the findings of model C11, attached in appendix C, as the effects of nature was significant across both methods. As result indicates that there is a clear negative relationship between the licence outcome if a project reports large negative EIA values for nature themes, with the additional support of the findings of Inderberg et al. (2020), I have high confidence in concluding that if the EIA reports high impacts to nature it will lower a project's chances of being accepted.

5.5.5 Land-Use

The results reported by model 5 found that the influence of high impacts for land-use were found to be uncertain. The reason why will be discussed here. The impacts reported for land-usage were found, as could be expected, too often be individual for each project based on its geographical location. This was because impacts to land-uses were reported using different sub-themes and were reported were that specific land-usage were affected. This individuality, is what I believe causes the uncertainties surrounding results as the grouping could not accurately account for all the different values and scale of impacts that were reported, compromising the representability of the grouped land-use theme. These uncertainties are supported by model C11 it can be found that the influence of the continuous land-use variable is still uncertain.

The best example of a land usage carrying high weight would be the theme Reindeer herding, which was reported as part of the theme land-use[46]. As reindeer herding is regarded as a theme of special interest by NVE, it can be assumed that this type of land usage carries extra weight in NVE's assessments. An assumption which can be backed by observations from the data collections, as the projects Blåheia, Kopperaa, and Hammerfest (NVE, 2010a; 2013b; 2013a), were all rejected based on their high impact to reindeer herding and Sami interests. The acceptance of the project Raggovidda I&II casts some doubt on these observations however, as this is the project that reported the highest impact to reindeer herding found during the data collection (NVE, 2010b). It should also be noted that theme of reindeer herding, and Sami interests is considered as a theme of particular interest by NVE, as it is part of the TKV system, and should be investigated further.

The result indicates that there are too many insecurities for how high impacts to land-use influences the licencing process and the method and data collection needs further improvements in order to correctly assess the relationship between high impacts to land-use and licence outcome. I therefor conclude that, according to this method, the impacts to land-use are too uncertain to safely conclude on its influence on the licence outcome.

[46] It was however only reported in a total of 30 out of the 95 project EIAs.

5.5.6 Sector

How high impacts to sector influences the outcome of the licencing process has been found to be highly uncertain. It can be observed that the general impacts to all the three themes aggregated together were reported were relatively low and were in most cases reported as negligible, causing only 2 out of 83 projects to report what my method defines as high impacts. There were some moderate reported conflicts with defence, but these could be observed as being of weak importance[47]. I can think of three reasons for this, the first is that impacts to sector, especially as conflicts with defence interests and aviation are easily predicted, the areas in question are avoided. Second reason would be, that if a project with significant impacts to either defence or aviation is detected early in the notification stage by TKV reports, it can be assumed that these would be halted or withdrawn. Thirdly, according to the TKV system, impacts reported as “C” or medium are possible to mitigate with smaller adjustments to the project, such as the moving or removal of a small amount of wind turbines (NVE, 2009). Only the project Faurefjellet reported impacts above “C” for defence.

These results indicate large insecurities surrounding how high impacts to sector influences the licencing process and the model would need significant improvements in order to correctly assess the relationship between high impacts and licence outcome. The insecurities of the results could be explained by the distribution of low and high impacts for sector (see table 13), which are highly skewed, but by inspecting model C12 in Appendix C, the continuous variable for sector is also far from significant. It can be assumed from the very few reported high negative impacts on this theme, that these are not taken lightly at all, or possibly that projects with these expected impacts are avoided all together.

My conclusion is that, due to a complex data collection and uncertainties in the licencing process, I can’t conclude how high negative impacts to sector reported in the EIA will influence the outcome of the licence process.

5.6 How are the different EIAs weighed

For my second research question I asked: *Are the EIAs weighted differently? Will high impacts to a single EIA be enough for a project to be rejected?* and as a hypothesis to this question I assumed that: *The EIAs will not be weighed equally. They will however not be influential enough to predict the outcome of the licence process.*

[47] Nine out of ten projects who reported a medium conflict to defence were approved.

