UNIVERSITY OF GOTHENBURG

DEPARTMENT OF MARINE SCIENCES

UNVEILING THE FUTURE:

Exploring Sweden's opportunities to transition to an auction-based system for offshore wind.

Hanna Savolainen

Thesis project for Master of Science (120 hp) with a major in Sea and Society
MAR480. 30 ECTS.
Second Cycle

Semester/year:	Spring 2023
Supervisor:	Lena Gipperth. Law.
Examiner:	Gabriela Arguello. Law.

POPULAR SCIENTIFIC SUMMARY

A successful energy transition in the European Union would reduce greenhouse gas emissions to 55% of 1990 levels. Furthermore, Russia's invasion of Ukraine has enforced targets of achieving independence in the energy market for the European Union and its member states. This can be achieved through an increased offshore wind sector because European companies are some of the best producers of necessary supplements in all parts of the process of establishing offshore wind. Producing energy from offshore wind has the benefit of providing more stable conditions than land-based alternatives. Additionally, technological development has helped offshore wind produce more energy, become more cost-efficient, and can soon be built on depths up to 2 kilometres. As a European member state, Sweden is going through the energy transition and has introduced targets to double its energy production by 2045. Offshore wind has the potential to support reaching the targets set by the nation. However, the current system for offshore wind establishment impedes offshore wind expansion and puts developers at risk. An auction-based system could support a structured, more simplified, and expanded deployment of offshore wind, and has been adopted by some of the world's leading nations in offshore deployment. This thesis aimed at providing knowledge about possible pathways to an auction-based system for offshore wind establishment in Sweden. Knowledge about necessary conditions, possibilities, and obstacles was studied through a literature review, focussing on the cases of Germany, Denmark, and Sweden. The study found that offshore wind expansion succeeds in nations where innovation and policies produced by the government are aligned. Further, the study found potential inspiration sources that could be adapted to the Swedish context if the nation established an auction-based system. Some findings included ensuring a seamless transition, handling old approvals, ensuring competition, and drawing on transitions to auction-based systems from other sectors. These suggestions can help Sweden to succeed better to create the right conditions for an expansion of the offshore wind sector through an establishment of an auction-based system.

ABSTRACT

The energy transition to reduce greenhouse gas emissions and the Russian Federation's war on Ukraine has incentivised targets of European independence in the energy market. Offshore wind is deemed an important energy source because technological advancements have made the sector cost-efficient while producing more capacity than before. Lower conflicts on the ocean allow for larger establishments with higher energy production. The Swedish scheme for offshore wind establishment impedes the possibility of the nation accelerating deployment. The Swedish scheme requires engagement with multiple regulatory bodies, and poses financial risks to developers, while legal unclarities for offshore wind deployment are present. Several Swedish agencies have posed suggestions to launch an auction-based system. This thesis aimed at providing knowledge about possible pathways to an auction-based system for offshore wind establishment in Sweden. Knowledge about necessary conditions, possibilities, and obstacles was studied through a literature review, focussing on the cases of Germany, Denmark, and Sweden. Reports from authorities and academic articles on the subject were examined. The study found potential inspirational sources that could be adapted if Sweden established an auction-based system. The findings included ensuring a seamless transition, ensuring competition, and drawing on transitions from other national sectors. These suggestions may support Sweden to better succeed in creating the right conditions for accelerating offshore wind deployment through an auction-based system.

UNIVERSITY OF GOTHENBURG

DEPARTMENT OF MARINE SCIENCES

Table of Contents

Introduction

1.1 Energy targets and policies in the EU

The European Union and its member states face challenges of increasing energy needs in the future, while the production and use of energy accounts for more than 75% of the continent's greenhouse gas emissions (European Commission, n.d; European Commission, 2022). The EU launched the European Green Deal in 2019, a long-term growth plan enshrined in European Climate Law and aims to achieve a climate-neutral and sustainable economy by 2050 to decrease greenhouse gas emissions by a minimum of 55%, compared to 1990 levels, becoming a resource-efficient and competitive economy while addressing climate change (European Commission, 2022). The European Green Deal includes measures and targets in several key areas, such as energy, transport, agriculture, industry, and infrastructure within which renewable energy will increase while promoting circular economy, innovation, and improving energy efficiency (European Commission, 2022).

Further incentives to increase renewable energy have been introduced in response to the Russian Federation’s war against Ukraine, which has put the European Union’s energy security at risk by reducing natural gas supplies to EU member states (European Commission, 2022). The REPowerEU Plan was presented as a response to the disruption in the energy market caused by Russia, to accelerate the process of transforming Europe’s energy system to end the dependence on Russian fossil fuels (European Commission, 2022). To accelerate the deployment of renewable energy in European member states, the European Council introduced regulation 2022/2577 on December 22, 2022, which provides a framework with guidelines to encourage member states to invest in renewable energy and reduce their dependence on fossil fuels. The regulation highlights the acceleration of renewables in other world nations, which challenges the European outlook in the area. On 14 March 2023, the Commission proposed a revision of the rules on the market design of electricity to increase the resilience of the EU energy market and reduce dependency on short-term agreements on electricity prices, which can be achieved through long-term contracts and agreements (European Parliament, 2023). The proposed changes aim to protect customers and accelerate

renewable energy deployment and integration, improving stability, transparency, and predictability.

1.2 Offshore wind in the EU

The offshore wind industry is constantly evolving, with advancements in technology increasing its efficiency and potential for providing predictable and sustainable energy. As the European Union strives to transition to cleaner energy and reduce its dependence on energy imports, offshore renewables offer a crucial solution by harnessing energy from the ocean through various technologies (European Commission, n.d). The EU is also a leader in developing new technologies for wind turbine components, such as cables and foundations, which supports the reduction of energy imports and aligns with Regulation (2022/ 2577). As a core energy source, offshore wind is an essential part of reaching the EU's climate and energy targets and aligns with initiatives such as the European Renewable Energy Directive and the European Green Deal.

1.3 Sweden

1.3.1 The energy transition in Sweden

Sweden is currently in the process of transitioning away from the use of fossil fuels, like other EU member states (European Commission, 2019; Energimyndigheten, 2022). This transition is aimed at reducing CO2 emissions and increasing energy independence. Compared to other European nations, Sweden has a relatively low dependence on fossil fuels and has made significant progress in reducing CO2 emissions (Eurostat, 2021). In 2021, the country's total energy production amounted to 166 TWh, with 140 TWh consumed domestically and 26 TWh exported. (SCB, 2021; Energimyndigheten, 2022). According to Eurostat (2021), over 60 percent of the nation's share of energy comes from renewable sources. Electricity demand is expected to increase from the current 140 TWh to the range of approximately 210-370 TWh by 2045, depending on various scenarios produced by the Swedish Energy Agency and Svenska Kraftnät (Energimyndigheten, 2020; Energimyndigheten, 2022). To meet the energy need, the expansion rate of electricity production will need to be at an historically high level until 2035 (Energimyndigheten, 2022). In the short term, onshore wind has the potential to

technically and economically account for the most considerable increase, while offshore wind and nuclear energy has significant potential to reach the increased demand in the long-term, until 2045 (Energimyndigheten, 2023). The higher levels of electricity need presumes that there will be significant expansion of electrification across industries. In comparison, the lower levels are based on presumptions of lower electrification across various sectors. This can be due to shortage of available electricity grid and lower conversion efficiency to fossil-free fuels (Energimyndigheten, 2022).

1.3.2 Swedish development of offshore wind

Offshore wind has until now, not been a prioritisation for the nation. Approximately 0,6 TWh is produced annually, with no additional offshore wind projects commissioned after 2013 (Svensk Vindenergi, 2022). However, the Swedish Government has produced several assignments that can support an expansion of offshore wind. The governmental assignments have included investigation of solutions to legally facilitate offshore wind establishment, coexistence solutions for offshore wind with surrounding interests and adding areas corresponding to 90 TWh offshore wind in the marine spatial plans (SwAM, 2022; Energimyndigheten, 2023). Most recently, the government launched a governmental assignment to streamline the establishment of offshore wind power (Dir. 2023:61).

1.3.3 Establishment of offshore wind through an open-door procedure

The schedule for offshore wind establishment in Sweden is internationally known as the open-door procedure where project developers apply for permission to establish offshore wind at their initiative, this provides flexibility for developers in choosing sites (SwAM, 2022). However, the procedure comes with high investment risks as projects are rejected mainly due to conflict of interests with sectors including the Swedish defence, nature conservation and shipping (SwAM, 2022). Furthermore, the design of the open-door procedure has caused permitting processes to decelerate. Investors reach significant levels of uncertainties during several steps in the application process for offshore wind deployment, as it can take developers years to pass all licensing processes (SwAM, 2022; FOI, 2022). Sweden’s potential to reach the energy targets are challenged with the current design, as it impedes large scale deployment of offshore wind through slow licensing procedures and

inflexibility in allowing for updated technological solutions, which may be introduced during the long processing times (FOI, 2022; SwAM, 2022). To succeed with the national energy transition, involved actors need effective and long-term guidelines to continue investing in the sector (Energimyndigheten, 2023).

1.3.4 Auction-based system for offshore wind deployment

The Swedish Marine and Water Management (SwAM) has been commissioned by the government to propose solutions for legislation on exclusive rights to deploy offshore wind in the territorial sea and exclusive economic zone. Solutions presented by the agency included temporary exploration permits in an open-door procedure, the introduction of an auction-based system, and a sectoral law (SwAM, 2022). The adoption of an auction-based system has been proposed by SwAM as a potential solution to the challenges posed by the current open-door procedure. This approach is believed to offer several advantages, including increased efficiency, predictability, and reduced uncertainties in the application process (SwAM, 2022). Furthermore, it enables the large-scale deployment of offshore wind and minimizes investment risks for developers. It is worth noting that the Swedish defense and the Swedish Defense Research Agency also support the implementation of an auction-based system (Försvarsmakten, 2020; FOI, 2022).

1.4 Aim and research questions

Establishment of an auction-based system to expand offshore wind deployment in Sweden has never been studied before. This thesis will build on the governmental assignments produced by SwAM to study the area further.

The aim of this thesis is to provide knowledge about possible pathways to an auction-based system for offshore wind establishment in Sweden. Knowledge about necessary conditions, possibilities and obstacles for such societal transition is gathered with the intention of inspiring future transition procedures. Societal transitions have occurred in various sectors; however, there is a knowledge gap of societal transitions that can accelerate the establishment of offshore wind projects through an auction-based system. This thesis focuses on the cases Sweden, Germany, and Denmark.

Research questions

- Which learning outcomes have derived from the establishment of auction-based systems?
- What challenges for stakeholders are associated with an implementation and operation of an auction-based system?
- Which approaches used in other nations could benefit or support a transition to an auction-based system in Sweden?

2 Background

This background chapter presents information on both the European energy market and on the three cases (Germany, Denmark, and Sweden) focussed on in this thesis. The ambition is to provide a better understanding of the current technologies, past, present, and future challenges.

2.1 Offshore wind technologies

Offshore wind comes with potential of utilising higher wind speeds from the sea and deployment of large wind parks since the spatial conflicts are lower compared to on land (MacKinnon, et al., 2019).

Advancements in technology are improving the sector, leading to the construction of larger and more cost-efficient structures, increased electricity production, and improved adaptation to wind conditions across different spaces (Energimyndigheten, 2017; Energimyndigheten, 2023). Fixed-bottom support structures are deployed in shallow waters with depths up to 60-70 metres and may eventually reach 100 meters (Energimyndigheten, 2023). In the future, floating arrangements will be available at depths of up to 2 kilometers (Energimyndigheten, 2023).

The industry faces several challenges, such as the increasing costs of wind parks located further away from the coast and onshore grid connections (UNFCCC, 2022). Consequently, larger projects are necessary to ensure economic viability (SwAM, 2023). Additionally, offshore wind technology has a shorter lifespan and higher installation, operation, and maintenance costs compared to onshore wind (European Commission, n.d.). However, the technology generates about 40% more power on average than onshore wind, which partly compensates for the higher costs. (Energistyrelsen, 2022; Energimyndigheten, 2022).

Environmental challenges

Offshore wind poses impacts on marine life during both the construction and operation phases.

Marine mammals, such as dolphins and porpoises, are particularly vulnerable to underwater noise created during construction (Energimyndigheten, 2023; SwAM 2023; Thomsen &

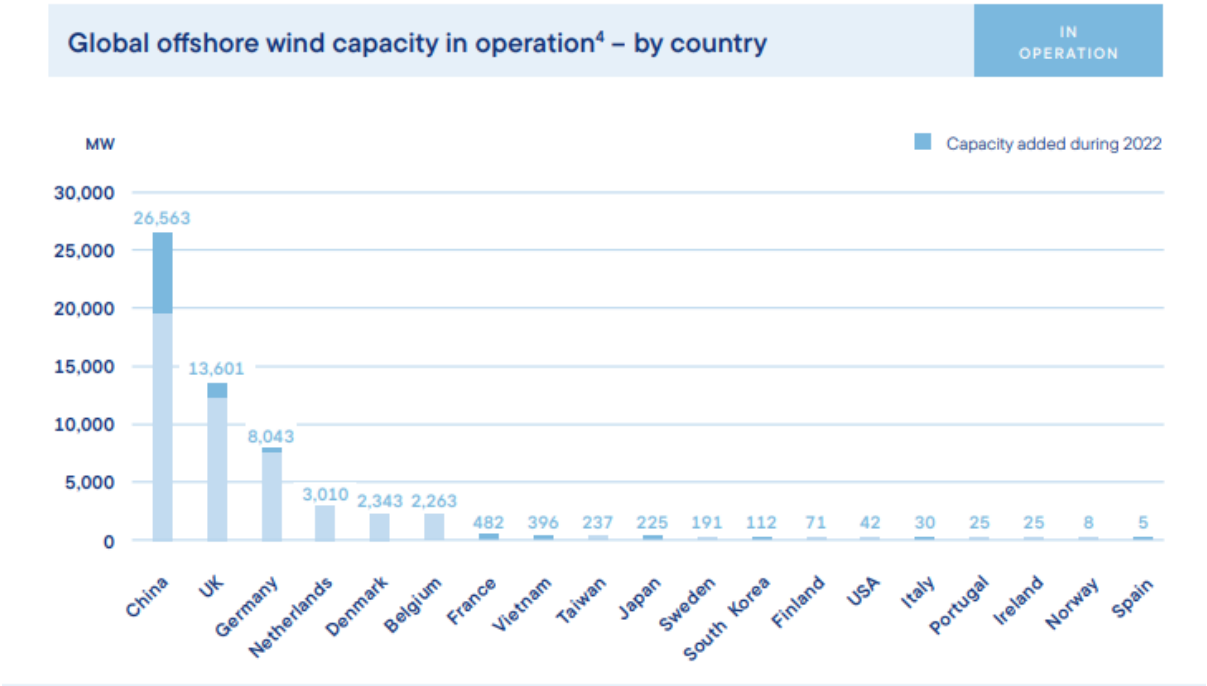
Stöber, 2022). Sea birds may also be affected during the operation phase, which could result in collision risks, displacement, barrier effects, and habitat loss (SwAM, 2023; IUCN, 2021). Studies have shown that painting one rotor blade black can reduce the risk of bird fatalities from collisions by more than 70% compared to unpainted blades (May et al., 2020; Thaxter et al., 2018). In the Netherlands, testing is underway to determine the effectiveness of temporarily shutting down offshore wind parks to reduce impacts on bird migration (Memija, 2023).

