Exploring Policy Support For Offshore Wind Parks In the Netherlands

Master Thesis

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Declaration of Academic Integrity

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August 2022, Ravenstein

Date, place

Signature

‘’How many roads must a man walk down
Before you call him a man?
How many seas must a white dove sail Before
she sleeps in the sand?
Yes 'n how many times must the cannon- balls
fly before they're forever banned?
The answer, my friend, is blowin' in the wind The
answer is blowin' in the wind’’

(Bob Dylan, Blowin’ in the Wind, 1962)

Preface

In front of you is the Master Thesis which I wrote to conclude my MSc in Public Policy & Human Development. It will discuss the role of policy support for offshore wind parks in the Netherlands. The topic of this Master Project is of great interest to me, mainly because it combines two topics that I like: technology and society. Being an engineer by profession, I often use my problem-solving skills to help find solutions for societal challenges. The energy transition therefore is and example of a challenge that I want to dedicate myself to wholeheartedly. In the last year, the people and courses of of Maastricht University & UNU Merit have made me very optimistic about tackling world challenges such as the energy transition. I learned how to develop, implement and evaluate new policies. I want to thank everyone that inspired me over the year. In the process of writing this Master Thesis, I learned a great deal on how to conduct qualitative research. Therefore, I would like to thank my supervisor dr. Ripa for guiding me the past months and all the help she gave me. I loved writing this Master End Project and will stay forever curious about the prospects of offshore wind parks and the role policy has in fostering this development. I hope you enjoy reading it.

Abstract

Offshore wind energy constitutes a critical component in the the worldwide energy transition to combat energy-related CO_2 emissions. As a result, the Netherlands will significantly boost its offshore wind power capacity from 1 GW in 2019 to 11.5 GW in 2030. However, stil a large gap exists between the planned and actual installed capacity of offshore wind parks. So, despite continuous efforts since the 1970s, offshore wind energy plays only a limited role in the Dutch energy system. The aim of this thesis is to investigate how policy can foster the development of offshore wind parks in the Netherlands. The research is twofold. The study is two-folded. On the one hand, the history of the slow development of offshore wind parks in the Netherlands is investigated. On the other hand, recommendations are explored as to how policy may help in the implementation of future offshore wind parks and the aspired sustainability targets. Positioned in the field of Science and Technology Studies (STS), research is devoted to understanding offshore wind parks as a socio-technical system. Different transition stages are defined and the niche-regime interaction is studied. In order to do so, the method of this thesis relies on the Strategic Niche Management (SNM) framework, whilst lending terminology from Multi-Level Perspective and Transition Management. A literature study is presented, which compiles a history of policy support for offshore wind parks over 50 years in the Netherlands. As a result, this thesis presents a chronological review of Dutch offshore wind park developments through the niche internal processes of shielding, nurturing and empowering. Consequently, the results of the analysis are contrasted with the wider scientific literature landscape on the energy transition. Moreover, limitations are elobared upon. Lastly, this thesis conludes on the main findings of the analysis and provides detailed policy recommendations on how policy can support the development of Dutch offshore wind parks in this decade.

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List of Acronyms

Alternating current (AC)

Dutch Energy Research Centre (ECN)

Giga-watt (GW)

Industrial Oceanography Council (IRO)

International Energy Agency (EIA)

International Maritime Organization (IMO)

Kilowatt-hour (kWh)

Multi-level Perspective (MLP)

Megawatt-hour (MWh)

Noord-Holland Province Electricity Company (PEN)

'Not in my backyard' (NIMBY).

Research and Development (R&D)

Science and Technology Studies (STS)

Strategic Niche Management (SNM)

Strategic Environmental Assessment (planMER)

Technology Innovation System (TIS)

Terawatt-hour (TWh)

Top Consortia for Knowledge and Innovation (TKI's)

Transmission System Operator (TSO)

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1. Introduction

‘Solar power, wind power, the way forward is to collaborate with nature - it's the only way we are going to get to the other end of the 21st century’.

Bjork

1.1 Problem Statement

In line with the Paris Climate Agreement, stating that global warming must be limited to less than two degrees Celsius above pre-industrial levels, the Dutch government agreed on a National Climate Agreement to decrease carbon dioxide emissions in the Netherlands by 49% in 2030 compared to 1990. Recently, this target has been updated to a reduction of 55% in light of the European Green Deal's Fit for 55 package (Rijksoverheid, 2021). To reach these decarbonisation targets, offshore wind has been identified as one of the main pillars of the energy transition. The ambition is high: offshore wind parks will have to deliver a total target capacity of 21GW, generating around 89TWh of offshore wind by 2030. As a result, offshore wind parks will then produce 75% of all electricity in the Netherlands (Rijksoverheid, 2021). Not only does offshore wind park help in the aspired sustainability targets, it also ensures a more independent energy supply. Given the current geopolitical situation, the need for an autonomous energy system becomes more and more relevant.

Although the ambitious objective of introducing offshore wind parks, a share of only 1GW of offshore wind energy was reached in 2019 (CBS, 2020), stemming from only 4 offshore wind parks. Still, as visible in figure 1, there is a huge gap between the aspired and the present installed capacity of offshore wind parks, made visible with a dashed line. So despite continuous efforts from the 1970s onwards, offshore wind parks still play a minor part in the Dutch energy supply. In the last decade, multiple academics have confirmed this observation. Verbong, Geels, & Raven (2008) consider offshore wind parks a minor *'niche'*, although noting the considerable potential of its implementation. In their quantitative review of the European offshore wind energy innovation system, Wieczorek et al. (2013) also find that Dutch offshore wind market formation is lacking compared to other European countries. Some challenges are identified that the offshore wind sector faces, such as fragmented policies and poor alignment of national regulatory frameworks.

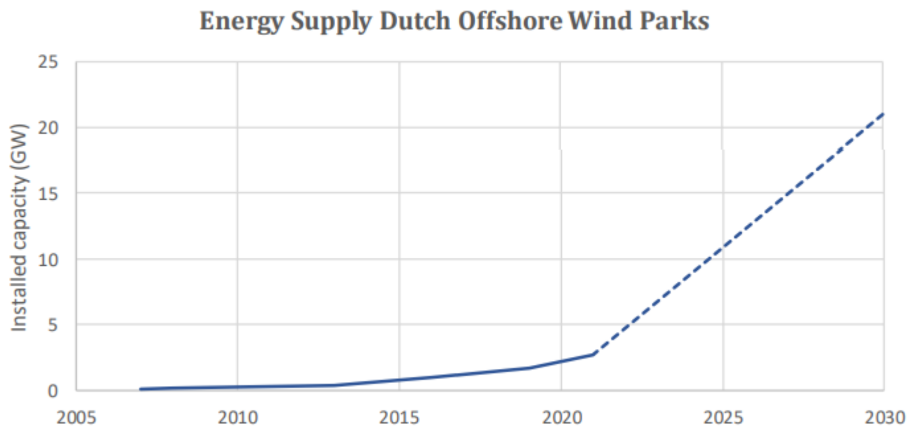

Figure 1. Energy Supply Dutch Offshore Wind Parks (CBS, 2022)

1.2 Relevance of the Research

As mentioned above, Dutch offshore wind parks will have to deliver a total installed capacity of 21 GW in 2030. However, the present installed capacity currently equals only 2.5 GW. Therefore, there is a huge challenge to implement offshore wind parks in this decade to achieve the aspired sustainability targets. Hence, research into this field is important. Below, the relevance of this research is further outlined.