By investigating how the different EIA variables influence the licence outcome, inspecting their p-value and 95% confidence intervals I found that the themes heritage and nature are the most important themes. They are statistically significant, indicating that high impacts to these will decrease a project's chance of receiving a licence. They are followed by the theme's recreation and land-use who are both close to having statistically significant effects on the outcome of the licence process, indicating some uncertainty in the effects. The two remaining themes are Landscape and Sector who are both very uncertain. The difference between these two themes were that the landscape variable was a non-grouped variable that consequently reported high impacts, while sector was a grouped variable for which were almost consequently reported low impacts. Both were also found to be very uncertain by the models C7 and C12, using continuous variables for both.

By looking at the AUC values for each of the models, it was found that none of none of the six models reaches the AUC threshold of 0.7. This implies that high impacts to neither one of the EIAs in my study can be used as an accurate predictor of the licence outcome on their own. While some EIA themes might be considered more important than others in the final assessment of the licensing process, it has been proven that high impacts to any single theme will not be enough to accurately predict the licence outcome.

I conclude that the most important themes found in this analysis are heritage and nature, none of the themes in this study carry enough weight by themselves to accurately predict the outcome of the licence process.

5.7 Limitations of the study

This study has several limitations and weaknesses that are worthy of discussion, and my goal for the interpretation of the results is to be as open as possible on any challenges, issues and uncertainties that existed when performing this study. The process has been challenging, and the issues have been many.

The main challenge, as expected when posing my research questions, was the many problems encountered when gathering the EIA-data due to the complexity of the licence process and the lack of a set standard for reporting. It was reported by the Norwegian Environment Agency (2015) that there were no guiding method for how to report the environmental impacts, other than the method used by The Norwegian Public Roads Administration to report non-priced environmental impacts (Norwegian Public Roads Administration, 2006). This I observed during my data collection to be true, and the amount of available and usable data has also been a limiting factor in this study. These inconsistencies and lack of data has caused many issues when trying to compare the impacts both within the projects themselves and between projects, both due to lack of data and inconsistencies in the reporting.

As a possible answer to this I tried aggregating the different impacts found in the EIAs into groups. In order to further decrease any uncertainties I followed the method used by Inderberg et al. (2020) and dichotomizing the impacts for each variable into high and low. The effects of both the grouping and the dichotomization could in addition to simplifying the result and complexity of the data, have unknown consequences for the results. This is due to the cut-off points that are used to determine which impact is considered as high and low, and that the results would. The fact that I also used different cut-off values for the grouped and non-grouped variables are also matter of debate and it can be argued that the grouped and non-grouped variables are no longer comparable due the different cut-off points.

Another weakness of the method I have used was the inability to investigate physical, pollution, protection, and society alongside the other variables. This means that I am not investigating all environmental impacts in the licencing process for wind as I have not been able to investigate all the themes that are normally reported in the EIA. It can also be assumed that by investigating the EIA variables independently and not together, I weaken the predictive powers of my models as they are clearly assessed as a gathered impact and not one and one.

Aside from the statistical problems encountered in the method, there are also other factors that increases the uncertainty surrounding the results. One important factor that gave me considerable trouble while investigating the EIAs influence on the licence outcome were the screening process utilized by NVE. This screening process is first discussed by Norwegian Environment Agency (2015) in their assessment of the licencing process, and explanation of the effect of TKVs. The effects of the screening process is further expanded upon by Inderberg et al. (2019), who found that NVE has developed a practice to advice developers to withdraw projects they regard as unfeasible. While the TKVs indicates that there are themes of special interest to NVE, the effects of which can be clouded by the fact that they potentially have removed projects early in the licence process (Fauchald, 2018, p. 40), possibly halting projects with large impacts (proof of informal screening process was found during the data collection and is presented in chapter 3.4.1). While this practice is mutually beneficial for both the NVE, OED and the developers, conserving both time and resources, its informal nature can be assumed to cause a loss of data on the impacts that are the most influential in terms of reducing a project's chance at being granted a licence.