On the other hand, there is currently no conclusive evidence of long-term environmental impacts on marine habitats caused by offshore wind energy, and it may even have positive effects by creating artificial reefs and protecting marine organisms from stressors caused by fishing activities (Dahlgren, 2023). However, further research is needed to fully understand the impact of offshore wind energy on the environment.

2.2 International overview

According to the World Wind Energy Association (WFO) (2023), the top five countries in offshore wind capacity are China, the United Kingdom, Germany, the Netherlands, and Denmark, as shown in Figure 1. All these countries have implemented auction-based systems for offshore wind.

Figure 1: Global offshore wind capacity in operation by country (all turbines installed). (WFO, 2023).



2.2.1 Offshore wind in reaching EU energy targets

The EU has established a strategy for offshore energy production with common targets of 60 GW (240 TWh) of offshore wind power by 2030 and 300 GW (1200 TWh) by 2050. Currently, the union's installed capacity is around 22 GW (European Commission 2022; Svensk Vindenergi, 2022). Europe is a leading region in installed offshore wind capacity, with the United Kingdom having the most mature market, followed by Germany, the Netherlands, and Denmark. All of these countries use either an auction-based system or a hybrid system that combines auctions with an open-door scheme (Åben-dør-ordningen) (Jansen et al., 2022; The Crown Estate, n.d; SwAM 2022[1]; Wind Europe, 2022). Key industries involved in the entire process of manufacturing and deploying offshore wind are concentrated primarily in Northern Europe and include offshore wind turbines, foundations, cables, and construction and installation of wind farms (Van der Loos et al., 2020). This technology can support the Union in increasing its independence in the energy market.

2.3 The offshore wind sector in Germany

This chapter provides a brief overview of energy targets, legislation, authorities involved in offshore wind expansion and marine spatial planning for offshore wind areas in Germany. Further information about the auction-system is provided in the result section.

Prior to 2023, Germany was the second largest importer of fossil fuels from Russia. However, in response to the invasion of Ukraine, the country implemented a comprehensive legislation called the Easter Package, which includes measures to accelerate the deployment of offshore wind energy (BMWK, 2022).

2.3.1 Legislation and targets for offshore wind in Germany

In 2000, Germany adopted the Renewable Energy Sources Act (EEG), which was revised to include a separate act for offshore wind expansion, the WindSeeG. The WindSeeG contains regulations of the offshore wind sector, including the auction-based system (WindSeeG, 2017). The act aims to increase the installed capacity of offshore wind in German waters and has been amended to include more ambitious targets (BMWK, 2022). The nation will deploy at least 30 GW by 2030, 40 GW by 2035, and 70 GW by 2045, as per WindSeeG Act 2022 (Bunderegierung, 2023; BMWK, 2022). To meet the 2030 objectives, Germany must increase its offshore wind capacity fourfold, given its current capacity of 8 GW in 2022 (*Figure 1*). In the marine spatial plans of 2021, the planned development of offshore wind is considered to serve the public good and safety (BSH, 2021).

2.3.2 pre-surveyed and un-surveyed sites

In the German auction-scheme, two types of sites are included: pre-surveyed and un-surveyed. The latter was added by the German government through the Easter Package (BMWK, 2022).

In pre-surveyed sites, the government investigates sites for auction and thereafter hands the results to the auction winner. The auction winner thereafter takes further steps, including conducting a detailed Environmental Impact Assessment (EIA) to determine the exact location for the installation of the wind park*, see Figure 3* (BMWK, 2022).

In un-surveyed sites, the government auctions areas with no prior investigations. In the un-surveyed sites, contracts are awarded to bidders based on a set of qualitative criteria,

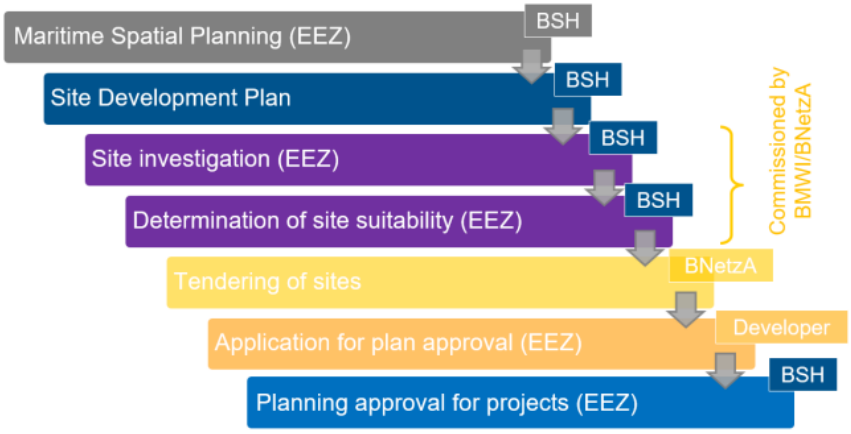
including energy produced, compatibility with nature conservation, and the recycling of rotor blades (BMWK, 2022).

2.3.3 Responsible authorities

To get a better understanding of the division of responsibility in the German auction system, Figure 3 is presented below.

The figure illustrates the authorities involved, including their responsibilities in the German auction-system for offshore wind. The Federal Maritime and Hydrographic Agency (BSH) is the authority responsible for marine spatial planning, including determination of suitable areas for offshore wind. The Federal Network Agency (BNetzA) takes care of tendering of sites including setting the funding level for operators, and connection to the transmission network (Bundesnetzagentur, 2023; BMWK, 2018). The Federal Ministry of Economics and Technology (BMWK) holds the overall responsibility and is the contracting authority. BMWK can also develop new agreements regarding national offshore wind targets (BMWK, 2022).

Figure 3. *Central model of offshore wind energy planning* (BSH, 2021).



*The Federal Maritime and Hydrographic Agency (BSH), The Federal Network Agency (BNetzA), The Federal Ministry of Economics and Technology (BMWK).

2.3.4 Offshore wind in the marine spatial plans

Offshore wind is primarily planned and developed in the Exclusive Economic Zone, as there is more space and less conflicts of interests, see Figure 4, 5 and 6 below (BMWK, 2015; BMWK, 2022). The government is responsible for granting permits in the German Exclusive Economic Zone. The Federal Maritime and Hydrographic Agency (BSH) is responsible for marine spatial planning in the EEZ, including the investigation and development of areas suitable for offshore wind. In the German territorial sea within 12 nautical miles off the coast, the Federal States grants approvals, however areas ideal for offshore wind in the territorial sea are limited (BMWK, 2016; BSH. 2021). Permission for offshore wind establishment may only be refused if public interests, such as the use of shipping lanes, flora, and fauna, are impaired or if there is a sea pollution risk (BMWK, 2022; BSH, 2021)

Figure 4 below illustrate offshore wind projects in German waters in 2019. Figure 5 and 6 illustrates German site development with areas designated for offshore wind. Figure 5 shows the North Sea and figure 6, the Baltic Sea.

Figure 4. *Offshore wind parks in Germany.* Source: Bundesregierung. 2019.

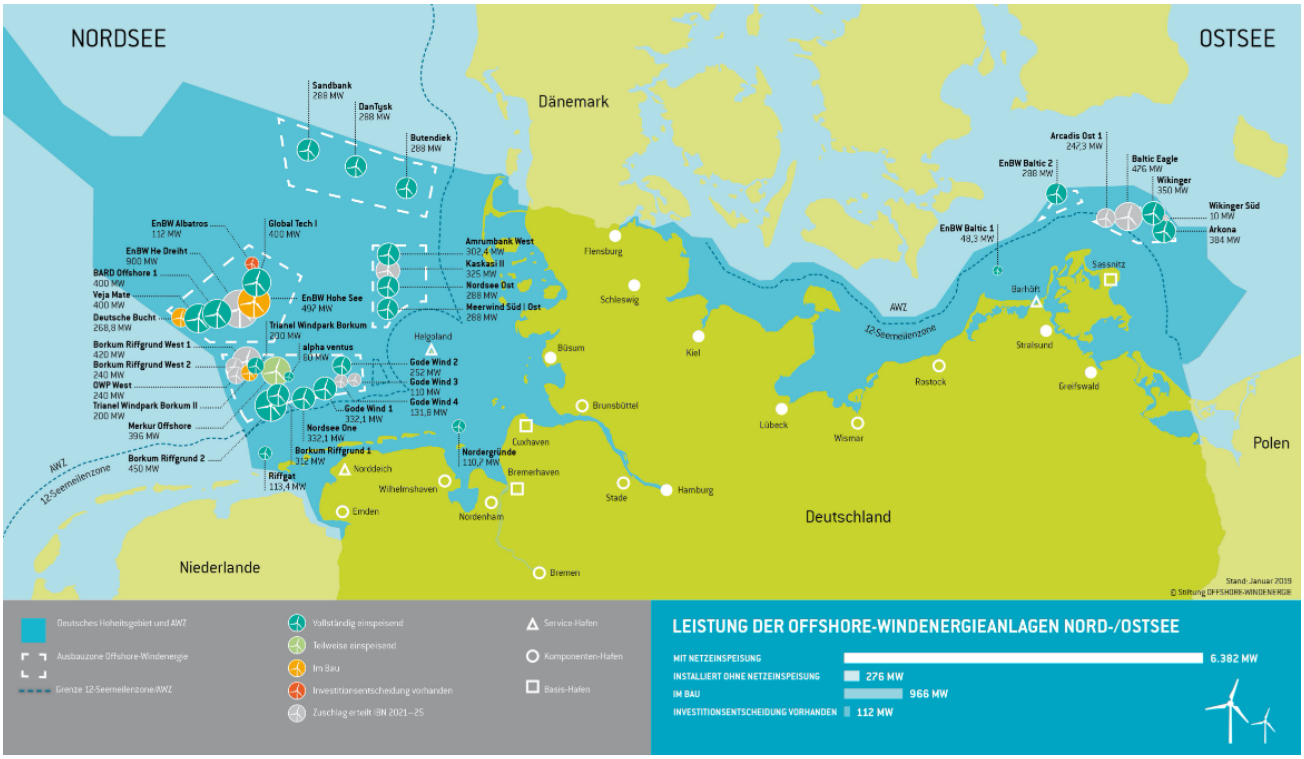


Figure 5. *Designations for Offshore wind Energy in the North Sea.* Source: BSH. 2021.

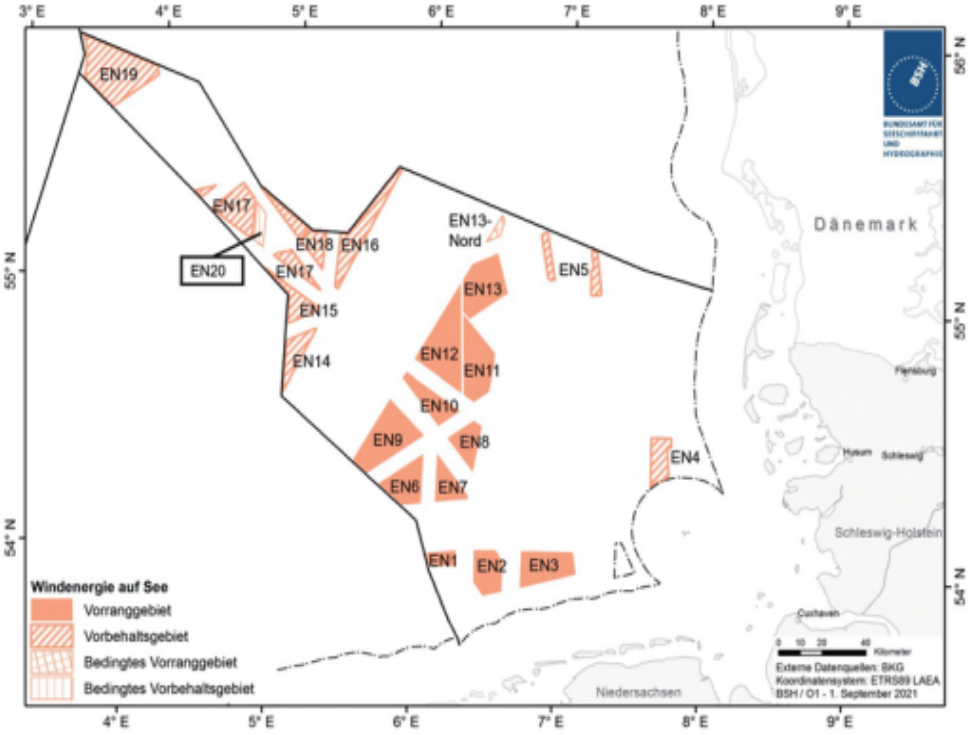
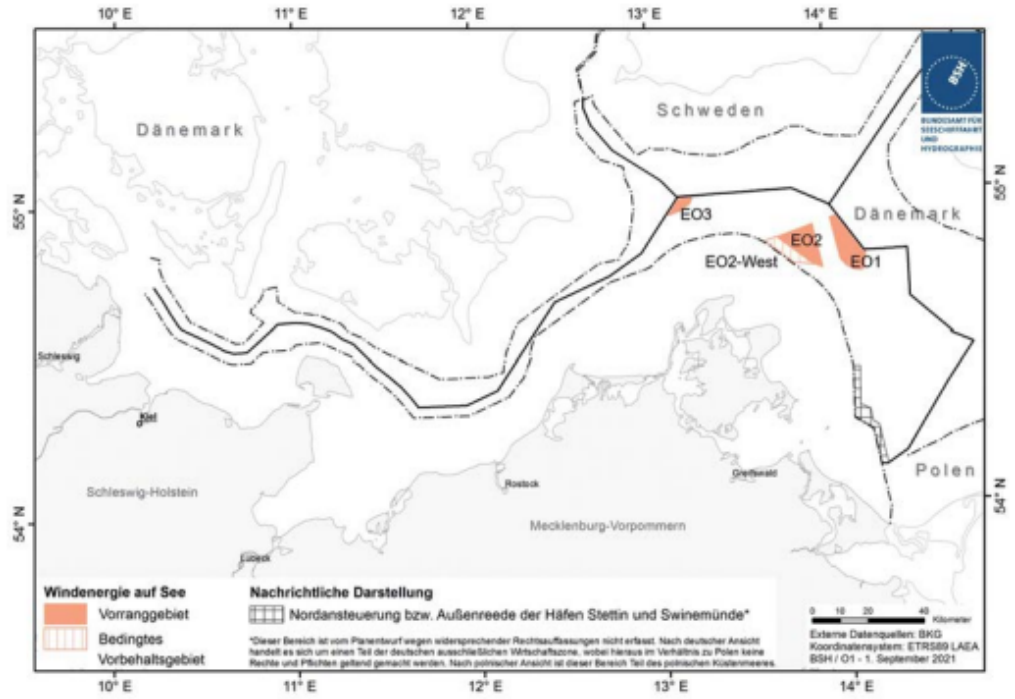


Figure 6. *Designations for Offshore wind energy in the Baltic Sea.* Source: BSH. 2021.