According to the Netherlands Enterprise Agency (2015), the conditions for offshore wind parks in the Netherlands are excellent. The Netherlands has a worldwide status for civil engineering in water infrastructure. Moreover, being home to the largest port in Europe, Rotterdam harbour, the Netherlands has an excellent infrastructure for offshore industries. Lastly, due to its near proximity to the wind resources of the North Sea with relatively shallow waters, the Netherlands seems to be in a perfect position of unleashing the potential of offshore wind parks. Though, albeit with the economic and technical potential for implementing offshore wind parks, few policymaking mechanisms are available for securing an integrated pathway toward the aspired decarbonisation targets (Muller, 2018). Thus, there is a need for an integrated policy approach.

As the number of offshore wind parks will grow in the coming years, an enormous infrastructural operation needs to be performed. There are also technical, social, economic and ecological constraints that need further investigation and are relevant for this research. For example, there are social problems with fisheries limited in their employment because of the installed offshore wind parks. Also, knowing that the North Sea is one of the busiest navigated seas in the world, current shipping navigation routes will have to be changed to ensure the accessibility of the main ports, which entails both risks and opportunities for the North Sea nature (Vrooman et al. 2018). Lastly, as offshore wind parks are still considered a 'niche' (Verbong, Geels, & Raven, 2008), there might be problems with upscaling this technology. For example, the whole implementation of offshore wind parks requires the installation of foundations, an offshore electricity grid, and other logistic and operational challenges (Vrooman 2018).

Therefore, many questions still need to be answered to manage the large-scale development of offshore wind parks properly. Moreover, there is a need for policy mechanisms to foster the large-scale development of offshore wind parks. Thus, the relevance of this research is concerned with analysing the overall Dutch offshore wind innovation system and strengthening it with recommendations.

1.3 Literature Contributions

This thesis is positioned in the field of Science and Technology Studies (STS) and transition studies. In this field, onshore wind parks have been extensively evaluated (Agterbosch et al., 2007; Kamp, 2004; Kamp, 2007) However, its offshore counterpart has so far received less attention. The contributions made in this field are reviewed briefly and contributions to existing literature are emphasised. Lastly, an argumentation is given for the choice of this thesis' theoretical framework.

Investigating the entire deployment of offshore wind parks in the Netherlands relies on relies on a multi-disciplinary typology. This typology concerns a socio-technical system in which social, political, economic, technological, and ecological issues are interconnected. Socio-technical systems are defined as: `systems at the sectoral level ..., made up by a cluster of elements, involving technology, science, regulation, user practices, markets, cultural meaning, infrastructure, production and supply networks' (Geels & Kemp, 2007).

This implementation is not only dependent on technical or economical advancements, like cost-minimisations or technical optimisations. Neither can one only concern the technology itself: the technology of offshore wind parks under investigation is part of its larger socio-technical system. Therefore, a socio-technical system is a system consisting of both social and technical elements, where the `technological components and social arrangements are so intertwined that the successful design of such systems require the joint optimisation of technological and social variables' (Bauer & Herder, 2009). A socio-technical system is not static, it is dynamic and can be analysed throughout time. Within this thesis, it is the change of the socio-technical system that is of interest, namely: the implementation of offshore wind parks.

An important contribution to examining the socio-technical systems of offshore wind parks is made by Wieczorek et al. (2013). This paper assesses offshore wind innovation systems in the following four countries: Denmark, Germany, the Netherlands and the United Kingdom. Their study aims to find recommendations for strengthening the overall European offshore wind innovation system. Their conclusion highlights the issues that Europe's offshore wind sector is facing. Some of these challenges are: a severe shortage of engineers, the high cost of technology and limited grid infrastructure of offshore wind parks and fragmented policies and poor alignment of national regulatory frameworks; (Wieczorek et al., 2013). The analysis proved to be very useful in detecting issues and challenges regarding the implementation of offshore wind parks.Yet this study only delivers a partial answer: it does not explain how differences in the presented important dimensions occurred and what policy can be recommended to support offshore wind parks in the Netherlands further. This thesis aims to extend on this research.

Next, Agterbosch et al. (2007) analysed the Dutch innovation system of offshore wind parks. They mentioned the choice of switching from onshore to offshore wind parks as favourable. Although this option is considered to be essential for sparing onshore locations, they are very sceptical about the feasibility of offshore wind power in the short run. Another criticism is put forward by Breukers & Wolsink (2007), which conclude that the early policy choice in Netherland to focus on offshore wind parks in a 'large-scale application' approach resulted in unsuccessful development trajectories.

Moreover, Kern (2013) compared empowerment for 'offshore wind parks' as sustainable niches in the UK and The Netherlands and concludes the presence of a powerful and resourceful actor in the UK but an absent one in the Netherlands. Likewise, Markard & Petersen (2009) suggest that policymakers interested in further pushing the offshore wind market will have to adapt their instruments to the new trends in ownership and the corresponding demands. Next, Bergek, Jacobsson, & Sandén (2008) recommend that smaller 'protected spaces' be provided for offshore wind parks to emerge in, long before the technology is competitive in the market, using a policy framework (Luo et al., 2012). In addition, van der Loos et al. (2020) proposes that the Dutch government has to ensure sufficient attention to variety and experimentation to enhance diffusion concerning offshore wind parks. In this paper, the role of policy in fostering offshore wind parks will be researched further to draw policy recommendations for the future.

Another relevant contribution is made by Kamp (2008), who analyses the introduction of wind parks in Denmark and the Netherlands. This comparative analysis is essential in order to understand the Dutch innovation system concerning offshore wind parks. Hence, Kamp (2008) concludes that:

> *'' Wind turbines proved to be a very hard technology. Therefore, in the case of wind power it is especially important to gain a lot of experience with the technology while it is in use, either as a prototype or as a commercial product. The Danish way of trial-and-error, slow upscaling and early market development proved to be more suited to this specific technology than the Dutch way of high-tech fast upscaling and science-driven technology development.''*

The conclusion confirms the importance of understanding the technical mechanisms in socio-technical analysis. Also, the conclusion marks the relevance of learning processes in technology development. In the choice of an applicable framework, this element should be integrated.

In order to research the advancements in the implementation of offshore wind parks, a framework is needed that can detect the barriers and catalysts in the slow development of offshore wind parks. Furthermore, a holistic framework is needed that incorporates parts from the socio-technical systems to give recommendations for the aspired large-scale development of offshore wind parks.

In light of the above, a suitable framework is called Strategic Niche Management (SNM). The SNM provides a way to investigate how and under what circumstances a successful emergence of a niche was or is possible. When taking note of the low share of energy generation of offshore wind parks, offshore wind parks can still be labelled as 'niche'. The SNM framework seems applicable for this thesis' analysis for multiple reasons. First and foremost, it includes the learning processes of technical development. Secondly, the framework focuses explicitly on niches. Analysing offshore wind parks throughout a certain timeframe requires a framework with a perspective that focuses on niche level, where actors can make a difference. Thirdly, SNM is explanatory (historical) as well as managerial (future oriented) in its nature. Because this thesis' aim is to both evaluate policy in the past, present and future, SNM seems suitable.