The complexity of the licence decision itself is also a factor that most likely causes major insecurities in the results, as the decision involves so many factors that they are impossible to account for using simple logistic regression. The controversies and EIAs are found to be distinct for each community (Rygg, 2012). There are mitigating measures to account for, distance from the project to the existing power-grid and the environmental impacts of building new powerlines, cumulative effects of clustered wind power projects, municipality stance etc. In addition to all these different factors it can also be argued that political situations and goals discussed in chapter 2.6 and 2.7 would add pressure on the licencing authorities to accept projects in order to reach political goals (For example Norway's goal of increasing the renewable share of the energy sector to 32% (KLD, 2020).

6. Conclusion

I asked: *How do perceived societal and ecological impacts influence the likelihood of a wind power licence decisions in Norway and are the EIAs weighted differently? Will high impacts to a single EIA be enough for a project to be rejected?*

For this study have I utilized information from all finalized wind power projects that were accessible through NVEs archives from the period of 2000 until 2020. In addition, I only used projects whose applications were larger than 10 MW. This yielded a total sample of 95 usable wind power projects. From these I manually coded data from the EIAs found in NVEs archives in order to create a new dataset that could be used in a statistical analysis.

For the 95 projects in my sample, there were a total of 37 different EIA themes reported. The methods used for the reporting of EIAs is recognised to be very unsystematic (Norwegian Environment Agency, 2015). Due to the sporadic and unsystematic reporting of EIA variables, it was impossible to investigate them without some modifications. I therefore aggregated the EIAs together into 10 grouped variables, leaving me with a total of 10 themes: 1) landscape, 2) heritage, 3) recreation, 4) nature, 5) physical, 6) pollution, 7) protection, 8) land-use, 9) sector and 10) society. However, as inconsistencies remained also after grouping, I was forced to abandon any further investigation of the themes 5) physical, 6) pollution, 7) protection and 10) society. In addition to leaving out four themes I was also forced to reduce the sample of project from 95 to 83 to remove all the remaining inconsistencies. In order to accurately answer my research questions, I followed the method used by Inderberg et al. (2020), dichotomizing the impacts reported for the EIA themes into "High" and "Low" impacts.

My findings show that if the EIAs of a project report high environmental impacts to the themes heritage and nature it will reduce the developer's chances to be granted a licence of this project. The results for the other themes were, however, less conclusive. This is, to my knowledge, the first time it has been found that high negative impacts reported for cultural heritage will decrease a projects chances of being accepted, while the influence of high impacts to nature have previously been investigated and is confirming my results (Inderberg et al., 2020). This strengthen my first hypothesis, as I can prove that high impacts on to two themes will lower a projects chance of receiving a licence. However, I am unable to prove that similar high impacts from other themes have any effect on a project's changes of receive a licence.

None of the models were found to have any significant predictive value, which demonstrate that high impacts to a single EIA theme can't be used to predict the outcome of the licence process. Nevertheless, this study has shown that the different EIA themes investigated are weighted differently as I can't prove any significant influence of the EIA themes landscape, recreation, land-use and sector, the themes nature and heritage have a proven significant influence on the licencing process. This strengthens my second hypothesis that the EIAs are assessed differently.

As controversies related to development of wind power vary geographically between Norwegian municipalities (Rygg, 2012) and there are a large variety of them being reported. The fact that I find no effect from the themes landscape, recreation, land-use, and sector, and as the effect from the left-out EIA themes (physical, pollution, protection, and society) remain unknown, indicates that the influence of a majority if the EIA made are still unclear. These uncertainties surrounding the outcome can be attributed to the complexity of the licencing process and a lack of clear guidelines for how to report assess environmental impacts (Fauchald, 2018; Norwegian Environment Agency, 2015). The Norwegian Environment Agency (2015) also found that the TKV system utilized by NVE to assesses impacts to themes of "special interest" (which include reindeer herding, impacts to defence purposes and environment and cultural heritage) have little influence on the process.