2.4 Denmark

In Denmark, energy production is to some extent lower than energy consumption (Energistyrelsen, 2021). The nation is therefore relying on imports to a certain degree (Energistyrelsen, 2021). Historically, the nation has been dependent on oil and coal, however, the dependence is decreasing while electricity production from renewables increases (Energistyrelsen, 2021; IEA, 2020). Denmark is one of the leaders in deployment of renewable energy (non-hydro) and has some of the world's largest turbine manufacturers, offshore wind owners and developers (Gonzáles & Kitzing, 2019; Van der Loos, et al., 2020).

2.4.1 The growth of the Danish offshore wind sector

Deploying the first offshore wind park in 1991, Denmark is a pioneer in the offshore wind sector on a global scale and has set political targets to remain a leader in the offshore wind industry (Energistyrelsen, 2022).

The approach to drive down costs for the offshore wind industry took place during the global economic crisis around 2010, when the costs for offshore wind were high and there was an increased need for innovation and technological advancement (Madsen & Ulhøi, 2021).

Denmark had a strong offshore wind industry with ambitions to make the industry profitable, which succeeded through the promotion of the state (Madsen & Ulhøi, 2021; Van der Loos et al., 2020). The early projects were costly, which were supported by the government through project-specific schemes (Energistyrelsen, 2022).

2.4.2 Legislation and targets for offshore wind in Denmark

Legal conditions for offshore wind are stated in the Promotion of Renewable Energy Act, which gathers all legislation on what is defined as "renewable energy sources"[1] (Energistyrelsen, 2009). Chapter 3 of the act specifies that Denmark has exclusive rights to utilise energy from water and wind within territorial waters and exclusive economic zone, up to 200 nautical miles off the Danish coast (Energistyrelsen, 2009). Legislation on offshore wind auctions is stated in the act [2]. Developers of offshore wind need three licences to: carry out preliminary investigations, establish offshore wind turbines, exploit wind energy for a given number of years and approval for production of electricity. Additionally, if the project is expected to have an environmental impact, an EIA is necessary, which has been needed in all projects up to present (Energistyrelsen, 2022). Denmark's offshore wind targets are based on the Climate agreement on green power and heat 2022, with the aim to establish a minimum of 9 GW before 2030 and the targets to be a green low carbon nation by 2050 (Energistyrelsen, n.d; Gonzáles & Kitzing, 2019).

2.4.3 Hybrid scheme for offshore wind establishment

Offshore wind has been deployed under a hybrid scheme in Denmark since 2003, meaning that offshore wind is either tendered by the government or built under the open-door procedure (*Åben-dør-ordningen*)(Energistyrelsen, 2022).

[1] "'Renewable energy sources' shall mean, amongst other things: wind power, hydropower, biogas, biomass, solar energy, wave and tidal energy, as well as geothermal heating." (Energistyrelsen, 2009).

[2] See the Renewable Energy Act for further information.
https://ens.dk/sites/ens.dk/files/Vindenergi/promotion_of_renewable_energy_act_-_extract.pdf

Most offshore wind parks are established through tenders (Energistyrelsen, 2022), meaning the government chooses suitable areas that are auctioned to developers.

No industrial scale projects have been deployed under the open-door procedure (Energistyrelsen, 2022), which is currently suspended as it may conflict with EU law (Energistyrelsen, 2023).

2.4.4 Responsible authorities

The Danish Energy Agency acts as a "one-stop-shop" for offshore wind developers by issuing all three licences required for offshore deployment to mitigate regulatory risks for developers (Energistyrelsen, n.d[1]; Energistyrelsen, 2022).

Energinet, the Danish Transmission System Operator (TSO), is accountable for the construction, reinforcement and operation of the grid connection which is included in the tender (Energistyrelsen, 2022). In contrast, the developer is responsible for the grid connection in the open-door scheme (Energistyrelsen, 2022).

2.4.5 Integration of offshore wind in the marine spatial plans

Areas that the government deems suitable for offshore wind activities are integrated in the national marine spatial plan. The Danish Maritime Agency is responsible for overseeing the marine spatial plans and collaborating with relevant authorities to determine these areas as for example, grid connection must be available (Energistyrelsen, 2022). The designated areas for offshore wind generation in the marine spatial plan are significantly larger than required for deployment of wind parks. Therefore, the Danish Energy Agency is responsible for a fine screening to optimise cost reduction and consider local environmental conditions (Energistyrelsen, 2022). Areas such as Natura 2000 sites, crucial shipping routes and defence areas have already been excluded (Energistyrelsen, 2022).

The governmental designated areas for offshore wind projects are shown in the two figures below. The first figure illustrates areas solely reserved for offshore wind activities, while the second figure depicts the reserved offshore wind areas along with pre-existing offshore wind parks (indicated in the smaller dark green areas), nature and environmental protection zones ("N" areas), and shipping lanes (in grey).

Figure 7. The Danish Maritime Authority. (2022). *Areas reserved by the government for offshore wind projects in Denmark's marine spatial plan*. Layer: Governmental offshore wind reservations.

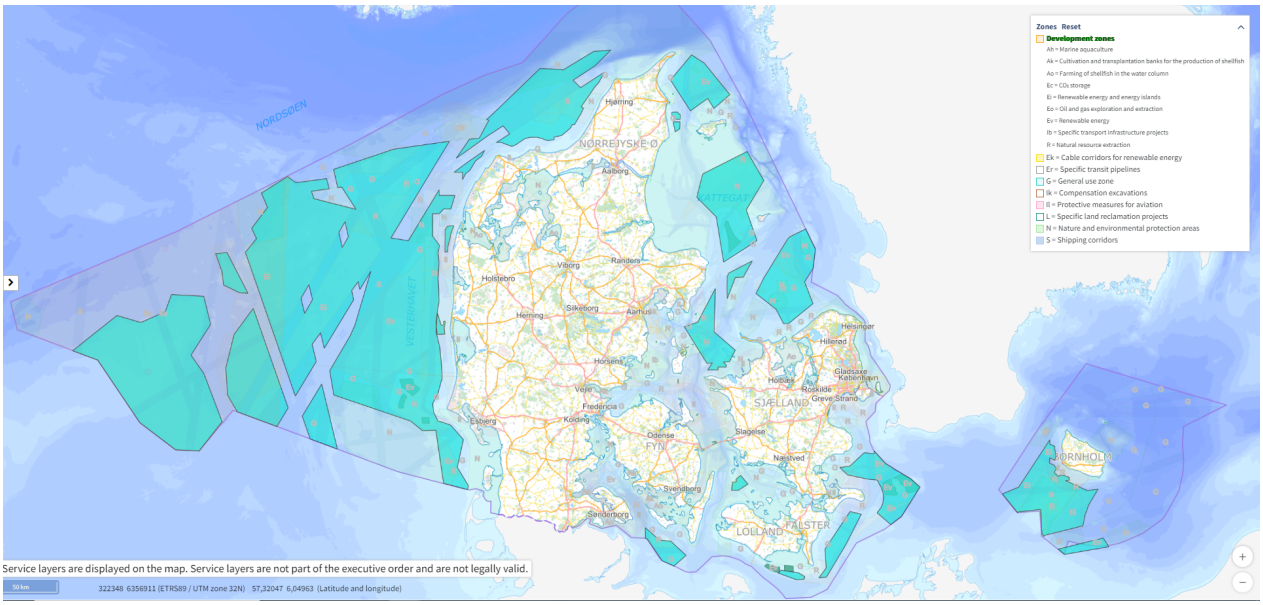
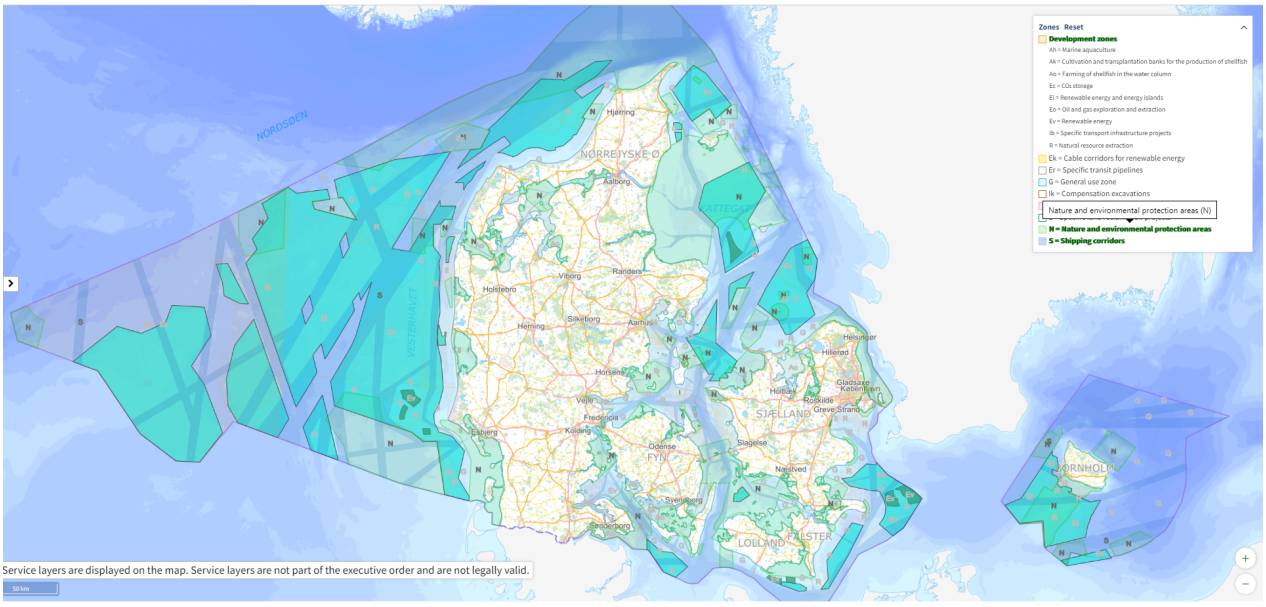


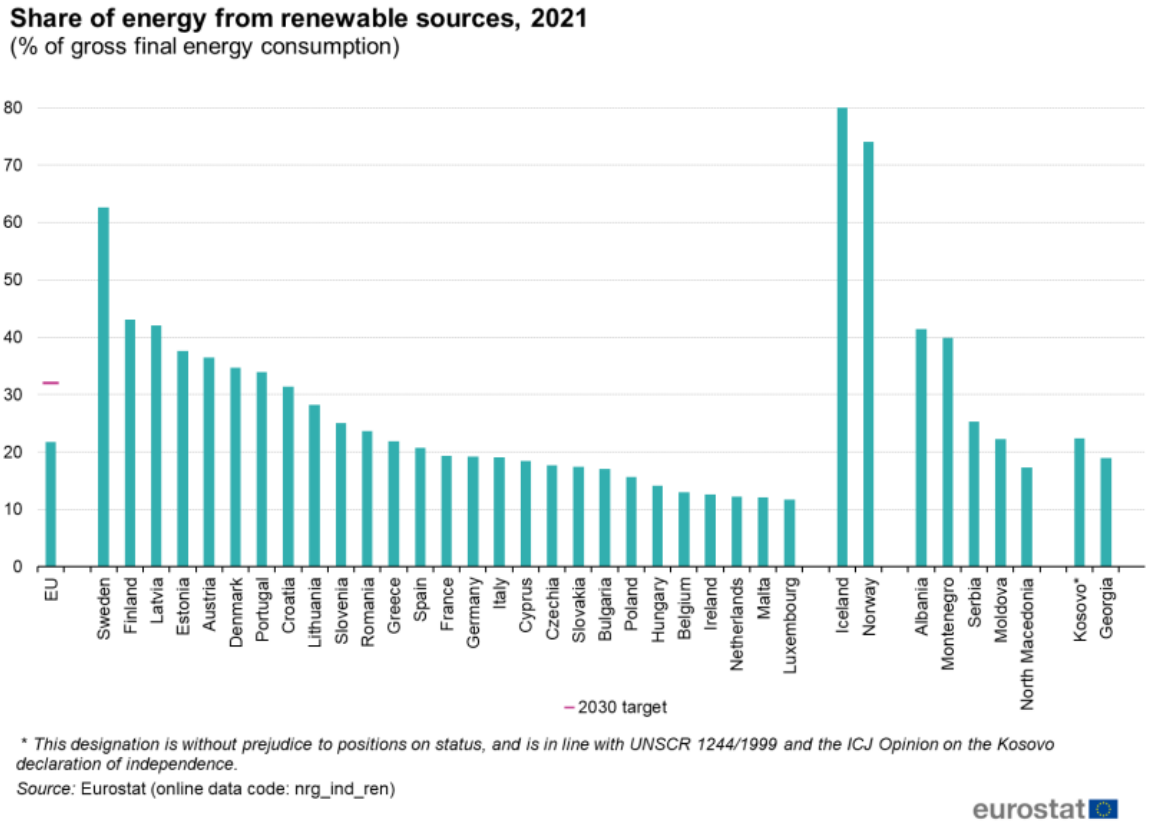
Figure 8. Danish marine spatial plans with existing wind farms in the Danish EEZ in dark green. Nature and environmental conservation ("N" areas) and shipping lanes (in grey). Source: The Danish Maritime Authority. (2022).



2.6 The energy market in Sweden

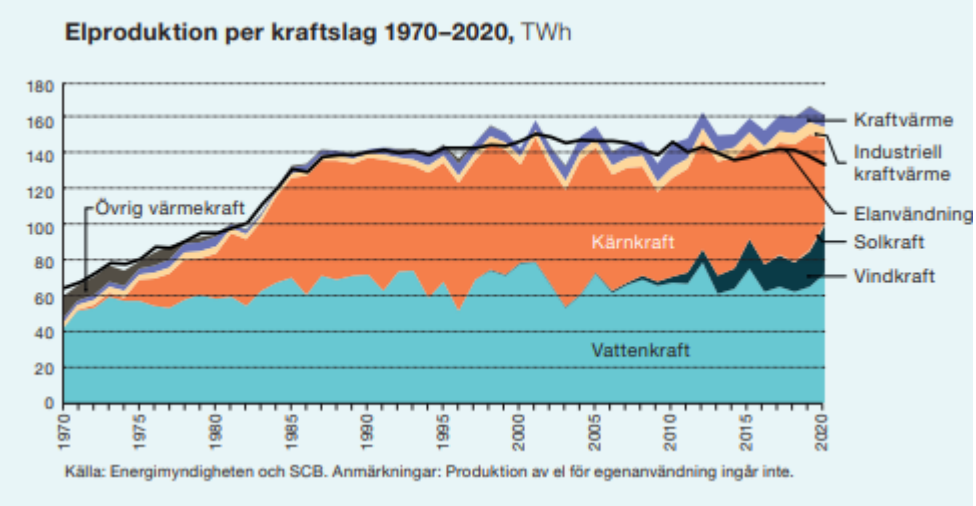
As mentioned in the introduction, Sweden produces more energy than the level of national consumption, and only needs to import energy at certain times (Energimyndigheten, 2022). The nation has exceeded the 2030 EU targets of 32% of consumed energy deriving from renewable sources (See figure 9 below). Previously, the European Union has set individual targets for member states on renewable energy usage according to the viability for individual member states to increase renewable energy sources (Langlet & Mahmoudi, 2016). Sweden was the nation with the highest target to reach 49 per cent of energy consumption from renewable sources in 2020. The target was exceeded according to figure 9.