An interesting application of SNM is done on solar photovoltaic (PV) technology in The Netherlands. The paper answers the question of how PV was able to survive in the Netherlands even though the existence of a very difficult policy setting. It follows a historical evaluation, combined with an analysis showing how PV promoters have been able to strategically secure and shape protective measures over four decades in the context of harsh regime selection environments. On the usefulness of SNM, they conclude that SNM proved very useful in unfolding the developments concerning PV technology (Verhees, Raven, Veraart, Smith, & Kern, 2013).

On the topic of offshore wind parks, no SNM analysis has been applied yet. Verbong, Geels and Raven (2008) used the former method of SNM that did not include shielding, nurturing and empowerment yet, to analyse the long-term innovation policy of four renewable energy technologies: wind energy biomass, fuel cells and hydrogen, and photovoltaics (Verbong et al., 2008). This analysis is particularly insightful in their conceptualisation of expectations dynamics, social networks and learning processes.

Verhees et al. (2015) used the niche transition processes of SNM in a framework called S/N/E to analyse the development of offshore wind energy. This thesis will partially draw upon their key historical timetable and aims to conceptualise expectations, dynamics, social networks and learning processes in a more coherent way.

Concerning the SNM framework, Raven, Kern, Verhees, & Smith (2016) stress the importance of broadening the framework's analytical focus by being more sensitive to the socio-political strategies of technology advocates, following calls for more politically informed analyses of transition dynamics and system transformation more generally (Hendriks & Grin, 2007). Therefore, this thesis will explicitly focus on the socio-political nature of the development of offshore wind parks.

1.4 Research Question and Sub-Questions

In the Netherlands, The Ministry of Economic Affairs and Climate policy is formally responsible for all policies concerning energy, including offshore wind parks. In collaboration with the Ministry of the Interior and Kingdom Relations, it is also responsible for the geographical feasibility of big energy projects like offshore wind parks. Therefore, and as already pointed out by Wieczorek et al. (2013), the progress of offshore wind parks is directly intertwined with the direction of how the political wind blows.

The overarching research question of this paper therefore reads:

'How can policy support the facilitation of

offshore wind parks in the Netherlands?'

This thesis aims to investigate how policy can support offshore wind parks in the Netherlands. The study is two-folded. On the one hand, the history of the slow development of offshore wind parks in the Netherlands is investigated. On the other hand, recommendations are explored as to how policy may help in the implementation of future offshore wind parks and the aspired sustainability targets.

In investigating the reasons for the slow development of offshore wind parks, an analysis is performed, where past policies that have advanced or restricted the development of offshore are analysed in order to unpuzzle the slow development of offshore wind parks in the Netherlands.

Therefore, a framework is necessary that answers questions related to the history and future of policy support for the development of Dutch offshore wind parks. Therefore, this thesis is accompanied by the following sub-questions:

1. How do social, environmental, technical and economic aspects affect Dutch offshore wind parks?
2. What is the history of the development of Dutch offshore wind parks?
3. What policies have restricted/supported the development of Dutch offshore wind parks?
4. What policy recommendations can be provided?

These sub questions are dealt with in a structured way. This thesis is structured as follows. *Chapter 2. Methodology* briefly outlines the Dutch energy situation and the methodological approach is explained. Moreover, *chapter 3. Analysis* dives into the results of this master thesis. Then, this thesis summarizes the main findings and in *chapter 4. Conclusion.* Next, discussion points and limitations are delineated in *chapter 5. Discussion.* Lastly, this thesis puts forward policy recommendations in *chapter 6. Policy Recommendations*.

2. Methodology

‘We are like tenant farmers chopping down the fence around our house for fuel when we should be using Nature's inexhaustible sources of energy wind, sun and tide’

Thomas Edison

2.1 The Dutch Energy Situation and Offshore Wind Sector

This chapter explains the current Dutch Government approach towards a feasible deployment of offshore wind farms. This comprises a 6-step approach, which is explained more in detail below. In this chapter, two international events are considered as laying the foundation for Dutch policy making concerning offshore wind parks.

Firstly, the European Commission began to move towards a low carbon economy by establishing the Renewable Energy Directive 2009/28/EC. This Directive aimed to promote renewable energy resources and demanded that all EU member states fulfilled a minimum of 20% of their total energy demand from renewable resources by 2020. Member states had to adapt to this objective by national targets. Following the 'Renewable Energy Directive 2009/28/EC', a bill named the 'Offshore Wind Energy Law' was put into place at the start of 2015. The bill provided an integral legal framework for the large-scale realization of offshore wind parks. The bill was intended to lead to cost reductions in the planning and construction of offshore wind parks.

Secondly, in 2015 the Paris Climate Agreement was signed, which stated that global warming had to be limited to less than two degrees Celsius above pre-industrial levels. This called upon drastic reductions of fossil fuels, upon which the Netherlands promised to act. Rutte III's coalition agreement announced a National Climate Agreement in aspiration of meeting the climate goals set out in the Paris Climate Agreement. The Dutch government aimed decrease carbon dioxide emissions in the Netherlands by 49% in 2030 compared to 1990 as set out in the National Climate Agreement. Offshore wind had been recognized as one promising way for reaching the goals with a target capacity of 11.5GW, generating around 49TWh of offshore wind by 2030. In line with the National Climate Agreement, the 'Ontwikkelkader Windenergie Op Zee' was published by the cabinet in 2018, containing the functional requirements of the offshore net grid.

Among the different actors, the Ministry of Economic Affairs & Climate plays the predominant role in shaping all renewable energy policies such as wind farm site decisions. The policies stemming from international events that have been explained above frame the conditions and rules needed to promote offshore wind parks in the Netherlands. Policies enable and constrain actors in the market. Renewable Energy Directive 2009/28/EC required EU member states to create an attractive environment for relevant investors. Therefore, the Dutch government created the subsidy scheme SDE+ to stimulate investors to enter and invest in developing renewable energy technologies such as offshore wind parks in the Netherlands.

An offshore wind park concerns the assets that generate electricity in the supply chain of an energy system. An offshore wind park contains many different components, as becomes visible in figure 2. These components are explained subsequently, as with regards to deployment of offshore wind parks in the Netherlands.