Even though I have found partial support for both hypothesises, that high impacts for EIAs lower a developer's chances of receiving a licence to build and operate a wind power facility, and that the EIAs are weighted differently, I would opinion that the EIAs are a poor measure for predicting these outcomes. As an alternative or supplement to this thesis, I would suggest further investigation of how other factors than the EIAs influence the licence process. I would also suggest further investigation how the EIA themes physical, pollution, protection and society are reported and if this process can be improved in order for their influence on the licensing process to be clearer, as these require a more elaborated study. As a final recommendation, I also suggest a detailed investigation of NVE's use of the TKV system and how they evaluated the advice given by the consulting agencies.

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Appendix A

The R script which is presented here can also be found on GitHub and is downloadable from:

https://github.com/TorbjornBNilsen/Master_thesis2022_Natural_Resource_Management

Appendix B

List of applications and their status, including only who received a licence decision

Table B.1 List of applications and their status.

Title	EIA status	Application status
Andmyran	Usable	Licence granted
Bessakerfjellet I	Usable	Licence granted
Bjelkeberget	Usable	Licence granted
Bjerkreim (Eikeland)	Usable	Licence granted
Bjerkreim (Steinsland)	Usable	Licence granted
Blåheia	Usable	Application rejected
Bremangerlandet	Usable	Licence granted
Brosviksåta	Usable	Licence granted
Brusali - Karten	Usable	Application rejected
Buheii	Usable	Licence granted
Bukkanibba	Usable	Application rejected
Dalbygda	Usable	Licence granted
Døldarheia	Usable	Application rejected
Dønnesfjord	Usable	Licence granted
Egersund	Usable	Licence granted
Engvikfjellet	Usable	Application rejected
Fakken	Unusable	Licence granted
Fálesrášša (Kvalsund)	Usable	Application rejected
Faurefjellet	Usable	Licence granted
Friestad	Unusable	Licence granted
Fræna	Not Available	Application rejected
Frøya	Usable	Licence granted
Geitfjellet	Usable	Licence granted
Geitfjellet (Zephyr AS)	Usable	Application rejected
Gilja	Usable	Licence granted
Gismarvik	Usable	Licence granted
Gravdal	Usable	Licence granted
Guleslettene	Usable	Licence granted
Hammerfest	Usable	Application rejected
Hamnefjell	Usable	Licence granted
Haram	Usable	Licence granted
Harbaksfjellet	Usable	Licence granted
Haugshornet	Unusable	Application rejected
Haugøya (Test turbine)	Unusable	Licence granted
Havsul I (Offshore)	Unusable	Licence granted
Havsul II (Offshore)	Unusable	Application rejected
Havsul IV (Offshore)	Unusable	Application rejected
Havøygavlen (Reestablishment)	Unusable	Licence granted
Heimsfjellet	Usable	Application rejected
Hennøy	Usable	Licence granted
Hitra I	Usable	Licence granted
Hitra II	Usable	Licence granted

Holmafjellet	Not Available	Application rejected
Hovatn Aust	Usable	Application rejected
Hovden	Unusable	Application rejected
Hundhammerfjellet	Not Available	Licence granted
Hundhammerfjellet (Reestablishment)	Unusable	Licence granted
Hundhammerfjellet demo I	Not Available	Licence granted
Hundhammerfjellet demo II	Not Available	Licence granted
Hywind (Offshore)	Unusable	Licence granted
Høg-Jæren	Usable	Licence granted
Innvordfjellet	Usable	Licence granted
Kalvvatnan	Usable	Application rejected
Karmøy (Floating offshore demo)	Unusable	Licence granted
Karmøy (Non-floating offshore test facility)	Unusable	Licence granted
Kjølberget	Usable	Licence granted
Kjølen	Usable	Application rejected
Kjøllefjord	Usable	Licence granted
Kollsnes	Usable	Application rejected
Kopperaa	Usable	Application rejected
Kvalsund (Ulveryggen & Magerfjellet)	Usable	Application rejected
Kvalvåg	Not Available	Application rejected
Kvenndalsfjellet	Usable	Licence granted
Kvinesheia	Usable	Licence granted
Kvitfjell	Not Available	Licence granted
Kvitsøy	Unusable	Licence granted
Kvitsøy (Reserach project- Offshore)	Unusable	Licence granted
Kvitvola/Gråhøgda	Usable	Application rejected
Langevåg	Usable	Application rejected
Lillesand	Usable	Licence granted
Lindesenes (Reestablishment)	Unusable	Licence granted
Lista	Usable	Licence granted
Lutelandet	Usable	Licence granted
Lutelandet (Test facility)	Unusable	Licence granted
Magerøya	Not Available	Application rejected
Marker (Elgåsen)	Usable	Application rejected
Marker (Høgås)	Usable	Licence granted
Marker (Joarknatten)	Usable	Licence granted
Maurneset	Unusable	Application rejected
Mehuken II	Usable	Licence granted
Mehuken III	Unusable	Licence granted
Midtfjellet	Usable	Licence granted
Moi-/Laksesvelafjellet	Usable	Application rejected
Moldalsknuten	Usable	Licence granted
Mosjøen	Usable	Application rejected
Måkaknuten (Downscaled "Ulvarudla")	Usable	Licence granted
Nevlandsheia	Usable	Application rejected
Nygårdsfjellet I	Unusable	Licence granted
Nygårdsfjellet II	Usable	Licence granted
Odal (Engerfjellet)	Usable	Licence granted