Figure 9. Share of energy from renewable sources, 2021. Source: Eurostat.



In Sweden, energy is produced mainly from hydropower and nuclear, with an upswing from wind power and solar energy in recent years (See figure 10).

Figure 10. Electricity production by power use 1970-2020, TWh. Source: Energimyndigheten, 2022.



Hydropower (“Vattenkraft”), nuclear (“kärnkraft”), wind power (“vindkraft”), solar energy (“solkraft”), electricity usage (“elanvändning”).

In Sweden, energy prices have remained relatively low compared to other EU nations thanks to a competitive energy market and a diverse range of energy sources. This is due to power plants that have already paid off their investment costs and rely less on fossil fuels (Energiforsk, 2022; Naturskyddsföreningen, 2022). While Sweden is affected by the fluctuating prices on the European energy market, it is not as severely impacted as other countries due to the country's high national production. Price increases tend to occur during energy imports. (Svenska Kraftnät 2022; Svenska Kraftnät, 2023).

2.6.1 Political measures to increase offshore wind

In May 2023, the Swedish government approved the offshore wind projects Galatea Galene (Regeringsbeslut, KN2023/01077) and Kattegatt Syd (Regeringsbeslut, KN2023/01060) on the west coast of Sweden. The government recently set targets to double the electricity production until 2045 since government plans for an increase in the electricity demand to reach 300 TWh (Regeringskansliet, 2023), and launched a governmental investigation to

streamline the establishment of offshore wind power, including investigating a potential establishment of a tender system (Dir. 2023:61).

2.6.2 Hindrances to offshore wind establishment in Sweden

This section presents different factors that hinders offshore wind deployment in Swedish waters.

The market-based system in Sweden has resulted in an interest to build offshore wind, corresponding to approximately 366 TWh in both territorial sea and the exclusive economic zone (Svensk Vindenergi, 2022). The projects are in different stages of the application procedure, with the majority at an early stage and in the phase of investigating the preconditions for exploiting offshore wind (Svensk Vindenergi, 2022).

Most projects are hindered from being realised due to slow permit processes which are prevalent in all phases in the open-door scheme, as developers need several permits to commission their projects (Svensk Vindenergi. 2022). Further hindrance to offshore wind establishments is that many applications are rejected as projects are conflicting with other interests such as Natura 2000 and the defence [3] (Malafry & Öhman, 2022). The municipal veto has a significant impact and prevents the deployment of offshore wind to a large extent in the territorial seas, where the municipalities hold veto power (Malafry & Öhman, 2022; FOI, 2022). Permit-processes can be extended for many years if cable-laying is prolonged (Malafry & Öhman, 2022). Additionally, the open-door scheme is inflexible in handling cases where the best technical solutions change during the permit process (Malafry & Öhman, 2022; SwAM, 2022).

2.6.3 Legal aspects for offshore wind in an open-door scheme

There is a lack of regulations regarding state ownership and the right to grant rights to a developer. Meanwhile, the deployment of structures at sea is subject to extensive and complex regulations, involving different authorities depending on project-location (SwAM, 2022; SwAM, 2023; Malafry & Öhman, 2022). Regardless of the location of the park,

[3] With an exemption of the Governmental approval of the offshore wind park Kattegatt Syd on 15th of May 2023. Kattegatt syd has been opposed by the Swedish defence (Regeringsbeslut KN2023/01060).

developers face protracted processes, due to the need for several separate permits related to the park and cable laying (SwAM, 2023; Malafry & Öhman, 2022). Moreover, developers are required to have extensive knowledge of the offshore wind industry, environmental effects, and procedures to minimise environmental impact in accordance with section 2 § 2 of the Environmental Code (Malafry & Öhman, 2022; SwAM, 2022).

In the territorial sea, permits are applied for at the Environmental Court. The developer needs endorsement from the municipality according to section 16 § 4 in the Environmental Code to receive the permit (Malafry & Öhman, 2022). Areas which may affect the interests of the military are assessed by the government according to section 21 § 7 in the Environmental Code (Malafry & Öhman, 2022). Military areas are often prioritised over the offshore wind interest (Malafry & Öhman, 2022; Hoppe & Nilsson, 2021). In the Exclusive economic zone, the government needs to take a decision according to law (1992: 1140) on Sweden's exclusive economic zone (Malafry & Öhman, 2022). Regardless of the deciding instance and according to the law the decision is based upon, a trial according to the basic decisions in the Environmental Code is necessary (Malafry & Öhman, 2022).

2.7 Theoretical background

The sustainability transition theory is applied since the aim of the thesis is to gather existing knowledge about necessary conditions, possibilities, and difficulties regarding societal transition processes to an auction-based system in order to inspire future transitioning procedures. The sustainability transition analysis includes factors such as technological and political investment, political willingness to create better understanding of how institutions and organisations can induce systemic change and contribute to transformative processes.

The sustainable transition theory emerged to address the need for a framework to comprehend societal shifts towards sustainable systems (Markard et al., 2012). The theory seeks to explain how societies transition towards more sustainable approaches of development and emphasise the role of technological innovation, social learning and institutional change driving these transitions (Kemp et al., 2007; Markard et al., 2012). The theory incorporates interdisciplinary insights, including political science, economics, ecology, etcetera (Kemp et al., 2007). The theory is based on the idea that social, technological, economic, and political changes can lead to the transformation of existing systems towards more sustainable ones (Kemp et al., 2007).

The theoretical field is of high complexity as interplay between different actors, institutions and societal norms are in focus and how they can influence the direction and pace of sustainability transitions (Kemp et al., 2007; Markard et al., 2012). Sustainable transitions aim to generate long-term effects and are more feasible in societies where interests are well organised (Kemp et al., 2007). Policies and technological innovation are critical to enhance economic development. Policy studies within sustainable transition theory emphasise power struggles and advice to broaden acceptance to open for systematic change, while technological innovation is necessary, although not sufficient to induce societal change (Kemp et al., 2007). Sustainable transitions are characterised by uncertain outcomes requiring investment, technological and socio-political innovation to become successful (Kemp et al., 2007; Markard et al., 2012). Large scale transitions occur when numerous technologies, policies and institutions interact and form synergies (Kemp et al., 2007). Kemp et al., 2007 further argues that structural crises are critical turning points where opportunities to change emerge, making it possible for industries to establish and develop, leading to a growing competition and lower technological costs. Policymakers play an important role determining long term investments on a national scale. After a structural crisis opening for opportunities, the investments posed by policymakers narrows the direction of the development and is therefore crucial in deciding future technological developments (Kemp et al., 2007).

3. Methods

3.1 Literature review

This thesis aimed at providing knowledge about possible pathways to an auction-based system for offshore wind establishment in Sweden. A literature review was conducted as the aim required a comprehensive understanding of current knowledge in the field. Due to limited literature on the subject, a qualitative research strategy was the relevant choice, since, as Bryman et al., (2004) indicates, the importance lies in understanding the subject through the existing literature. In this case, it was critical to understand the ideas behind wanting to change to an auction-system, which is not possible to generalise to suit all nations.

To find information about transitions to auction-based systems for offshore wind, Germany and Denmark were studied as they both have gone through transitions to establish such systems.

To collect data, reports from agencies involved in offshore wind establishment were identified with the help of the supervisor from the Swedish Agency for Marine and Water Management (SwAM). The Federal Maritime and Hydrographic Agency of Germany (Bundesamt für Seeschifffahrt und Hydrographie), responsible for marine spatial planning and site development of auctions were contacted and provided reports on the subject. The material included the regulation, WindSeeG 2017, published site development plan, evaluation of the first auction-rounds and a report preparing for transitioning to an auction-system. The Danish Energy Agency never responded, and the material used from Denmark is therefore reports found on the website and academic articles. In Sweden, reports were gathered from the research project Vindval, SwAM and the Swedish Post- and Telecom Agency. The Vindval research project focuses on impacts from wind energy on people, nature, and environment. SwAM recently reported the governmental assignment on exclusive rights for offshore wind establishment which served as a base for this thesis.

Academic articles were found through a combination of Google Scholar and Gothenburg University library. Following search strings were created:

(transition* OR introducing* OR establishing*) AND (Denmark*) AND (Offshore wind*) AND (auction* OR tender*)

(transition* OR introducing* OR establishing*) AND (Germany*) AND (Offshore wind*) AND (Auction* OR Tender*)

The results provided articles related to the specific auction-systems in Germany and Denmark, together with articles providing international overviews of offshore wind expansion, mainly comparing European nations.

For Germany, selected studies were from 2013-2023. For Denmark the selected studies were from between 2013-2023 and 2003-2013. The timespan was set prior to the establishment of the auction-system in both nations, extending to today. The time was set accordingly to follow any changes as a proper implementation of a system takes several years. The search provided 24 articles with relevant titles and a selection was made to include studies with the relevant keywords. Only peer-reviewed articles were chosen.

Additional interviews

Additionally, two semi-structured interviews were conducted to create a better understanding of the material. The first interview was held with a civil servant at the Federal Maritime and Hydrographic Agency of Germany to better understand the material about the German system for developing offshore wind energy. Another interview was held with Lina Kinning at the Swedish Wind Energy Association to better understand the Swedish outlook from a market perspective. Kinning's experience from the government offices, coupled with her present responsibility to advocate a unified voice within the Swedish offshore wind industry, made her a relevant choice.

3.2 Delimitations

A key limitation of this research was difficulties finding sufficient information on Denmark. Additionally, it would be interesting to include more background on the Swedish spectrum auctions. However, only one evaluation from 2010 was found through contacting the Post and Telecom agency. There were no studies on transitions to auction-based systems for offshore wind, therefore it was necessary to explore related areas, including national expansion of offshore wind, critical variables, and drivers for green transitions, to draw conclusions on the material found. The theoretical choice, sustainable transitions theory, is interdisciplinary by

nature and aims to understand complexities leading to systematic change. This resulted in an overview of the research area, aiming at achieving a holistic view. However, detailed investigations from law, economy, political science, environmental science, and business would be of interest for future research.

4. Results

In this chapter, the aim is to provide a comprehensive overview of the key themes that emerged from the literature search. The chapter starts by the presentation of more general themes on offshore wind acceleration and auction-designs in European nations. As the chapter progresses, more detailed examples that illustrates the key concepts and ideas identified are presented.

The literature was extensive and has already passed through a selection process, to emphasise information that can be interesting from a Swedish perspective. Therefore, the result section focusses on providing measures and inspiration that could be applicable in Sweden.

4.1 Accelerating the establishment of offshore wind energy in Europe.

Several of the academic articles examined the green energy transition to increased levels of offshore wind. The articles found that socio-political and technological innovation, along with financial investments are important in making offshore wind attractive and driving down costs. This can lead to an increased offshore wind deployment, where governments play an important role in providing the right setting for energy development (Wieczorek, et al., 2013; Madsen & Ulhøi, 2021; Berg & Envoldsen, 2021; Grashof, 2019; MacKinnon, et al., 2022).

MacKinnon et al., (2022) and Wieczorek (2013) distinguished legitimacy as an essential dimension for a new technology to be established as it needs to gain social acceptance and comply with relevant institutions. To achieve legitimacy, governments have a significant responsibility to create narratives, value and cost reduction by financial investments and job opportunities in cooperation with a strong industry sector (MacKinnon et al., 2022; Wieczorek, 2013). MacKinnon et al., (2022) and Wieczorek (2013) emphasise that legitimacy levels increase if offshore wind is needed to meet national renewable targets and if costs for the technology is driven down.

Governments that have a strong consensus on environmental and energy targets have achieved positive outcomes in terms of increased offshore wind establishments, as a strong consensus provides greater market security for developers in the long term (MacKinnon et al., 2022; Energistyrelsen, 2022; Ropenus & Jacobsen, 2015; Van der Loos, et al., 2020). Gusatu

et al., (2020) argue that nations applying an integrated management with stakeholder collaboration, a strong consensus and clear legal frameworks are successful. Germany and Denmark are both nations with a strong political consensus and will to accelerate offshore wind deployment (MacKinnon et al., 2022; Energistyrelsen, 2022). MacKinnon et al., (2022) argue that the German government provides comprehensive, stable support and is therefore an example on how the government and industry together can create narratives which leads to great systematic change. The situation is similar in Denmark, as the government produced policies aligned with industrial innovation (van der Loos, et al., 2020). Denmark also held a strong industry sector, with ambitions to reduce the price on offshore wind technology below the costs for fossil fuels (Madsen & Ulhøi, 2021).

Private investments in the technology facilitates further development and is realised when it is considered a long-term profit (Wieczorek, et al., 2013; Madsen & Ulhøi, 2021; Karnøe, et al., 2022). For example, in the UK, there has historically been insufficient confidence in the technology, causing banks, often tending to be risk avoidant, to be unwilling to finance new technologies without a track record (Wieczorek, et al., 2013). This was strengthened during the financial crisis, when banks' project funds for offshore wind were lowered, challenging offshore wind establishments unless projects received increased involvement from financing organisations (Wieczorek et al., 2013). In contrast, Denmark serves as a successful example, as the nation lowered costs and reduced development risks through streamlining planning and consent processes (Energistyrelsen, 2022). This attracted institutional investors such as pension funds due to stable financial conditions and regulations (Wieczorek et al., 2013; Energistyrelsen, 2022).

4.2 Auction-systems for offshore wind

This section provides technical details of the auction system, highlighting the outcomes observed in established auction-based systems and the significance of customising the auction-design to fit the specific context of the implementing nation. The section starts by presenting an overview of findings, to at the end of the section focus on the findings from Germany and Denmark.

Auction-based systems have been implemented globally as a tool to increase offshore wind deployment. This is a preferred alternative for policymakers with ambitions to realise more than 200 GW of offshore wind energy with ambitions to control and plan the amount of implemented capacity (Toke, 2015; Jansen, et al., 2022). Globally, auction-systems have resulted in significant cost reductions of offshore wind technology, opening for a competitive market (Jansen, et al., 2022; Rubio-Domingo & Linares, 2021; Kanumarath, 2022). However, Toke (2015) argues that the cost-reductions are mainly due to declines in technology costs and not necessarily to the auctions themselves.