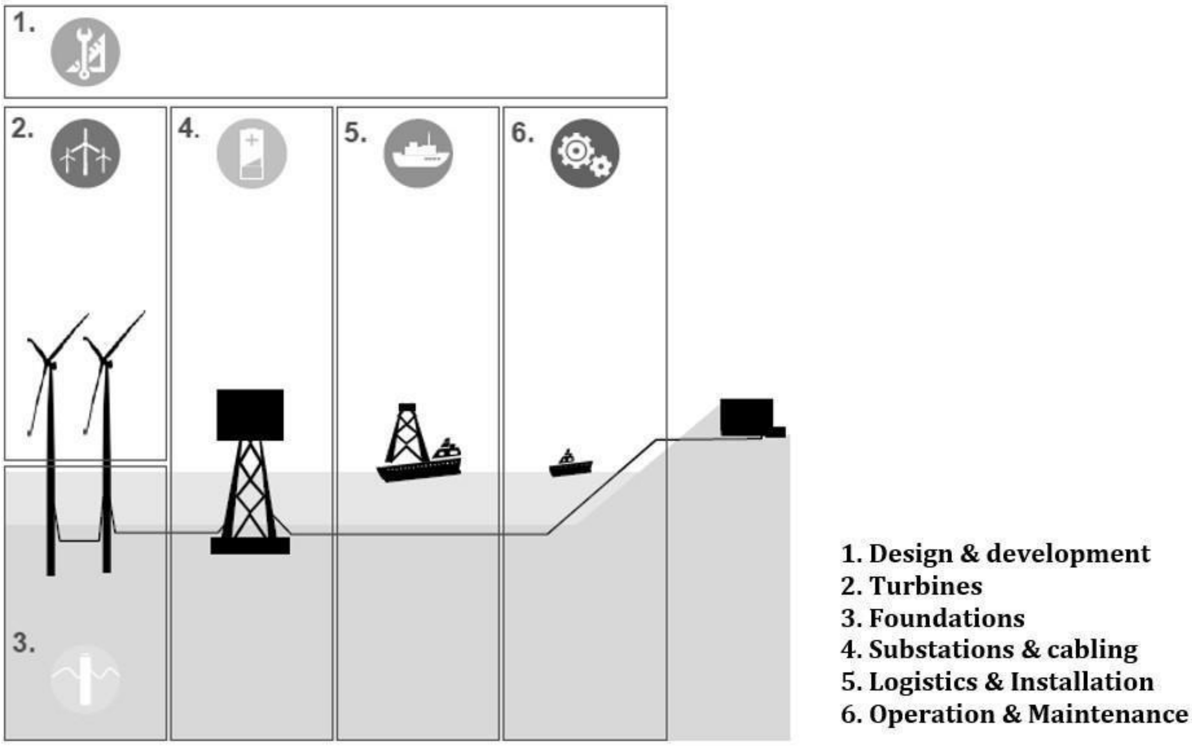

Figure 2. Offshore wind energy system

1. Design & development

The initial step focuses on design and development. The Ministry of Economic Affairs and Climate Policy and the Ministry of Infrastructure and Environment designate the areas for future offshore wind farm development in the Dutch territory of the North Sea through the National Water Plan, which has the Water Act as its legal foundation. The particular rollout order in which wind turbine areas and associated sites will be created is then given, along with a schedule.In the Netherlands, energy companies invest, construct and own offshore wind parks. Vatenfall, Eneco, and Van Oord are the three biggest energy companies with concern for offshore wind parks in the Netherlands. Ballast Nedam, Van Oord, and Mamomoet are three of the most famous Dutch companies that specialize in offshore wind parks construction (Wieczorek et al., 2013).

2. Turbines

A wind turbine typically contains a tower, nacelle, hub, and blades. The tower is installed on the transition piece of support system, and nacelle is placed on the tower. The hub and blade form the rotor which is attached to the nacelle. Fixed speed wind turbines and variable-speed wind turbines are two main available designs of wind turbine technologies in the market. Variable-speed technology captures the energy from the wind better and is the most widely used design (Carrasco et al., 2006). Offshore wind turbines typically range from 2 to 5 MW (Kaiser & Snyder, 2012). The growth of wind turbine capacity results into an increase of offshore wind parks' total capacity, as it is observed in the Netherlands. Appendix IV summarizes the different turbine models of offshore wind parks in the Netherlands and gives information on rated power and turbine type. In the Netherlands, wind turbines are built by Danish companies like Nordtank or Vestas. However, Gemini's turbines were manufactured by Siemens. Construction of larger offshore wind turbines leads to more productivity that could compensate costs of installation and operation, which are typically higher (Esteban et al., 2011).

3. Foundations

The support foundation consists of the foundation, transition piece, and scour protection. The foundation supports the turbine. The site condition, size and weight of the turbine determine the type and design of foundation technology. The site condition is a function of maximum wind speed, water depth, wave heights currents, and surf properties. Therefore, each foundation within a wind park is customized to its particular location and the water depth. Monopiles, jackets, tripods, gravity, and floating foundation are the five basic types of foundation (M.J. Kaiser & Snyder, 2012). In the Netherlands, the type of foundation is monopile for all realized offshore wind parks, however there are different dimensions per offshore wind parks, as is shown in appendix V

4. Substations & cabling

The cabling connects the offshore wind park to the electrical grid. The cabling is combined with a substation, where the different cables come together for transmission. Two kinds of cables exist: the inner-array cables and the export cables. The wind turbines are connected by the inner-array cables which connect the wind turbines of the offshore wind parks to an offshore substation (Kaiser et al., 2010). Next, the offshore substation is connected to the onshore grid by means of export cables. Typically, this is installed in one continuous operation (Kaiser & Snyder, 2012).

The reason why offshore substations are installed is to minimize the transmission losses. Offshore substations are necessary for all offshore wind parks. (M.J. Kaiser & Snyder, 2012). Although offshore wind parks face the problem of generating intermittent power, just as with solar panels, some measures exist to combat this problem, defined as ‘’special gird-connection codes’. These codes make sure active and reactive powers are supplied for frequency and voltage recovery (Carrasco et al., 2006).

The offshore energy grid connection of the wind farms is the legal responsibility of the Dutch national electricity Transmission System Operator (TSO), TenneT. Due to the fact that the planning and construction of an offshore grid network typically takes 8 to 10 years (depending on the technique, distance, permission procedures, and EIA). TenneT's grid operation makes it easier to compensate for grid variations, manage flows, and balance supply and demand. Integral grid operation also results in a clear division of labor in the power system. Appendix VI summarizes the cabling facilities of offshore wind parks in the Netherlands.

5. Logistics & Installation

TenneT is the responsible grid operator in the Netherlands. It takes care of the logistics of the high-voltage grid, supplied in 220 and 380 kV, transforming high voltage electricity from generation to regional and local distribution grids. In the case of offshore wind parks, Tennet faces a problem of fluctuating electricity generation due to the inherent problem that the wind does not always blow. Because of this intermittent power supply, sometimes the electricity generated might be abundant and thus may be exported abroad or stored in an energy carrier. In addition, offshore wind parks pay a balancing cost if there is less wind than predicted. In order to resolve this issue, cross border cooperation with the UK has led to the idea of an interconnector which bundles the different national offshore grids. The possibility of a WindConnector requires anticipatory investments in IJmuiden Ver. On the 2 GW DC platforms an additional space can be reserved to handle an interconnector. The high-voltage installation will be made suitable for use as an interconnector in the future. Any decision concerning the realization of a WindConnector itself is taken by the government, so Tennet is not responsible for this.

As grid operator, TenneT maintains the grid and makes investments in grid connections if deemed necessary. In 2015, TenneT invested €1.46 billion in grid connections for offshore wind parks, providing a connection between offshore wind parks and the national grid. TenneT will need to make investments between 6 and 7 billion euros in the construction of the offshore grid in the future. Concerning the offshore grid, there are two types of concepts that will be applied for the future. One being the standardized grid concept for 700 MW AC (alternating current), the second being a concept with 2 GW DC (direct current). Firstly, the standardized grid concept for 700 MW AC (alternating current) will be applied in the wind areas Borssele, Hollandse Kust (south), Hollandse Kust (north), Hollandse Kust (west) and North of the Wadden Islands. The platforms are designed for unmanned operation. The offshore grid for the Borssele, Hollandse Kust, and North of the Frisian Islands Wind Farm Zones has been configured for alternating current due to the short proximity of the wind farms to the onshore connection sites and the relatively small size of the capacity to be provided (AC).