Odal (Songkjølen)	Usable	Licence granted
Oddeheia	Usable	Licence granted
Okla	Usable	Licence granted
Rákkocearro (Raggovidda) I & II	Usable	Licence granted
Rakkocearro (Raggovidda) III	Unusable	Licence granted
Rapheia	Usable	Application rejected
Raskiftet	Usable	Licence granted
Raudfjell	Usable	Licence granted
Remmafjellet	Usable	Licence granted
Rennesøy (Reserach project - Offshore)	Unusable	Licence granted
Rieppi	Usable	Application rejected
Roan	Usable	Licence granted
Røst	Unusable	Application rejected
Røyrmyra	Unusable	Licence granted
Sandhaugen (Research project)	Unusable	Licence granted
Selbjørn	Not Available	Application rejected
Siragrunnen	Unusable	Application rejected
Skallhalsen	Not Available	Application rejected
Skinansfjellet	Usable	Licence granted
Skogvatnet	Usable	Application rejected
Skomakerfjellet (Bessakerfjellet II)	Usable	Licence granted
Skorveheia	Usable	Licence granted
Skurvenuten	Unusable	Licence granted
Skveneheii	Usable	Application rejected
Sleneset	Usable	Application rejected
Smøla	Not Available	Licence granted
Smøla (NEAS)	Not Available	Application rejected
Stadlandet	Not Available	Application rejected
Stigafjellet	Usable	Licence granted
Stokkfjellet	Usable	Licence granted
Stolmen	Not Available	Application rejected
Store Kalsøy	Not Available	Application rejected
Storhei	Usable	Application rejected
Storheia	Usable	Licence granted
Storøy	Unusable	Licence granted
Svarthammaren / Pållifjellet	Usable	Licence granted
Svåheia	Unusable	Licence granted
Sørfjord	Usable	Licence granted
Sørmarkfjellet	Usable	Licence granted
Tellenes (Helleheia)	Usable	Licence granted
Tellenes (Tellenes)	Usable	Licence granted
Test area Stadt - Floating windturbines	Unusable	Licence granted
Tindafjellet	Unusable	Licence granted
Tonstad	Usable	Licence granted
Tysvær	Usable	Licence granted
Ulvarudla	Usable	Application rejected
Utsira	Unusable	Licence granted
Valsneset	Not Available	Licence granted

Valsneset (Test facility)	Unusable	Licence granted
Vardafjellet	Usable	Licence granted
Vardøya	Unusable	Licence granted
Vikna	Unusable	Licence granted
Vågsvåg	Usable	Application rejected
Ytre Sula	Unusable	Application rejected
Ytre Vikna I	Usable	Licence granted
Ytre Vikna II	Unusable	Licence granted
Øyfjellet	Usable	Licence granted
Ånstadblåheia	Usable	Licence granted
Åsen II	Unusable	Licence granted

Appendix C

A list of all single variable EIAs using the dichotomized variables, and below are the models utilizing EIA as a continuous variable.