4.2.2 Auction-design

Several academic articles have discussed the impact of design elements for auction-systems which may have significant effects on the outcomes. When it comes to auction-design, there is no one size fits all (IRENA, 2015). The design should be customised to technology, the maturity of the auction-system in the region and the political environment (Kanumarath, 2022; Jansen, et al., 2022; Rubio-Domingo & Linares, 2021; Hvelplund et al., 2017). Technology innovation and improvements in capacity, leads to significant cost-reductions for the offshore wind sector (Toke, 2015) and can be included in the auction design by promoting new offshore wind technology (Rubio-Domingo & Linares, 2021; Kreiss et al., 2017; Kanumarath, 2022). Auction designs should be adjusted to the maturity in the region by providing a system that can support real price discovery and reduce risks for developers which can be done through revenue stabilisation measures such as reducing exposure to price fluctuations on the market (Kreiss, 2017; Jansen et al., 2022; Kanumarath, 2022). Further, states may as an auctioneer carry the responsibility for the EIA and grid connection as it reduces risks for developers and thereby stimulate competition and increase realisation rates (Kreiss, 2017; Jansen et al., 2022; Kanumarath, 2022).

Penalties for non-compliance to a set realisation period can help the nation reach policy targets as project deliveries increase, although setting penalties too high may decrease competition (Gonzáles & Kitzing, 2019; Toke, 2015; Kanumarath, 2022; Musgens & Riepin, 2018). This was the case in Denmark during the tendering of the Anholt project in 2009, where the increased penalties together with other factors diminished competition. During the preceding tender, the project winner withdrew from the process. For the Anholt tender, the Danish Energy Agency adjusted the tender design by including the EIA in the tender material,

relying on price as the primary award criterion and adding penalties to reduce withdrawal risks (Energistyrelsen, 2022). However, the increased penalties combined with limited supply of wind turbines and an inflexible project delivery schedule induced by politics resulted in only one bidder putting a high bid (Energistyrelsen, 2022).

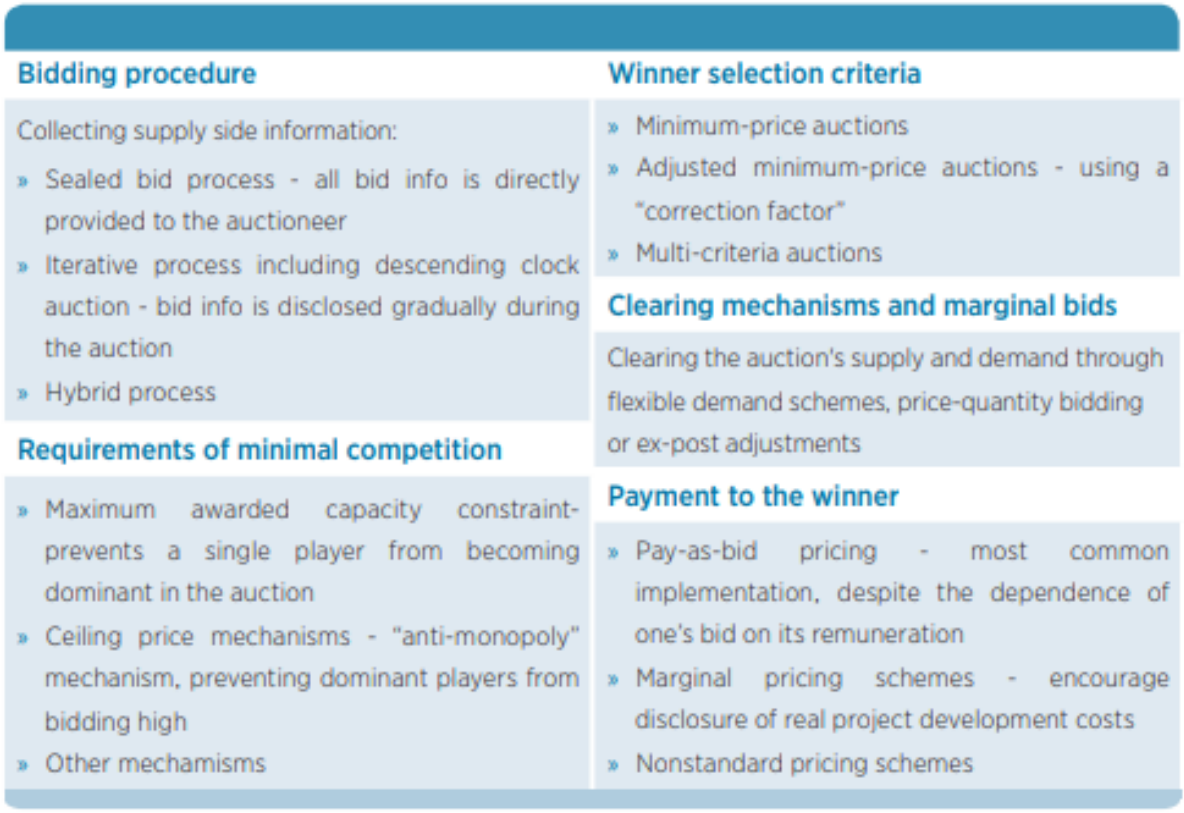
In emerging market regions, the use of dynamic auctions[4] is recommended to support real price discovery while mature markets can use sealed bids[5] as a faster design element with lower administrative costs (del Río, 2017; Kanumarath, 2022). Another critical point to enhance transparency and predictability for project developers is the implementation of regular auction schedules to mitigate uncertainty, as compared to irregular schedules (Côté et al, 2022). States can offer either single or multi criteria auctions. In single criteria auctions, the winner is chosen solely based on their price bid while in multi criteria auctions, bidders are assessed on further criteria, such as environmental and technological aspects in addition to their bid price (Del Río, 2017; Kanumarath, 2022).

Ceiling prices are used in nations such as the Netherlands, Germany, and the UK, which is a mechanism to guide bidders and impose a maximum value (see table 1). Ceiling prices should be set carefully as setting the price too high weakens the competition while a low price can lead to underbidding (Gonzáles & Kitzing, 2019; del Río & Kiefer, 2021). The appearance of open dialogue between developers and governmental bodies may lead to improved results, as does consulting developers prior to designing the penalty scheme since it brings about transparency and security for developers (Gonzáles & Kitzing, 2019). Denmark is a successful example of inviting developers for transparent discussions, which will be described further in section 4.6.

Table 1. Overview of a range of options for auction design elements. Source: IRENA & CEM, 2015. For further details of design elements, including a summary for policymakers, see IRENA.

[4] In Dynamic auctions, bidders interact with each other when placing their bids and are free to adjust their bids. The risk of underbidding is lower in dynamic auctions (del Río, 2017).

[5] In sealed bid/ static auctions, bidders privately submit their bid to the auctioneer, who then ranks the projects based on the received bids (del Río, 2017).



Germany

When deciding to adopt an auction-system in Germany, the auction-design and transitional regulations had to be decided at an early phase of the process (BMWK, 2019). During the transitional period in Germany, maximum values were introduced on the same levels as remuneration rates[6] in the previous feed-in-tariff system. The maximum values served as prevention of cost increases in case of market failure (Deutscher Bundestag, 2016).

Remuneration for projects commissioned between 2021-2025 is received for twenty years and is set according to the price bid (BMWK, 2019). Further, Germany ensured creditworthiness and realisation rates through the security deposit and prequalification procedure as developers state the chosen material for the project (Deutscher Bundestag, 2016; BMWK, 2016). However, Musgens & Riepin (2018) identified that penalties are set low in the nation which may have a negative impact on project realisation. This results in difficulties for Germany to

[6] Remuneration rate: the guaranteed price the developer receives for the electricity produced by the wind farm for a set time decided by the government. In Germany, the remuneration rate is set at 20 years and the amount is determined during each bidding period (Deutscher Bundestag, 2016; BMWK, 2019).

control the amount of deployed offshore wind and can lead to companies blocking grid connection waiting for the project to be economically viable before commissioning (Musgens & Riepin, 2018).

Denmark

In Denmark, the first two tenders, Horns Rev II and Rødsand II, resulted in one project withdrawal due to inability to deliver the project because of the low bid price (Energistyrelsen, 2022). The tenders followed the one-stop-shop approach, including licences for pre-investigation, construction, and electricity production. The winning bidder was responsible for conducting the EIA, as it allowed for a better micro-siting and wind farm layout during development (Energistyrelsen, 2022).

After the auction-winner withdrew, the Danish Energy Agency adjusted the tender design by adding penalties to reduce withdrawal risks, price as the main award criterion and including the EIA in the tender material, which resulted in only one bidder participating (Energistyrelsen, 2022).

The tender design was modified again for the Horns Rev III project by opening for transparent discussions on the tender framework, with the purpose to align tender conditions with market terms, to encourage more competition than the Anholt project (Energistyrelsen, 2022). The last adjustments for the Horns Rev III project succeeded far better than the previous projects (Energistyrelsen, 2022).

4.3 Reasons behind transitioning

This section presents the main reasons for Germany and Denmark to establish an auction-based system, according to the literature. More information was found on Germany in this section, which gives the nation a more detailed presentation.

In Germany, offshore wind increased in importance as the government decided to phase out nuclear power (Wieczorek et al., 2013). The nation wanted to increase electricity production from offshore wind, but experienced setbacks as numerous projects were never realised in the prior, feed-in-tariff system[7] (Deutscher Bundestag, 2016). Transitioning to an auction-based

[7] Interview with a civil servant at the Federal Maritime and Hydrographic Agency

system would mean a structured, simplified system with higher realisation rates, quantity control by limiting the installations to reach economic viability and reduced costs from increased competition (Deutscher Bundestag, 2016; BMWK, 2015).

Germany transitioned from the feed-in-tariff system to the auction-based system in 2017 under the lead of the Federal Ministry for Economic Affairs and Energy (BMWK, 2015[a]). The nation has been particularly involved in offshore wind initiatives led by the European Union, which has been an important pacesetter in the German energy sector (BMWK, 2015[a]). Most offshore wind projects in Germany were made feasible due to funding and loans provided by the EU, as an example, the EU granted 50 million euros of investment subsidies to the offshore wind project Nordsee Ost (BMWK, 2015[a]). Further, the European Union specifically provided support to Member States aligning the promotion of renewables to market conditions (BMWK, 2015[a]). Germany amended the Renewable Energy Sources Act (EEG) 2014 to state the decision to transition to an auction-system for offshore wind in 2017, as the auction-system adhered to EU regulations, encouraging member states to adopt market-oriented frameworks for renewable energy projects (BMWK, 2015[a]; iea, 2016). By aligning with these regulations, Germany became eligible for additional EU funding (BMWK, 2015[a]).

In Denmark, the implementation of the tender system was prompted by the electricity reform in 1999[8] and the liberalisation of the European electricity market. Tendering as a selection process functioned as a market-oriented management tool with the ambitions to increase competition in the sector (Energistyrelsen, 2022; Munksgaard & Morthorst, 2008). By increasing the offshore wind sector, the nation would become less dependent on fossil fuels, which aligned with the targets set by the state (Energistyrelsen, 2022).

4.4 Drawing on previous experience to introduce auctions.

Before deciding to establish an auction-based system, Germany already had a site development plan with focus areas for offshore wind and a marine spatial plan (Bundestag, 2016). To proceed, the auction-design was decided upon, and legal alternatives were

[8] The electricity reform in 1999 included main goals of reducing CO2 emissions for electricity production and increasing the efficiency and competition in the electricity sector (Hauch, 2001).

investigated. To decide on legal amendments, experience from the pilot auction in solar photovoltaics in 2015 served as a base (Bundestag, 2016). Implementing regulation and establishing the auction-based system was made easier because it was only introduced in the Exclusive Economic Zone[9].

In 2016, the German parliament proposed an amended draft law for introducing renewable energy tenders for offshore wind energy, which was based on the Renewable Energy Sources Act- EEG 2016. Thereby, the offshore wind sector was regulated on a stable and reliable framework (BMWK; 2019). After its implementation, both the EEG and auction-design have been amended several times as the system matures (BMWK, 2019; BMWK, 2022).

4.5 Ensuring a seamless transition by handling old approvals

The Federal Ministry for Economic Affairs and Energy was particularly concerned with transitioning seamlessly from the feed-in tariff system to auctions since the systematic change is sensitive due to long lead times (BMWK, 2015[b]). Therefore, the clarification of handling of permits and accelerated grid expansion was a short-term priority (Deutscher Bundestag, 2016). To ensure a seamless transition, transitional regulations were designed to avoid a potential break in continuity (Deutscher Bundestag, 2016). The transitional system was deemed necessary for offshore wind projects holding approvals without a confirmed grid connection. Projects with funding for operations after the establishment of the auction-system were also considered (BMWK, 2015[a]). The Federal Ministry for Economic Affairs and Energy emphasised the need to have clear rules and guidelines that address activities and investments undertaken before the transitional phase (BMWK, 2015[b]).

Two transitional auctions were launched for pre-developed projects with a project realisation period between 2021 and 2023 (BMWK, 2019). The auctions included companies already holding approvals, planning permission and developers far into the permit procedure and thus, included projects both with and without a confirmed grid connection (BMWK, 2016; BMWK, 2019). Immediately after the EEG 2016 entered into force, up to 2400 MW was put up for

[9] Interview with a civil servant at the Federal Maritime and Hydrographic Agency

auction with grid connections confirmed (BMWK, 2016). Developers within the set criteria were invited to participate (BMWK, 2016).

After the one-time auction was held, “old approval” projects not receiving contracts and who shared the data generated during the project planning (e.g. wind and environmental conditions) were granted financial compensation based on the cost of the project (BMWK, 2016; BMWK, 2019). Areas occupied by projects not winning in the auction were made available for the central system in 2017 (BMWK, 2019).

After the one-time auction with “old approval” projects, the results were evaluated. The first auction round showed significantly reduced bid values, ensuring that the auction-based system did not lead to overall cost increases, although administrative costs in the federal government increased since the auctions are carried out by federal authorities (Deutscher Bundestag, 2016). The two auctions led to significant reductions in the funding requirements for offshore wind energy and competition to reach this result was secured as the project's planned capacity (6,900 MW) was more than two-fold the tender volume put up for auction (3,100 MW) (BMWK, 2019).

Developers' opinions differed when the new system was adopted. Some were welcoming as new sites were presented, while developers already holding approvals were most displeased[10].

The civil servant at the Federal Maritime and Hydrographic Agency highlights the need to understand the agendas of developers already holding approvals, as the government had to reach a balanced decision on how much they were willing to spend to satisfy developers already holding approvals. In Germany, the transition resulted in legal consequences as several developers went to the Constitutional court because the sites, they held approvals for were taken away by the government. As the developers won the case, the German government amended the law[11].

[10] Interview with a civil servant at the Federal Maritime and Hydrographic Agency.

[11] Interview with a civil servant at the Federal Maritime and Hydrographic Agency.

4.6 Ensuring competition and attractive auction-rounds.

This section presents measures discussed and taken by the nations to ensure competition in the auction-rounds.

Germany

In Germany, the state took advantage of the results from the two transition-auctions and used them as a base for planning further adjustments to upcoming auctions, allowing for increased competition (BMWK, 2019). The main discussions after the transition-auctions included adjustment of the ceiling price, dealing with zero bids, and increasing the auction volume (BMWK, 2019). Further, Germany argued that to increase competition which serves in lower levels of state support, comprehensive area development and consultation with potential bidders are critical (BMWK, 2019). Marketing options and strategic actions can be a central driver resulting in lower need of state support (BMWK, 2019). Germany takes measures where the developers do not need to pay for seabed leases or grid connections, which increases competition in offshore wind auctions (Jansen et al., 2022).