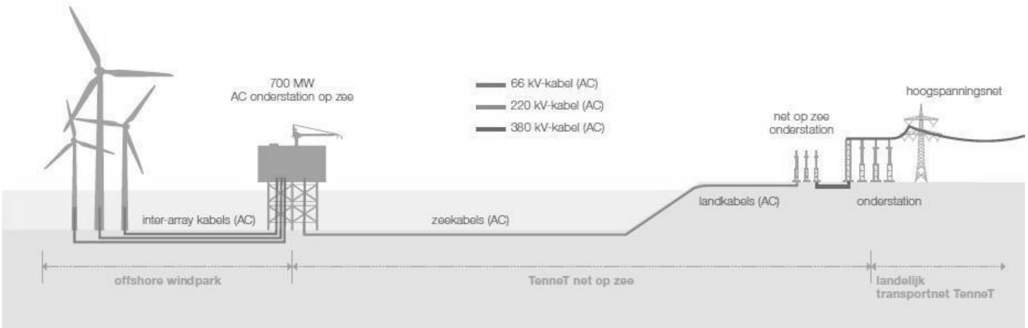

Figure 3. standard grid concept 700 MW AC

Secondly, TenneT is currently developing a standard grid concept for 2 GW DC (direct current) connections, two of which will be used in IJmuiden Ver. The aim for the DC platform, just like the AC platform, is to have platforms that are designed for unmanned operation. Second, noting the relatively large distance (70 km) to the onshore connection sites and the large capacity to be connected (approximately 4 GW), the IJmuiden Ver wind park will be connected using DC.

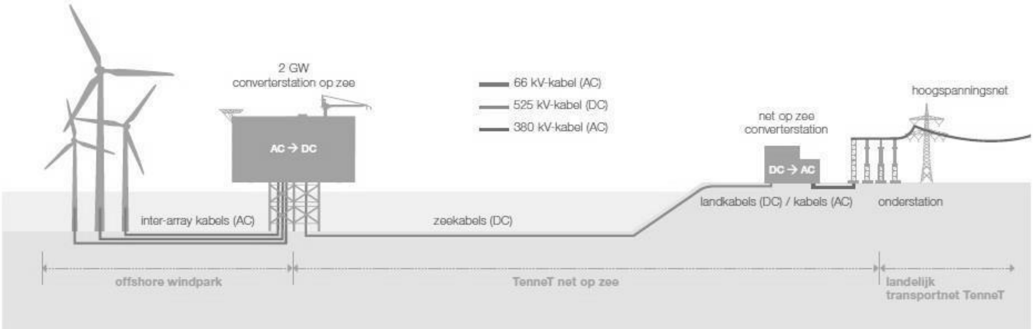

Figure 4. standard grid concept 2 GW DC

2.2 Methodological approach

In this paragraph, the methodological approach is outlined. Figure 5 displays the flow diagram of the sub-questions, the required method and the expected results. Positioned in the field of Science and Technology Studies (STS), research is devoted to understanding policy support for offshore wind parks. This method of this thesis relies on the Strategic Niche Management (SNM) framework. This framework and its application is explained in the next section titled *2.3 Theoretical Framework*.

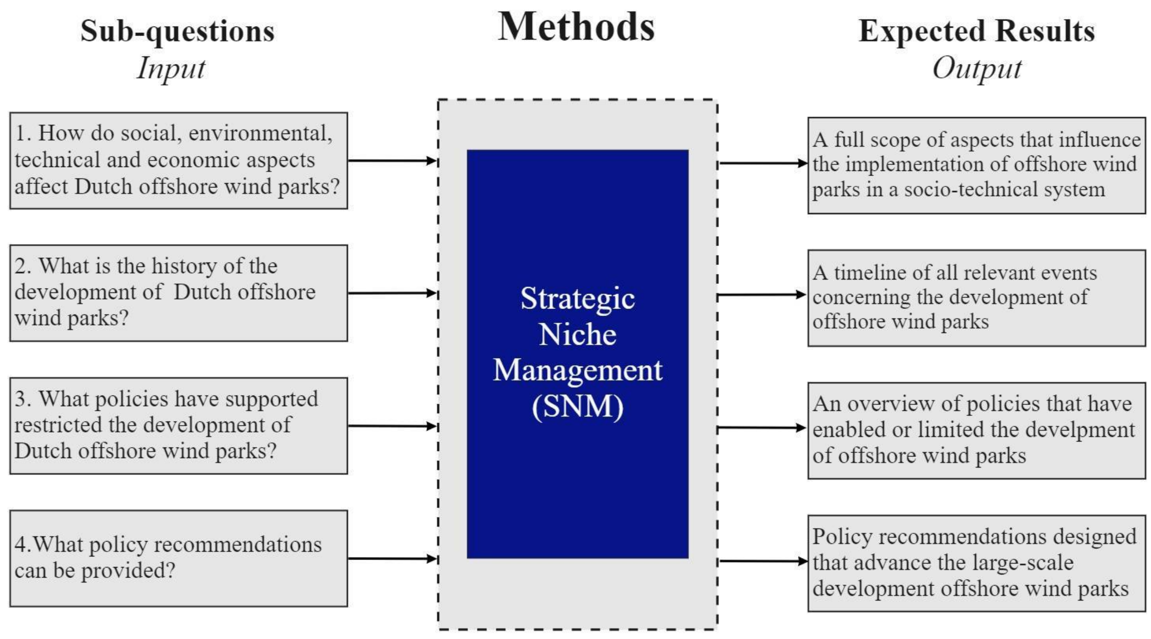

Figure 5. Methodological approach flow diagram

Data-collection for this thesis relies on literature study. A literature review, according to Xiao and Watson (2017), is an integral component of academic research. Because academic research is based on previous work, having a comprehensive understanding of the available material is critical for performing excellent research. In order to get a better knowledge of offshore wind parks as a socio-technical system, a literature study is conducted on academic literature as well as *'grey material'*. This is explained more thoroughly below in paragraph *2.4 Data Analysis.*

2.3 Theoretical Framework

In transition literature, niches are mostly introduced as novelties and radical innovations. Niche-innovations that are supported by more actors and more resources have more momentum. Most inventions remain at the "niche" level and do not receive sufficient support to be pushed to the upper level (Raven and Verbong, 2009). As a result, for niches to be adopted, a special style of management known as Strategic Niche Management is necessary (Kemp, Schot & Hoogma, 1998).

Strategic Niche Management belongs to the 'process theory', which is different than 'variance theory' in social sciences (Ven & Poole, 2005). Whereas variance theory tries to explain outcomes as the product of independent variables acting on dependent variables, process theory takes a different perspective. Process theory focuses rather on events than causal factors (Abbott, 1992). As such, process theory adopts qualitative, interpretive methods, rich in context that allow for 'process tracing' of event chains and social interactions (Woodman, Sawyer, & Griffin, 1993). Hence, Strategic Niche Management uses this process theory to research how and under what circumstances the development of offshore wind parks became possible.