Appendix C 1: Model 1 excluding the control variables.

Model C1	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	2.67	0.77 – 12.17	0.147
Landscape [High Impact]	0.66	0.14 – 2.52	0.569
Observations	83		
R^2 Tjur	0.004		
AIC	111.075		
log-Likelihood	-53.537		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 2: Model 2 excluding the control variables.

Model C2	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	3.17	1.71 – 6.33	**<0.001**
Heritage [High Impact]	0.3	0.11 – 0.75	**0.012**
Observations	83		
R^2 Tjur	0.08		
AIC	104.825		
log-Likelihood	-50.413		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 3: Model 3 excluding the control variables.

Model C3	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	2.9	1.46 – 6.26	**0.004**
Recreation [High Impact]	0.45	0.17 – 1.14	0.097
Observations	83		
R^2 Tjur	0.034		
AIC	108.579		
log-Likelihood	-52.29		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 4: Model 4 excluding the control variables.

Model C4	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	5.00	1.89 – 17.19	**0.003**
Nature [High Impact]	0.27	0.07 – 0.83	**0.032**
Observations	83		
R^2 Tjur	0.06		
AIC	106.04		
log-Likelihood	-51.02		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 5: Model 5 excluding the control variables.

Model C5	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	2.23	1.36 – 3.75	**0.002**
LandUse [High Impact]	0.32	0.09 – 1.11	0.075
Observations	83		
R^2 Tjur	0.041		
AIC	108.197		
log-Likelihood	-52.098		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 6: Model 6 excluding the control variables.

Model C6	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	1.89	1.21 – 3.03	**0.006**
Sector [High Impact]	0.53	0.02 – 13.70	0.656
Observations	83		
R^2 Tjur	0.002		
AIC	111.219		
|log-Likelihood	-53.609		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 7: Modelling the continuous landscape variable.

Model C7	**Dependent variable**		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	3.58	0.63 – 23.79	0.164
Landscape	1.34	0.62 – 3.03	0.458
Observations	83		
R^2 Tjur	0.007		
AIC	110.854		
log-Likelihood	-53.427		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 8: Modelling the continuous heritage variable.

Model C8	**Dependent variable**		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	4.91	1.68 – 16.43	**0.006**
Heritage	1.86	1.00 – 3.63	0.057
Observations	83		
R^2 Tjur	0.048		
AIC	107.554		
log-Likelihood	-51.777		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 9: Modelling the continuous recreation variable.

Model C9	**Dependent variable**		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	14.13	2.80 – 99.49	**0.003**
Recreation	3.09	1.31 – 8.43	**0.017**
Observations	83		
R^2 Tjur	0.074		
AIC	104.385		
log-Likelihood	-50.192		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 10: Modelling the continuous nature variable.

Model C10	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	9.67	2.07 – 56.35	**0.007**
Nature	2.58	1.11 – 6.63	**0.036**
Observations	83		
R^2 Tjur	0.056		
AIC	106.538		
log-Likelihood	-51.269		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 11: Modelling the continuous land-use variable.

Model C11	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	2.11	1.31 – 3.55	0.003
LandUse	1.39	0.90 – 2.24	0.147
Observations	83		
R^2 Tjur	0.027		
AIC	109.215		
log-Likelihood	-52.608		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

Appendix C 12: Modelling the continuous land-use variable.

Model C12	Dependent variable		
	Project licence approval		
	OR	*CI*	*p*
(Intercept)	2.21	1.28 – 3.97	**0.006**
Sector	1.76	0.60 – 5.22	0.3
Observations	83		
R^2 Tjur	0.013		
AIC	110.345		
log-Likelihood	-53.173		

Observations are the number of projects that has received a licence decision that are included in the model. Coefficients that have a p-value <0.05 are marked in bold. OR = Odds ratios, CI = Confidence interval, p = p-value. The variables are described in chapter 3.4.

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