Denmark

The approach to ensure competition took several auction-rounds to develop and the nation has previously experienced auction-rounds with project withdrawal and low-competition (Energistyrelsen, 2022).

Denmark currently assures competition by setting pre-qualification criteria concerning financial, economic, and technical qualities of the applicants (Energistyrelsen, 2022). The criteria are set high to attract competent bidders, although not unattainable as this would diminish competition (Energistyrelsen, 2022). Before each bidding round, pre-qualified developers receive tender documents including tendering conditions, a draft concession agreement, and draft licences for pre-assessment (Energistyrelsen, 2022). The data is supplied to developers well in advance to support real price discovery (Energistyrelsen, 2022).

By receiving all necessary data from the government, potential bidders can determine project specifications and evaluate project costs for construction, operation, and decommissioning (Energistyrelsen, 2022). The state initially covers the costs of both the environmental assessments and the preliminary investigations, which are included in the tender documents,

because the costs for the investigations are refunded by the winner of the tender (Energistyrelsen, 2022). Project developers can include these costs when determining the bid price (Energistyrelsen, 2022).

Once the draft material is released, a consultation including the prequalified bidders can lead to modifications or further comments which are integrated in the relevant documents. The consultation process enhances the resilience of the tender material and reduces the risk of subsequent complaints (Energistyrelsen, 2022).

4.7 Inclusion of stakeholders and planning

Germany

The German auction-design was developed through various expert discussions, stakeholder meetings and extensive consultation with the Federal Ministry for Economic Affairs and Energy, serving as the responsible authority, through a public participation process (Deutscher Bundestag, 2016). Germany stated the aim to achieve actor diversity as the nation sees positive outcomes from including a variety of actors in the construction and operation of plants (BMWK, 2016). Therefore, the nation aimed to identify if the auction-design affects the possibilities for different actors to participate by analysing risk and access barriers for a variety of actors. The Federal Ministry for Economic Affairs and Energy concluded that a simple and transparent auction-design where all actors are granted equal opportunities according to their economic capabilities would support actor diversity (BMWK, 2016). Germany additionally emphasised the importance of the planning and investment security for the young offshore wind industry to succeed in further development (BMWK, 2016).

Eventually, the auction-based system resulted in a more central planning where sites with least environmental impact and conflicting interests are prioritised for offshore wind. By providing stricter guidance, it has become easier to structure interests, prioritise areas, support coexistence solutions and environmental conservation (BMWK, 2016; BMWK 2019).

To successfully plan a transition, the civil servant at the Federal Maritime and Hydrographic Agency recommends putting an emphasis on planning and structure which is made possible through the involvement of all relevant stakeholders in an early phase. Through detailed planning and communication with relevant interests and authorities, conflicts are identified at

an early stage, which supports conflict solutions[12]. Transparency increases as clear aims and plans are presented to involved actors early in the process. Further, detailed planning supports the process by simplifying delegation of responsibility and ensuring that all units understand expectations, which serves in improved coordination, for example through grid connection[13]. Additionally, a detailed plan of the capacity needed on a yearly basis can be important in the auction-system to plan electricity production instead of relying solely on companies' realisation rate[14].

Denmark

The Danish Energy Agency emphasises that the national wind energy sector is successful due to a distinctive collaboration between academia, industry, society, and decision makers (Energistyrelsen, 2022). The sector is based on a combination of an experienced supply chain, academia, research, and a cost-efficient political framework, which attracts major players in the offshore wind industry (Energistyrelsen, 2022). The Danish Energy Agency has established a legal framework to facilitate the coexistence of offshore wind and the fishing interest (Energistyrelsen, 2022). Thereby, developers are required to consult with local fishermen, who are sometimes represented by the Danish Fishermen Association, to discuss potential mitigation measures or economic compensation for the fishing areas lost due to the establishment of the offshore wind project (Energistyrelsen, 2022). The developer and fishermen are to determine the compensation amount and conditions for fishing within the wind farm prior to the construction phase of the project (Energistyrelsen, 2022).

4.8 Auctions and social acceptance

Social acceptance is an important factor to consider for wind farm establishments on land and can pose an inhibiting effect on offshore wind establishments (Grashof, 2019). The main factors determining local acceptance levels in areas connected to wind farm establishments are visual and noise impacts of the wind farms, associated health issues, environmental

[12] Interview with a civil servant at the Federal Maritime and Hydrographic Agency.

[13] Interview with a civil servant at the Federal Maritime and Hydrographic Agency.

[14] Interview with a civil servant at the Federal Maritime and Hydrographic Agency.

effects, individual attitudes to wind energy and trust to the developer (Grashof, 2019; Bolin et al., 2021). Koelman et al., (2021) emphasise the need to include design elements that aid in gaining social acceptance for offshore wind such as, by involving communities in wind energy projects which has resulted in positive effects, which is also supported by Bolin et al., (2021). Additionally, wind energy projects led by local companies have proven important to gain social acceptance, since external, large companies can be suspected of trying to 'bribe' locals to accept a project (Grashof, 2019). Large companies often prioritise maximising their own profits rather than considering the best interests of the local community (Hvelplund et al., 2017).

Auction-based systems risks resulting in low levels of actor diversity as smaller companies generally do not have as many resources to quickly adapt in auctions (Grashof, 2019; Koelman et al., 2021; Kanumarath, 2022; Hvelplund et al., 2017). This can be seen in Germany, where local companies are underrepresented as the government seeks to establish large projects where community companies face difficulties to compete (Grashof, 2019). Small project developers face further difficulties recovering after an unsuccessful bid due to lower development budgets (Hvelplund et al., 2017). In Denmark, the offshore wind sector is dominated by large resourceful companies where lobbyism can be strong (González & Kitzing, 2019; Hvelplund, et al., 2017; Toke, 2015; Wieczorek et al., 2013).

Due to lobbyism, resourceful companies with good social networks finds it easier to gain information and make projects viable, which cannot be seen for local companies (Wieczorek et al., 2013). As companies have varying capabilities to structure offshore wind projects in a short amount of time, implementing sufficient time between the publication of the final tender material and the final bid can be a method to promote actor diversity (González & Kitzing, 2019). Through previous experience, three weeks was insufficient for smaller companies to compete (Energistyrelsen, 2022). Further solutions could be to pose special regulations for smaller companies or pose bidding rounds only for local companies (Grashof, 2019; Kanumarath, 2022).

Public acceptance can also be increased by including locals to participate in project consultation and planning (Energistyrelsen, 2022). Nevertheless, there has also been insufficient efforts taken to increase local support. The study by Hvelplund et al., (2017) examined the policy attempt for companies to allocate twenty percent of wind energy projects

for sale to local citizens. However, these efforts were deemed insufficient by local developers and citizens, resulting in growing resistance towards investing in the project (Hvelplund et al., 2017).

4.9 Future challenges

The offshore wind sector has matured in both Germany and Denmark, leading to high competition (MacKinnon et al., 2022). Subsidy prices have reduced to a level below the actual costs of developing and operating offshore wind projects (MacKinnon et al., 2022). In Germany, zero bids have occurred indicating that the market views the technology as viable to the extent that developers expose themselves to market price risks (GWEC, 2022; BMWK, 2022). The zero bid auctions that have occurred means that the developer is fully exposed to market prices and receives no funding from the state (Jansen et al., 2022). In Denmark, developers have expressed interest in taking larger risks and would rather pay the state a seabed lease fee instead of receiving subsidies when the market price is below the auction price (Mahdi, 2023). Danish developers have expressed a will to be responsible for project risks, including early site assessments and the integration of a combination of price-based and qualitative criteria (Mahdi, 2023).

Until now, offshore wind has mainly been developed in areas with low interest conflicts (Salomon & Schumacher, 2022). As deployment targets increase, it will be necessary to integrate interests further as multi-use can be a solution for cost-efficient, stakeholder engaging and more sustainable options for energy deployment (Gusatu et al., 2020). The need for coexistence solutions amongst uses are increasing (Energistyrelsen, 2022; Nordic Research, 2023; SwAM, 2023) Salomon & Schumacher (2022) emphasises the importance of marine spatial planning as it also serves protection of interests where coexistence is difficult to reach. The fishing sector is especially at risk since offshore wind development together with increased marine conservation can forbid fishing (Salomon & Schumacher, 2022). Even when fishing is allowed within offshore wind parks, it comes with security risks and is often avoided (Nordic Research, 2023; SwAM, 2023).

The European outlook on cost-decreasing potentials for offshore wind technology depends on the long-term ambitions of more European states. A higher integration of the technology reduces prices further (BMWK, 2018).

4.10 Sweden

The thesis included a short interview with Lina Kinning at the Swedish Wind Energy Association to further understand the opinions of offshore wind developers towards establishment of an auction-system. The market is predominantly concerned with deploying offshore wind without delay. Thereby, the risk of a break in continuity for offshore wind deployment is the primary concern. The offshore wind market exhibits a strong willingness to increase the nation's energy production by establishing offshore wind. However, the sector is limited by protracted permit processes extending over multiple years, sometimes causing permits achieved at an earlier stage to expire[15].

Experience gathered from Swedish spectrum auctions.

In early 2000s, Sweden established an auction-system for spectrum under the responsibility of the Post- and Telecom Agency (PTS, 2010). Furthermore, reverse auctions for carbon capture and storage will soon be launched by the Swedish Energy Agency (Energimyndigheten, 2022). The Post- and Telecom agency was contacted during this thesis and asked to provide experience and evaluations on spectrum auctions implemented in Sweden. An evaluation from 2010 was provided, discussing the spectrum auctions five years after implementation.

The establishment of spectrum auctions led to lower administrative costs for both applicants and the Post- and Telecom Agency. Transparency increased through clearly defined game rules and developers saved time compared to the previous system (PTS, 2010).

During the transition period, the Swedish Post- and Telecom Agency internally held different perceptions of the relevant legal adjustment, which prescriptions to pose and if pre-qualification criteria should be included (PTS, 2010). The auction design chosen promoted competition by facilitating the participation of new companies.

The evaluation revealed that the choice of auction-method had a significant impact on the auction results and costs for participating companies (PTS, 2010). Furthermore, the Swedish Post- and Telecom Agency plays a crucial role in making appropriate adjustments to planned auctions to suit each spectrum and a lack of competition rises when the auction-design is too

[15] Interview with Lina Kinning at the Swedish Wind Energy Association (Svensk Vindenergi).

complex (PTS, 2010). Developers viewed the auction-design as acceptable, although “second price” was requested, where the highest bidder wins the auction and pays the price equivalent to the second highest price bid (PTS, 2010)

Developers emphasised having a clear spectrum plan for the next 10-15 years and transparency in targets and aims for each spectrum, was more important than the method for assigning spectrum (PTS, 2010). Five years after the introduction of auctions, stakeholders called for clear purposes for announced auctions and stance taking, improved communication between the Post and Telecom Agency and companies (PTS, 2010). Furthermore, after five years, there are indications that actors compete for frequencies using auction game theories rather than relying on sound business plans and market utilities (PTS, 2010). Developers experienced difficulties planning participation in the auctions as the length of the auctions was unknown. Ceiling price was viewed positively as developers expressed worry about expensive outcomes for auctions with high competition. Auctions without ceiling prices could lead to the financially strongest developer buying the spectrum to hinder competition from other developers. Smaller companies participated in auctions with lower levels of competition (PTS, 2010).

5. Discussion

This thesis aimed to provide knowledge about possible pathways to an auction-based system for offshore wind establishment in Sweden by gathering knowledge about necessary conditions, possibilities, and obstacles for such societal transition, to answer following research questions:

- Which learning outcomes have derived from the establishment of auction-based systems?
- What challenges for stakeholders are associated with an implementation and operation of an auction-based system?
- Which approaches used in other nations could benefit or support a transition to an auction-based system in Sweden?

By analysing literature on German, Danish and Swedish auction-based systems, transitions to auction-based systems, green energy transition and offshore wind expansion; this thesis provides an overview of important variables and methods to succeed in a green transition through an expansion of the offshore wind sector. This thesis has focused on the launch of an auction-based system for the offshore wind sector but may be used as a base for other sectors as well.

The establishment of an auction-based system induces large scale changes in the marine area, and requires investments, regulatory adjustments, and policies, whereas the extent of necessary amendments vary depending on the nation in question. Therefore, it is difficult to draw too strict conclusions based on the methods used in other nations, including Germany and Denmark, since governmental systems differ extensively.

5.1 Accelerating offshore wind

The literature identified several factors that help nations accelerate offshore wind deployment.

Legitimacy serves in increasing social acceptance and supporting an emerging technology to comply with existing institutions (Wieczorek, et al., 2013; MacKinnon et al., 2022). It emerges through the alignment of governmental policies and a strong industry sector (Wieczorek, et al., 2013; MacKinnon et al., 2022), which was seen in the Danish development of the offshore wind sector (Madsen & Ulhøi, 2021).

A government with clear aims and a strong consensus, including a willingness to invest in the technology helps the sector succeed in the long-term (Wieczorek, et al., 2013; Madsen & Ulhøi, 2021; Karnøe, et al., 2022; Berg & Envoldsen, 2021; Grashof, 2019; MacKinnon, et al., 2022). The government holds the ability to make a strong, willing industry sector more attractive to private investors to help drive down industry costs further (Van der Loos et al., 2020). Thereby, the government has a critical responsibility to create the right conditions for offshore wind expansion and technological development in the sector (Wieczorek, et al., 2013; Madsen & Ulhøi, 2021; Berg & Envoldsen, 2021; Grashof, 2019; MacKinnon, et al., 2022).

5.2 Potential sources of inspiration for establishing an auction-based system for offshore wind in Sweden.

Based on the examination of potential sources of inspiration from Germany and Denmark, and the evaluation of the spectrum auctions in Sweden as presented in the results section, a multidisciplinary approach is essential for achieving success in offshore wind expansion. This is aligned with the sustainable transition's theory. The approach to expand offshore wind should involve the integration of various disciplines such as technology, economy, political science, law, environmental science, marine science, and sociology, to develop customized solutions that are suitable for Sweden.

Overall, auction-based systems are preferred by policymakers wanting to realise more than 200 GW offshore wind, with ambitions to plan the amount of implemented capacity to suit the nations need (Toke, 2015; Jansen et al., 2022). In Sweden, this could be advantageous as the nation historically has strict environmental regulations. By appointing auction areas, the government can at an early stage take important habitats and other interest conflicts into account by finding coexistence solutions or guiding establishments away from critical areas.

The establishment of an auction-based system could be beneficial in bypassing the municipal veto, currently impeding offshore wind establishment. Another possibility is establishing an auction-based system only in the exclusive economic zone, similar to Germany, as the technology soon allows offshore wind establishments at all depths in Swedish waters (Energymyndigheten, 2022).