Schot and Geels (2008) define successful strategic niche management by three important factors: (i) a clear vision, (ii) multi-level learning processes, and (iii) the formation of social networks among advocates. The impact of expectations and social network formation in the development of offshore wind farms is particularly important. Niches typically face an uphill struggling against existing systems, because they are more expensive (since they have not yet benefited from economies of scale and learning curves), require changes in user practices, face a mismatch with existing regulations, or lack an appropriate infrastructure. Throughout this research, offshore wind parks are seen as a niche. This is because offshore wind parks hold considerable potential, yet only contain a minor role in the Dutch energy system. Therefore, developments around offshore wind parks are investigated through SNM. There are three effective forms of niche protection in wider transition processes. The first one is called shielding. Shielding prevents a nice from premature rejection by incumbent regime selection pressures. Its objective is to prevent a niche from premature rejection by incumbent regime selection pressures. This is done for instance in the form of financial support or mobilizing pre-existing generic support (Smith & Raven, 2012)

The second process is called nurturing. Nurturing involves processes that support the development of pathbreaking innovation within passive and active shielded spaces through the development of shared, positive expectations. Nurturing a niche involves development, as it includes building up both broad and deep social networks in which expectations are then aligned and lessons are shared to augment learning, to create a more stable socio-technical configuration.

Lastly, the third process is called empowerment. There are two types of empowerment. First, empowerment in the form of stretch and transform consists of institutionalizing the shield to weaken incumbent regimes, therefore restructuring the present trajectory. Second, fit and conform empowerment includes removing the shield which leads to a nonradical innovation that is competitive (or symbiotic) with the incumbent regime and leaves the selection environment unchanged (Smith & Raven, 2012).

This thesis will analyse policy that supported or restricted the development of offshore wind parks in the time frame of 1970-2020 with Strategic Niche Management. Related to the niche transition processes, this thesis carries the following assumptions concerning the role of policy. These assumptions are based on Smith & Raven (2012) and Verhees et al. (2015) but also include my own work.

1. **Shielding** may happen by means of, such as but not limited to:

- Finance research and development (R&D)
- Tolerating 'poor' economic and technological performance and temporary rule exemptions
- Performing feasibility or effectivity studies
- Pre-existing generic support
- Set out favourable geographical locations

2. Policy is able to, deliberately or not, support or restrict the **nurturing** process of offshore wind parks by means of, such as but not limited to:

- Contributing to an organization of learning processes within offshore wind parks
- Constituting the formation of deep and broad networks
- Expressing expectations and ambitions and setting out road maps
- Setting up consortia to enhance learning experiences

3. Policy is able to, deliberately or not, support or restrict the **empowering** process of offshore wind parks by means of, such as but not limited to:

- Institutionalization of environmental/sustainability-related value and norms in policy
- Increase the competitiveness of offshore wind parks by cost reductions
- Providing subsidies in a subsidy system for renewable energy technologies
- Policy that is aimed at new regulations and reforms that benefit offshore wind parks.

Moreover, based on the key events that take place in the development of offshore wind parks, three transition stages are identified. These transition stages are considered time periods in the development of Dutch offshore wind parks between 1970-2020. For characterizing the different transition stages, terminology from the Multi-level Perspective (MLP) is used.

The MLP is a well-known theory for analyzing system changes, and it has been used to a wide range of scenarios, from the development of steamships in the 1780s to current transitions such as decentralized power generating systems. First described and coined by Rip and Kemp (1998) and further developed by Geels (2002), the MLP is conceptualised through three nested levels of socio-technical systems. The general dynamic of transitions is described by Geels (2006) through the interaction among processes at different levels: niche-innovations build up internal momentum, changes at the landscape level create pressure on the regime, and destabilisation of the regime creates windows of opportunity for niche innovations. As shown in figure 3, the first level is the *landscape* level, which forms an exogenous context in the forms of macro-economic pressures. The second level is the *regime* level, which refers to the rules that enable and constrain various incumbent actors, who reproduce existing systems. The last level is the *niche* level, where (radical) innovations emerge. The implementation of Dutch offshore wind parks through the landscape, regime and niche level is analysed by the Strategic Niche Management framework. As such, three transition stages are identified in the Dutch offshore wind park development from 1970 to 2020 in which policies shield, nurture, or empower offshore wind parks. These transition stages are also shown in figure 6. This visualization is based on earlier work (Campfens, 2022). Transition stages describe how technological innovations mature and how they are developed by different social actors. Different types of interactions between different levels and between different actors lead to different transition stages (Geels, 2002). Three transitions stages are considered: (i) formation, (ii) growth and (iii) stabilisation, these are explained more in detail below.

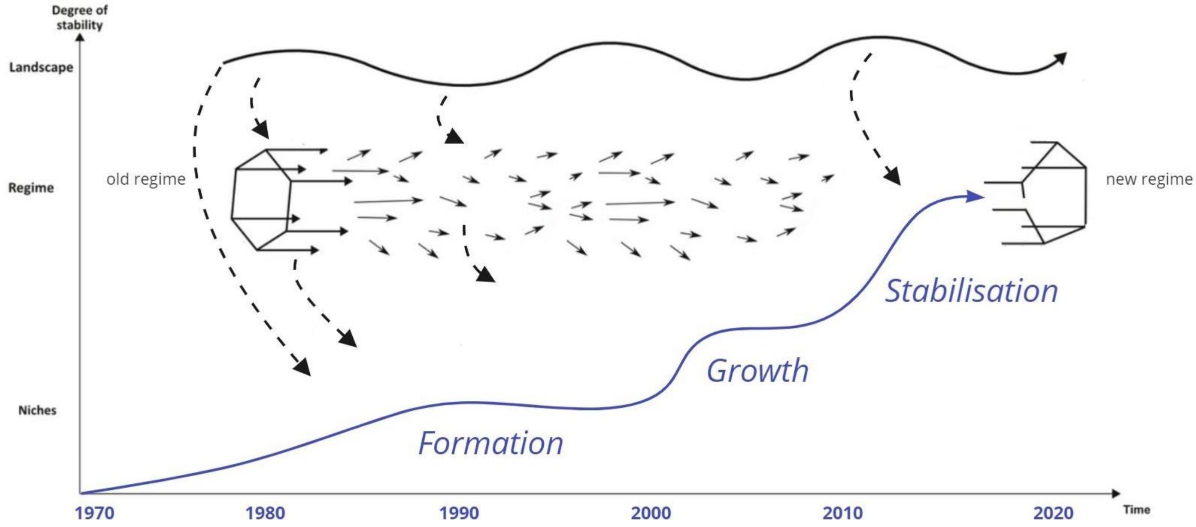

Figure 6. MLP scheme with transition stages (Campfens, 2022)

2.4 Data Analysis

The literature review consists of multiple steps, following Crawford (2011), Pautasso (2013) and Post et al. (2020) in their procedures. Figure 7 shows a flow diagram of the literature selection process. The literature review procedure and the steps taken are explained below. The publications are eventually sub-divided into three transition periods, namely formation, growth and stabilisation, which are explained below.