5.2.1 Drawing on auction-based systems in other sectors

To investigate regulation and management features, Sweden could, similarly to Germany, rely on experience and evaluations from auction-based systems in other sectors. Germany gathered experience from the pilot auction for German solar photovoltaics to establish the auction-based system for offshore wind (Deutscher Bundestag, 2016).

From a Swedish perspective, it could be helpful to gain experience from the spectrum auctions conducted by the Post- and Telecom agency since the early 2000s. Gaining experience from management and regulatory adjustments for the spectrum auctions could provide ideas and indications of necessary amendments to launch an auction-based system, although it will likely result in internal discussions to reach conclusions in the matter.

The Post- and Telecom Agency were contacted within the scope of this thesis to provide material about the spectrum auctions, and only the 2010 evaluation was provided. However, further knowledge should be possible through more extensive, direct contact. The evaluation highlights the developers desire to receive a long-term plan, transparency in targets and aims, clear purposes when the responsible authority takes a stance and improved communication and ceiling price to avoid expensive outcomes for developers (PTS, 2010). The information provided in the evaluation aligned with the information this thesis found on design elements for offshore wind auctions in section 4.2.

In Denmark, regulation for offshore wind is stated in the reform on electricity production, gathering all regulation of renewable energy sources (Energistyrelsen, 2009). Meanwhile Germany introduced the WindSeeG (Deutscher Bundestag, 2016), gathering all regulations concerning offshore wind.

If Sweden wants to provide a similar solution, a sectoral law gathering regulation of offshore wind and other renewable energy sources would be an alternative, as current regulation is dispersed, as mentioned in the background chapter. Establishing a sectoral law was also an alternative solution according to SwAM (SwAM, 2022).

5.2.2 Ensuring a seamless transition.

One of the main concerns in Germany was to transition seamlessly without inducing a break in the continuity (BMWK, 2015[b]). This concern is also evident in Sweden. Lina Kinning from the Swedish Wind Energy Association emphasises that the technology is mature, developers' ambitions are to establish offshore wind projects promptly and the concern lies in whether there will be a pause in the system for establishment.

To transition seamlessly, Germany introduced two "transitional auctions" as a method to deal with old applications (BMWK, 2019). Companies fulfilling the set criteria could participate in the transitional auctions. However, there could be consequences with this alternative, as in Germany when companies losing their sites won against the state in court. There might be other alternatives such as finishing all existing applications, or properly including companies with existing projects to agree on potential arrangements. Although it is necessary to ensure that competition will still be possible, as the transition auctions in Germany quickly lead to a competitive market (BMWK, 2015[b]).

It could be possible to, similar to Denmark, introduce a hybrid system (Energistyrelsen, 2022). Thereby the auction-based system could be established in parallel to the current open-door system. However, this might be a difficult alternative to align with EU-regulation, as the Danish open-door procedure has been suspended and awaits clarification whether it is complied with EU law (Energistyrelsen, 2023).

5.2.3 Ensuring competition and attractive auctions.

For both Germany and Denmark, the establishment of auction-based systems for offshore wind has resulted in cost reductions and a competitive market (BMWK, 2019; Energistyrelsen, 2022). This has been observed in other nations establishing auction-based systems for offshore wind (Jansen, et al., 2022; Rubio-Domingo & Linares, 2021; Kanumarath, 2022).

The literature indicates that there are measures leading to increased competition such as customising the system to the technology, the maturity of the auction-based system in the region and the political environment (Kanumarath, 2022; Jansen, et al., 2022; Rubio-Domingo & Linares, 2021; Hvelplund et al., 2017). Project based adjustments can

additionally be placed to suit the context, which has been evident in Denmark (Energistyrelsen, 2022). In a new market, competition is stimulated while realisation rates increase when states carry the responsibility for the EIA and grid connection, as it reduces developer risks (Kreiss, 2017; Jansen et al., 2022; Kanumarath, 2022).

Overall, successful design elements for a new market include establishing ceiling price, announcing continuous auction-rounds, and applying design elements to increase safety for developers (Energistyrelsen, 2022; Rubio-Domingo & Linares, 2021; Kanumarath, 2022).

Penalties serve in increasing realisation rates, however setting them too high diminishes competition levels (Gonzáles & Kitzing, 2019; Toke, 2015; Kanumarath, 2022; Musgens & Riepin, 2018).

In Denmark, insufficient competition emerged in the early auction rounds due to inflexible schedule for project delivery and high penalties (Energistyrelsen, 2022). The Danish Energy Agency solved the situation by increasing transparency and invited pre-qualified bidders to consultation when draft tender documents were released prior to bidding. By involving developers in the final amendments of the tender documents, the Danish state can ensure attractive tenders with a flexible design (Energistyrelsen, 2022). The approach also serves in reducing risks of complaints later in the process (Energistyrelsen, 2022). The pre-qualification criteria are set high to ensure competent bidders, while still setting the criterias low enough to allow for competition (Energistyrelsen, 2022).

This section indicates that from a Swedish perspective, competition and successful outcomes should be reachable with the right design elements, however, it is important to find the right balance of the criteria to fit the Swedish scenario. Thereafter, the auction-based system can serve in reaching governmental targets. If a full transition is aimed for, like Germany, it is possible to use the transition auctions, or only the first auctions (if transitional auctions are not applied), to evaluate the outcomes and make amendments for future auction-rounds. Pre-qualification criteria can support in balancing competition and ensuring competent bidders.

Meanwhile, multi-criteria auctions can be a design-element interesting from a Swedish perspective, where the winner is also based on environmental and technological aspects. This could potentially align the sector with Sweden’s strict environmental policies.

5.2.4 Inclusion of stakeholders and planning

In Germany, the auction-based system has resulted in better structure and less conflicts of interests. The state applies detailed planning to facilitate the process and builds amendments on evaluations of previous auction rounds (Deutscher Bundestag, 2016). The planning serves in understanding the responsibility of each unit and therefore aids in providing an efficient process[16]. Including stakeholders as early as possible and being clear with aims and targets is important in reducing conflicts, as it enhances transparency. By detailed planning, the nation continuously produces clear targets for offshore wind expansion within a given timeframe (BMWK, 2016).

Denmark engages decisionmakers, academia, industry, and society in offshore wind establishment. Additionally, developers need to consult with local fishermen on which mitigation measures to take. Thereby, the nation takes actions to support the fishing sector which suffers from increased uncertainties through expanded offshore wind areas (Salomon & Schumacher, 2022).

5.2.5 Auction-based systems and social acceptance

Hvelplund et al (2017) and Grashof (2019) emphasise that social acceptance increases with the inclusion of local companies, since larger actors are both viewed as trying to "bribe" themselves into establishing wind farms, and often care more about maximising their own profits than caring for the local area.

Meanwhile, multiple sources corresponded on one point: The auction-based system is beneficial for large companies (Energistyrelsen, 2022; Grashof, 2019; MacKinnon et al., 2022; Hvelplund et al., 2017; Kanumarath, 2022) and smaller companies experience difficulties in participating due to less resources to compete with including economic resources, difficulties to establish wide social networks within the offshore wind sector, less time available for project planning, etcetera (Grashof, 2019; MacKinnon et al., 2022; Kanumarath, 2022; Wieczorek et al., 2013). Therefore, the establishment of an auction-based system risks opposing social acceptance.

[16] Interview with the Federal Maritime and Hydrographic Agency

However, acceptance levels can be dealt with by including locals in project development (Energistyrelsen, 2022). Although, it is important to ensure that the measures taken are effective. For example, Denmark has previously attempted measures to allocate twenty percent of offshore wind projects for sale to local citizens, which resulted in a growing local resistance (Hvelplund et al., 2017). Adjusting the timeline between the launch of an auction and the deadline for the last bid to be sufficient, can open for further actor diversity. In Denmark, three weeks were insufficient for smaller companies to participate (González & Kitzing, 2019; Energistyrelsen, 2022). Another suggestion could be to launch specific auction-rounds for smaller projects. A similar approach was used in the spectrum-auctions as the actor diversity increased since smaller actors could participate in auctions with lower levels of competition (PTS, 2010).

If Sweden would establish an auction-based system covering the territorial sea, the above section supports the argument to include the local municipality in the project development. Additionally, Sweden could investigate alternatives to include local companies or locals in project development.

5.2.6 Future challenges - an increased competition

Both Denmark and Germany have experienced a maturing market, leading to a change in attitude of bidders as they have started to pose lower bids. The spectrum auctions held by the Post- and Telecom Agency in Sweden also resulted in developers changing strategies and answering more to auction-theoretic approaches (PTS, 2010). In the German case, the change of bidding behaviour shocked the auctioneers and led to amendments of the auction-based system (GWEC, 2022; BMWK, 2022; Jansen et al., 2022). This development might occur in Sweden. It can be advantageous to be aware of this development in advance, as the nation might be able to plan for solutions.

5.3 Offshore wind expansion through the sustainable transition's theory

The study supports the sustainable transitions theory, which suggests that the growth of offshore wind energy requires a multidisciplinary approach considering various factors. The success of systematic change does not solely rely on a crisis or industry expansion. An auction-based system seems to serve as a useful tool for successfully achieving offshore wind

expansion, as it has in both Germany and Denmark. However, the design-elements of such a system must be carefully chosen to avoid reducing competition, creating a monopoly, or excluding smaller players (IRENA, 2015; Rubio-Domingo & Linares, 2021; Côté et al, 2022).

In theory, turning points that allow for change are identified as structural crises. For both Germany and Denmark, one such crisis is the need to reduce their historic dependence on fossil fuels. Germany has also heavily relied on energy imports, but the decision to decommission nuclear energy has pushed the country towards self-sufficiency. The adoption of an auction-based system was also driven by political will, as it was favoured by EU funding and helped increase realization rates. (BMWK, 2015a).

Denmark successfully established commercial scale projects by adopting the auction-based system, despite high technological costs (Energistyrelsen, 2022). The nation had not fully succeeded in the green transition for the offshore wind sector. However, the economic crisis around 2010 marked as a turning point for Denmark. The strong offshore wind sector pushed for innovation, and the Danish government amended their environmental targets to achieve independence from fossil fuels by 2050 (Energistyrelsen, 2022; Madsen & Ulhøi, 2021; Van der Loos et al., 2020). With governmental investments in the sector, technology developed and became cheaper than fossil fuels, making it easier to attract private investors (Energistyrelsen, 2022; Van der Loos et al., 2020).

5.3.1 Sustainable transitions theory from a Swedish perspective

Throughout history, Sweden has maintained a high level of independence in the energy sector, with a minimal reliance on fossil fuels. As of now, the country has not needed to expand its offshore wind sector. However, the offshore wind technology has advanced significantly, and the Swedish market is now ready for expansion. According to the theory, the energy transition could be considered a structural crisis since electrification in all sectors leads to a significant increase in electricity demand.

To effectively implement sustainable transitions, governmental policies and targets play a crucial role in inducing change. There are indications of increasing governmental will to expand the offshore wind sector, as evidenced by recent project approvals and appointed

governmental investigation aimed at streamlining the establishment of offshore wind power (Regeringskansliet, 2023; Dir. 2023:61).

5.4 Summary and further research

This chapter presented learning outcomes and challenges deriving from transitioning to an auction-based system. Further, the chapter introduced important variables to succeed with a green transition and suggestions of areas to consider if an auction-based system is to be introduced in Sweden. Launching an auction-based system is a complex process which takes several years to plan and realise. Undergoing a full transition comes with risks and challenges of posing a disruption to the offshore wind sector if the transition fails in being seamless. Additional challenges are the companies already holding approvals, which can result in legal consequences. The government plays an important role in balancing risks and concluding which measures to take in relation to the targets of the business. Overall, an auction-based system has been connected to an expansion of offshore wind and cost reductions, perhaps because the system requires investments and policies to be established, which is, according to green transition literature, vital to succeed in large-scale offshore wind expansion.

Moving on from an open-door procedure could be an alternative if Sweden wants to significantly expand their offshore wind sector, as Denmark also using an open-door system has not succeeded in establishing commercial scale projects through the open-door procedure (Energistyrelsen, 2022). It might be possible for Sweden to extensively increase offshore establishment through the auction-based system, although this can come with risks of a growing social resistance and issues providing coexistence solutions as the system is not as predictable as an auction-based system (SwAM, 2022).

There is a lack of research on systematic transitions to an auction-based system, which is essential to address if more nations want to transition to succeed in expanding the offshore wind sector. From a Swedish perspective, several questions will likely be solved through the governmental investigation to streamline the establishment of offshore wind power (Regeringen, 2023), such as allocating responsibility, investigating methods to simplify establishment, for example by introducing a “one-stop-shop”.

To take this overview further, it would be interesting to on a more detailed note investigate the procedures of how Germany and Denmark decided on auction-design elements and legal

additions. Further studies could gather information from the Post- and Telecom Agency on the legal adjustment and transition process to an auction-based system, which could additionally be done from the Swedish Energy Agency, currently preparing the first reverse auction for bio-ccs (Energimyndigheten, 2022). Sweden could take inspiration from Germany and build on transitions to auctions that have already taken place nationally in other sectors.

In an academic context, it would be interesting to study auction-based systems for offshore wind through an auction-theoretic perspective.

In this thesis, the insufficient information about the Danish transition made it difficult to provide information on all parts from a Danish perspective. Therefore, this thesis only included material found on the website, with risks of missing important documents. However, gathering more information from the Danish energy agency could be beneficial to easier succeed in a Swedish transition.

6. Conclusions

In order to promote a green transition by expanding the offshore wind sector, the government must establish the right conditions to support the industry's success. This entails implementing policies, creating jobs, and making financial investments. To achieve a higher probability of success, the government needs to have clear objectives and a strong consensus. Auction-based systems have proven effective in countries that aim to expand their offshore wind sector, as they promote competition and reduce technological costs. The successful outcomes of auction-based system might be due to the system requiring governmental investments to be established. If more nations adopt auctions, reduced technological costs will likely become more significant in Europe.

Germany faced legal challenges in transitioning seamlessly to the new system due to the "old approvals" from the previous system. Denmark had to balance creating competitive, flexible tenders with ensuring realisation. To increase social acceptance, setting sufficient time between the release of tender documents and the deadline for the last bid was emphasised.

In Sweden, developers required clearer aims and targets with each auction-round and ceiling price to reduce expensive outcomes. As the auction system matures, all three cases have experienced a change in actor strategies, conforming more to auction theories as developers are willing to take higher risks.

An auction-based system could be established in the exclusive economic zone, similar to Germany, and then extended to the territorial sea at a later stage. With technology advancements, establishing all depths in Swedish water will likely be possible. If Sweden decides to establish an auction-based system, they could learn from previous transitions to spectrum auctions and reverse bio-CCS auctions.

To establish an auction-based system, it is vital to plan for a seamless transition without delay for developers. Increasing competition by consulting developers ahead of each auction round, detailed planning to ensure all entities are fully aware of their responsibilities, finding solutions to include local companies and locals in project development are all areas worthy to investigate further if a decision to establish an auction-based system is taken.

7 References

BMWK (2019). *Wissenschaftlicher Endbericht Vorbereitung und Begleitung bei der Erstellung eines Erfahrungsberichts gemäß § 97 Erneuerbare-Energien-Gesetz Teilvorhaben IIf: Windenergie auf See*.