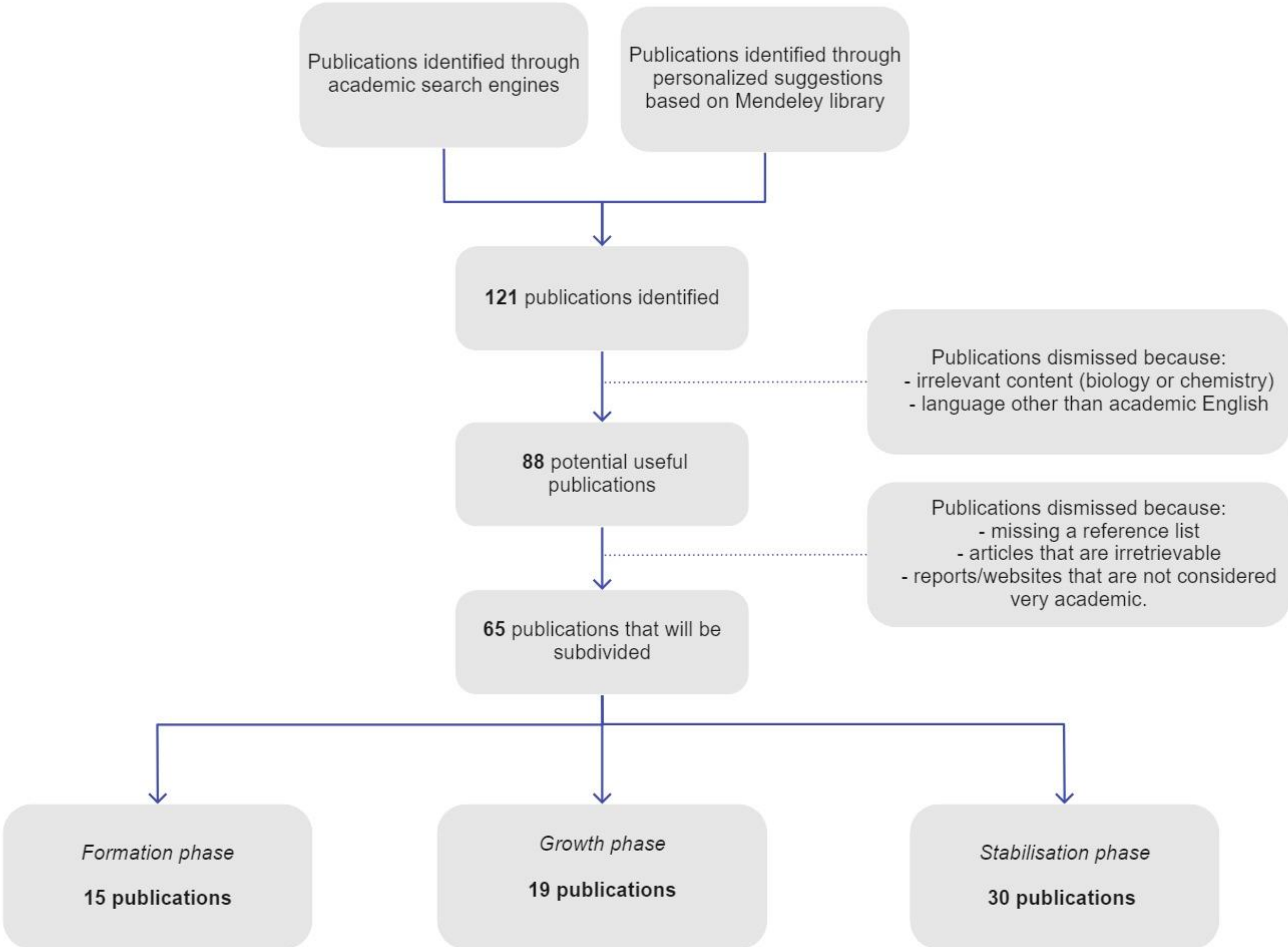

Figure 7. Literature review procedure

The literature review is conducted using the search engine Scopus. The used query makes use of multiple operators and key words. In general, the operator TITLE is used to find publications with titles related to important key words such as boundary work. Next, general operators like AND and OR are used to typify relationships with key words. An important first observation is that the AND operator frequently inhibits the literature selection process by requiring more keywords to be utilized in articles, resulting in fewer publications. The W/3 proximity search operator was used to address this problem. This operator searches for two or more words that appear within a specified number of words of each other. Finally, the OR operator is commonly employed..

An important note to be expressed is that the literature review is conducted following an *iterative* method, meaning the literature selection process is repeated over and over. This serves two aims. First and foremost, repetition ensures that better optimized queries are created. Secondly, rehearsing the literature selection processes over and over with slight changes will obtain a more ‘robust’ selection of work. This means that possible relevant publications can be included which would be kept in the dark if the iterative method would not be applied. Additionally, searching strategies like ‘snowballing’ are used, which are explained below. A majority of the gathered literature was stored in a Mendeley folder. As a result, useful personalized suggestions for articles to read based on the Mendeley library were sometimes also integrated. The search query that was carried out figure 8.

```
TITLE (offshore wind W/3(park* OR mill* OR turbine* OR energy OR source* OR sector))
AND (TITLE-ABS-KEY(offshore wind W/3(polic* OR politic* OR government* OR societ*)))
AND (TITLE-ABS-KEY(offshore wind W/3(the Netherlands OR dutch OR holland)))
AND ( LIMIT-TO(SUBJAREA, 'SOCI') OR LIMIT-TO (SUBJAREA, 'ENVI') AND PUYEAR>1970)
```

Figure 8. Query search code

As visible, only publications were considered with a publication year after 1970. Before 1970 not much literature was contributed to the field, and this thesis assumes that all relevant literature on the notion of offshore wind parks in the Netherlands before 1970 is reproduced in later publications. Furthermore, it should be noted that publications had to explicitly use the term “offshore’’ in order to be selected. Query 1 provided 121 publications. Some general remarks of these 121 publications are that almost 75 percent of the publications have been published since the year 2006, and 50% of the publications have been published since 2015. This signals that the research in this field is relatively premature. Moreover, a regularly recurring source title is ‘Environmental Science And Policy’, whilst most publications come from the UK and the Netherlands. This query has been repeated over and over to have the most up-to-date literature review. Repeating the query trough the period of April until June did not lead to a different selection of publications. Then, the selected publications are further filtered. Because of having irrelevant content (e.g., similar keywords but different contents, such as biology or chemistry) or a language used different than academic English, 33 publications are dismissed. An exemption is literature written in Dutch, as this is particularly relevant for the implementation of Dutch offshore wind parks. This filtering eventually yields a list of 88 potentially useful publications. Next, other publications are dismissed if they do not have a reference list, articles that are irretrievable or reports/websites that are not supported by academic material. All in all, this yields a list of 65 potentially useful publications for the literature review. Next, the search operator “relevance” is used to order the findings, and the abstracts are read to summarize their main message. Then, all publications were stored in a shared Mendeley folder and were structured on a timeline. Based on common characteristics and mutuality's (same types of experiments, policies or actors), these publications were then subdivided into three transition periods. If you would take a summation of the amount of publications per period, as visualized in figure 7, you would surpass 65 publications. The reason for this is that some articles were so influential in all transition periods they do not belong to one particular transition stage. As mentioned above, the publications were subdivided into different transition periods based on mutual characteristics.