Bolin, K., Hammarlund, K., Mels, T., & Westlund, H. (2021). *Vindkraftens påverkan på människors intressen: Uppdaterad syntesrapport 2021*.

BSH. (2021). *Maritime spatial-relevant developments*

BSH. (2021). *Maritime spatial-relevant developments in the German Exclusive Economic Zone in the North Sea and the Baltic Sea.* https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/Maritime_Spatial_Plan_2021/_Anlagen/Downloads/ROP_2021/Maritime_Spatial_Plan_2021.pdf?__blob=publicationFile&v=5

Cordle, A., & Jonkman, J. (2011). *State of the art in floating wind turbine design tools.* In The twenty-first international offshore and polar engineering conference. OnePetro.

Côté, et al., (2022), *The price of actor diversity: Measuring project developers' willingness to accept risks in renewable energy auctions*.

Dahlgren, T. (2023, may 2). Havsbaserad vindkraft är bra för den marina miljön. *Göteborgs-Posten*.

Del Río, P. (2017). Designing auctions for renewable electricity support. Best practices from around the world. *Energy for Sustainable Development*, *41*, 1-13.

Del Río, P., & Kiefer, C. P. (2021). Analysing patterns and trends in auctions for renewable electricity. *Energy for Sustainable Development*, *62*, 195-213.

Deutscher Bundestag. (2016). *Beschlussempfehlung und Bericht des Ausschusses für Wirtschaft und Energie* (9. Ausschuss). 18/9096.

Dir 2023:61. *En ordnad prövning av havsbaserad vindkraft.* https://www.regeringen.se/contentassets/4f4071e6545741f5ab7604907cc7704c/kommittedirektiv-202361-en-ordnad-provning-av-havsbaserad-vindkraft.pdf

EU. *On the promotion of the use of energy from renewable sources.* (Directive 2018/ 2001). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG

ekonomiska zon för uppförande och drift av vindkraftparken Galatea-Galene. https://www.regeringen.se/contentassets/133d5d2c84504300bdf2fc7ec7a5642a/regeringsbeslut-kn2023-01077---galatea-galene.pdf

ekonomiska zon för uppförande och drift av vindkraftparken Kattegatt Syd. https://www.regeringen.se/contentassets/cc45734be4ea4e23b57a24021e0df08a/regeringsbeslut-kn2023-01060---kattegatt-syd.pdf

Energimyndigheten, (2022). *Myndighetsgemensam uppföljning av samhällets elektrifiering.* https://www.svk.se/siteassets/om-oss/rapporter/2022/myndighetsgemensam-uppfoljning-av-samhallets-elektrifiering---huvudrapport.pdf

Energimyndigheten. (2023). Report 2023:12. *Förslag på lämpliga energiutvinningsområden för havsplanerna. Redovisning av uppdraget att ta fram ett underlag för nya eller ändrade områden för energiutvinning i havsplanerna som möjliggör ytterligare 90 TWh årlig elproduktion. https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=213740*

Energistyrelsen. (2009). *Promotion of Renewable Energy Act*. https://ens.dk/sites/ens.dk/files/Vindenergi/promotion_of_renewable_energy_act_-_extract.pdf

Energistyrelsen. (2022). *Offshore Wind Development.* https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf

Energistyrelsen. (2023). *Sagsbehandlingen under Åben dør-ordningen er stillet i bero*. https://ens.dk/ansvarsomraader/vindmoeller-paa-hav/aaben-doer-ordningen-havvindmoeller/information-projektudviklere

European Commission. (2022). *communication from the commission to the european parliament, the european council, the council, the european economic and social committee and the committee of the regions. (*Report COM/2022/230). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN

European Parliament. (2023). *Wholesale energy market: Union's protection against market manipulation.* (Proposal COD/2023/0076). https://oeil.secure.europarl.europa.eu/oeil/popups/printsummary.pdf?id=1737035&l=en&t=E

European Commission. n.d. *Offshore renewable energy*. https://energy.ec.europa.eu/topics/renewable-energy/offshore-renewable-energy_en

European Council. (2022). laying down a framework to accelerate the deployment of renewable energy. (Regulation 2022/2577). https://eur-lex.europa.eu/eli/reg/2022/2577

European MSP Platform. European Commission. n.d. *Improving the co-existence of Offshore Energy Installations & Shipping*. https://maritime-spatial-planning.ec.europa.eu/practices/improving-co-existence-offshore-energy-installations-shipping

Eurostat. 2021. *Renewable Energy Statistics.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics

Federal Ministry for Economic Affairs and Climate Action. (2022). *Overview of the Easter Package*. https://www.bmwk.de/Redaktion/EN/Downloads/Energy/0406_ueberblickspapier_osterpaket_en.pdf?__blob=publicationFile&v=1

Federal Ministry for Economic Affairs and Energy (BMWK), (2015[a]). *The energy transition – a great piece of work- Offshore wind energy - An overview of activities in Germany.* https://www.bmwk.de/Redaktion/EN/Publikationen/offshore-wind-energy.pdf?__blob=publicationFile&v=3

Federal Ministry for Economic Affairs and Energy (BMWK), (2015[b]). *Ausschreibungen für die Förderung von Erneuerbare-Energien-Anlagen.*

Federal Ministry for Economic Affairs and Energy (BMWK), (2018). *Vorbereitung und Begleitung bei der Erstellung eines Erfahrungsberichts gemäß § 97 Erneuerbare-Energien-Gesetz Teilvorhaben IIf: Windenergie auf See.*

Federal Ministry for Economic Affairs and Energy (BMWK), (2019). *Evaluierungsbericht der Ausschreibungen für erneuerbare Energien Ausschreibungen für Erneuerbare Energien nach dem ErneuerbareEnergien-Gesetz (EEG) und dem Windenergie-auf-See-Gesetz (WindSeeG)*

Gazzola, P., Roe, M., & Cowie, P. (2015). Marine spatial planning and terrestrial spatial planning: Reflecting on new agendas. *Environment and Planning. C, Government & Policy, 33*(5), 1156-1172.

González, M. G., & Kitzing, L. (2019). Renewable Energy Auctions in Denmark: A Case Study on Results and Lessons Learnt.

Grashof, K. (2019). Are auctions likely to deter community wind projects? And would this be problematic?. Energy Policy, 125, 20-32.

Gusatu, L., Yamu, C., Zuidema, C., & Faaij, A. (2020). A spatial analysis of the potentials for offshore wind farm locations in the North Sea region: Challenges and opportunities. ISPRS International Journal of Geo-information, 9(2), 96.

Hauch, J. (2001). The Danish electricity reform. Energy policy, 29(7), 509-521.

Hoppe & Nilsson (2022). *Samexistens mellan Försvarsmakten och havsbaserad vindkraft. Analys av utmaningar och diskussion kring möjliga lösningar*. Lunds Tekniska Högskola.

Hvelplund, F., Østergaard, P. A., & Meyer, N. I. (2017). Incentives and barriers for wind power expansion and system integration in Denmark. *Energy Policy*, *107*, 573-584.

Institute for Energy Economics and Financial Analysis (IEEFA). 2022. *China's offshore wind industry giant stimulated global growth*.

Interreg, North Sea Region. (2022) https://northsearegion.eu/northsee/e-energy/offshore-renewable-energy-developments-offshore-wind/

IRENA and CEM (2015), *Renewable Energy Auctions – A Guide to Design*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/Jun/IRENA_Renewable_Energy_Auctions_A_Guide_to_Design_2015.pdf

Jansen, M., Beiter, P., Riepin, I., Müsgens, F., Guajardo-Fajardo, V. J., Staffell, I., ... & Kitzing, L. (2022). Policy choices and outcomes for offshore wind auctions globally. *Energy Policy*, *167*, 113000.

Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. *The International Journal of Sustainable Development & World Ecology*, *14*(1), 78-91.

Kjellén, R. (1916). *Politiska handböcker 3 Staten som lifsform*.

Koelman, M., Hartmann, T., & Spit, T. J. (2022). When tensions become conflicts: wind turbine policy implementation and development in the Netherlands. *Journal of Environmental Planning and Management*, *65*(3), 375-397.

Langlet, D., & Mahmoudi, S. (2016). *EU environmental law and policy* (First ed.).

MacKinnon, D., Dawley, S., Steen, M., Menzel, M., Karlsen, A., Sommer, P., Normann, H. (2019). Path creation, global production networks and regional development: A comparative international analysis of the offshore wind sector. *Progress in Planning, 130*, 1-32.

Madsen, H. L., & Ulhøi, J. P. (2021). Sustainable visioning: Re-framing strategic vision to enable a sustainable corporate transformation. *Journal of Cleaner Production*, *288*, 125602.

Mahdi, M. (2023). Designing Denmark's future offshore wind policy framework: A pathway for policymakers to achieve 12.9 GW deployment by 2030.

Malafry, M., & Öhman, M. C. (2022). *Rättsliga förutsättningar för havsbaserad vindkraft*. Naturvårdsverket.

May, R., Nygård, T., Falkdalen, U., Åström, J., Hamre, Ø., & Stokke, B. G. (2020). Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. Ecology and evolution, 10(16), 8927-8935.

Memija, A. (2023). *Dutch Stop Offshore Wind Turbines to Protect Migratory Birds in 'International First'*. https://www.offshorewind.biz/2023/05/17/dutch-stop-offshore-wind-turbines-to-protect-migratory-birds-in-international-first/

Musgens, F., & Riepin, I. (2018). Is Offshore Already Competitive? Analyzing German Offshore Wind Auctions. *2018 15th International Conference on the European Energy Market (EEM), 2018*, 1-6.

Naturskyddsföreningen. (2022). *Hur sätts elpriset och varför går det upp? https://www.naturskyddsforeningen.se/artiklar/hur-satts-elpriset-och-varfor-ar-det-hogt/*

Naturskyddsföreningen. 2022. *Höga elpriser- vad beror det på?* https://www.naturskyddsforeningen.se/artiklar/hur-satts-elpriset-och-varfor-ar-det-hogt/

Nordic Energy Research. (2023). *Coexistence and nature-inclusive design in Nordic offshore wind farms*. https://www.nordicenergy.org/wordpress/wp-content/uploads/2023/03/Pdf-Coexistence-rapport.pdf

Ratzel, F. (1893). *Politische geographie*. Germany: R. Oldenbourg, 1893.

Regeringen (2022). *The Marienborg Declaration. The Baltic Sea Energy Security Summit.* https://www.regeringen.dk/media/11544/the-marienborg-declaration-_300822.pdf

Regeringsbeslut KN2023/01060. *Ansökan om tillstånd enligt lagen (1992:1140) om Sveriges*

Regeringsbeslut KN2023/01077. *Ansökan om tillstånd enligt lagen (1992:1140) om Sveriges*

Regeringskansliet (2023). *Regeringen tillsätter utredning för att effektivisera etableringen av havsbaserad vindkraft.*[pressmeddelande], 3 maj. https://www.regeringen.se/pressmeddelanden/2023/05/regeringen-tillsatter-utredning-for-att-effektivisera-etableringen-av-havsbaserad-vindkraft/

Regulation 2022/ 2577. *Laying down a framework to accelerate the deployment of renewable energy*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R2577#ntr4-L_2022335EN.01003601-E0004

Salomon, M., & Schumacher, J. (2022). Maritime spatial planning: Germany as a forerunner in ecosystem-based management? Planning, Practice & Research, 37(6), 739-750.

Salomon, M., & Schumacher, J. (2022). Maritime spatial planning: Germany as a forerunner in ecosystem-based management? Planning, Practice & Research, 37(6), 739-750.

Svensk Vindenergi. (2022). *Sammanställning över planerad havsbaserad vindkraft i Sverige.* https://svenskvindenergi.org/wp-content/uploads/2022/05/Sammanstallning-over-planerad-havsbaserad-vindkraft-2022-05-03-1.pdf

Svenska Kraftnät. (2022). *Tema: Elmarknad och elpriser.* https://www.svk.se/press-och-nyheter/temasidor/tema-elmarknad-och-elpriser/

Svenska Kraftnät. N.d. *Tema: Elmarknad och elpriser.* https://www.svk.se/press-och-nyheter/temasidor/tema-elmarknad-och-elpriser/

SwAM (Havs- och Vattenmyndigheten), (2022). Dnr 01393-2022. *Uppdrag att utreda frågor om exklusivitet för anläggande av vindkraftsparker i allmänt vatten och i Sveriges ekonomiska zon. Redovisning av regeringsuppdrag M2022/00768*.

SwAM (Havs- och Vattenmyndigheten). (2022). *Havsplaner för Bottniska viken, Östersjön och Västerhavet - Statlig planering i territorialhav och ekonomisk zon*. https://www.havochvatten.se/download/18.5a0266c017f99791d0e68c2b/1655131290482/havsplaner-beslutade-2022.pdf

SwAM (Havs- och Vattenmyndigheten). (2023). *Samexistens mellan havsbaserad vindkraft, yrkesfiske, vattenbruk och naturvård.*

TBC. 2021. Biodiversity impacts associated to offshore wind power projects. https://www.iucn.org/sites/default/files/2022-06/01_biodiversity_impacts_associated_to_offshore_wind_power_projects.pdf

Thaxter, C. B., Ross-Smith, V. H., Bouten, W., Masden, E. A., Clark, N. A., Conway, G. J., ... & Burton, N. H. (2018). Dodging the blades: new insights into three-dimensional space use of offshore wind farms by lesser black-backed gulls Larus fuscus. *Marine Ecology Progress Series*, *587*, 247-253.

The Federal Maritime and Hydrographic Agency (BSH), (2020). *Site development plan 2020 for the German North Sea and Baltic Sea*. https://www.bsh.de/EN/TOPICS/Offshore/Sectoral_planning/Site_development_plan/_Anlagen/Downloads/FEP_2020/Site_Development_Plan_2020.pdf?__blob=publicationFile&v=2

The Federal Maritime and Hydrographic Agency. (2021). *Maritime Spatial Planning*. https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/maritime_spatial_planning_node.html;jsessionid=7C59E14FA6659CB6843B5B1AA9225F95.live11291

Thomsen, F., & Stöber, U. (2022). Operational underwater sound from future offshore wind turbines can affect the behavior of marine mammals. *The Journal of the Acoustical Society of America, 151*(4), A239.

Toke, D. (2015). *Renewable energy auctions and tenders: how good are they?*. International Journal of Sustainable Energy Planning and Management, 8, 43-56.

van der Loos, H. A., Negro, S. O., & Hekkert, M. P. (2020). International markets and technological innovation systems: The case of offshore wind. *Environmental Innovation and Societal Transitions*, *34*, 121-138.

WFO, 2023. *Global Offshore Wind Report 2022.* https://wfo-global.org/wp-content/uploads/2023/03/WFO_Global-Offshore-Wind-Report-2022.pdf

Wieczorek, A. J., Negro, S. O., Harmsen, R., Heimeriks, G. J., Luo, L., & Hekkert, M. P. (2013). A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews*, *26*, 294-306.