These transition periods' characteristics are explained as follows. The first transition stage is characterised by coalition building of initial actors that undertook experiments upscaling offshore wind parks in the Netherlands. In this transition period, expectations of the technology are relatively high. This period is further characterized by experimentation. Experiments are considered vital in the initial stage of a technology, as they are considered '*an inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of deep uncertainty and ambiguity*" (Sengers, Wieczorek, Raven, 2016). Experimentation concerning offshore wind parks started around 1970 and the formation phase takes roughly until 2000.

The second transition stage is known as the "growth" stage. During this time, the developed socio-technical setup has grown further. The formation of social networks, the synchronization of expectations and goals and appropriate policy tools that support the ongoing development of offshore wind parks in the Netherlands are crucial in this period. Or in the words of Smith & Raven, this period *"provides an opportunity to advance path-breaking innovation as it supports the development of path-breaking innovation."* (Smith & Raven, 2012, p.1027). In order to let viable niche-innovations break through more widely, the learning processes of the formation phase should have yielded a dominant design with a stable social network of powerful actors that support offshore wind parks in the Netherlands. Lastly, it is important that performance improvements have taken place (Schot & Geels, 2007).

The last transition phase is called the *stabilisation phase*. This period is defined in Transition Management as a phase '*where the speed of change decreases and a new dynamic equilibrium is reached'* (Rotmans, Kemp & van Asselt, 2001). This period is helpful to understand *''how radical innovations escape their protective spaces and interact with wider regime change processes."* (Smith & Raven, 2012) In this period, the formed socio-technical configuration has settled within the existing regime and has acquired enough momentum to change the *'rules of the game'* (Campfens, 2022). This means that offshore wind parks have become competitive with conventional, fossil fuel energy production, and in that way, challenge and transform the rules of the game of the energy sector.

3. Analysis

‘Madame, bear in mind that princes govern all things--save the wind’

Victor Hugo, The Infanta's Rose

3.1 Formation Phase

Research in offshore wind parks: from aimlessness to real ambitions

Several Western countries, including the Netherlands began to explore the possibilities of renewable energy technologies from approximately the 1970s onwards. The main reasons for this were the oil crisis and the Club of Rome Report, which warned of imminent shortages of traditional energy sources such as oil and gas, and the dependency of these energy sources on other nations. Wind energy was seen as the renewable energy source with one of the highest expectations (Kamp, 2004).

The Industrial Oceanography Council (IRO) was found in 1971 to represent the interests of the Dutch offshore industry. Normally, IRO investigated the drilling of gas in the North Sea. However, after the oil crisis, IRO started to consider offshore wind energy a possibility for energy supply and studied the economic and technical feasibility of this idea. A particular research group called "Werkgroep Windenergie" was found with researchers from TNO and multiple engineering companies. Together they publicized a report titled ''Windenergie parken op de Noordzee'', concluding that future offshore wind parks had the potential of contributing significantly to the energy supply through the production of electricity and in the Netherlands (Van Staveren, 1974).

Besides, this report pointed to the need of more future research into offshore wind energy. The higher costs of offshore wind parks compared to fossil fuels were refuted by deployment in the sector and the potential of offshore wind turbines as an export product. The North Sea was considered the only option for the installation of offshore energy parks. Other advantages of offshore wind parks in comparison with its onshore counterpart, such as visual interference or disturbance of radio- and television receptions were used as arguments for the choice of offshore wind parks (Verbong, 2001).

The research group ambitioned a first offshore wind park to be installed in 1980. They envisioned an offshore wind park with a maximal capacity of 10 MW, including a design that was similar to a triple-nacelle wind turbine constructed in 1972 in the USA, with an in-between distance of 1 kilometer (Rogers, Manwell, & McGowan, 2003). This was summarized in a technical report.

This technical report was handed over to the Ministries of Economic Affairs and Science Policy in 1974 (IRO, 2011). Moreover, this report was presented to the National Steering Group Energy Research, which was founded earlier that year and had the goal of evaluating choices for the modification of the Dutch energy market and set up research programs accordingly. The National Steering Group Energy Research filed a report including proposals for research programs around numerous different energy suppliers, including offshore wind parks as an option (Verhees et al., 2015).Besides the proposal for researching offshore wind parks, they also requested more in-depth research of electricity transport issues in general. To overcome possible 'grid congestions' in the electricity grid caused by large wind turbines, the National Steering Group Energy Research suggested smaller onshore wind parks as well as medium size offshore wind parks, to be placed around the Ijsselmeer, Waddenzee and Oosterschelde. Lastly, there was a call for big offshore wind parks in the North Sea (LSEO, 1975).

The suggested offshore wind parks thus focused on medium and big sized parks (>300 kW). This was based on the spatial planning of the Netherlands. Being aware of the Netherlands large population density, placing the bigger wind turbines offshore is a smart strategy. Based on these recommendations, a coordinated national research program was set up in 1976 by the Ministry of Economic Affairs, called the first National Research Program Wind Energy. This program solely focused on research of offshore wind parks (Verhees et al., 2015).

The first National Research Program Wind Energy program contained only a very small part of research on offshore wind parks and focused mainly on onshore, The focus still was placed on discovering whether or not wind energy might significantly contribute to Dutch energy supply (Verbong, 2001). As a result, the ambition of researching the offshore application of wind energy was limited, only 440 thousand euros, equalling 2% of the program's budget, was spent on offshore wind parks, whilst its onshore counterpart received 80% of the budget (Beurskens, 1985). Unsurprisingly in the first final National Research Program Wind Energy report offshore wind parks received little credit, whilst the report was very positive about onshore wind parks. The report deemed the associated costs with placing wind parks offshore too large. The report estimated these costs two times as much as when implementing onshore wind parks. However, the report did suggest that placing offshore wind parks was easier in terms of spatial planning than onshore wind parks when considering big capacity instalment of wind parks, and it also mentioned other advantages of offshore compared to onshore, such as less visual hindrance (BEOP, 1976).

Eventually, the first National Research Program Wind Energy was succeeded by the second National Development Program Wind Energy. The difference of 'research' as compared 'development' was attributed to a shift in ambition. Explorative research now paved the way for developing actual implementation (Verbong, 2001). Parallel to the first, the second National Research Program Wind Energy gave a lot of optimism on onshore wind parks. As a result, offshore wind was neglected once again and received 640 thousand euros, again equalling 2% of the total research budget.

From the 640 thousand euros of the second National Research Program Wind Energy that was spent on offshore wind parks, research was performed in collaboration with the International Energy Agency (IEA). The IEA worked with countries around the world to shape energy policies for a secure and sustainable future. In a joint international research program of IEA titled 'Wind Energy Conversion Systems', the purpose was to unfold the feasibility of offshore wind parks in terms of finance and spatial planning and to come up with a strategy for a working prototype. The Netherlands was represented by the Dutch Energy Research Centre (ECN). The ECN would later bundle forces with the more known TNO. The ECN and gained the task of designing a concept of an offshore wind energy conversion system. The Netherlands' contribution, a 6.5 MW wind energy conversion design system with a rotor diameter of 80 meter is depicted in figure 9. This picture is not perfectly visible, but is rather an insight in the level of experimentation at the time.

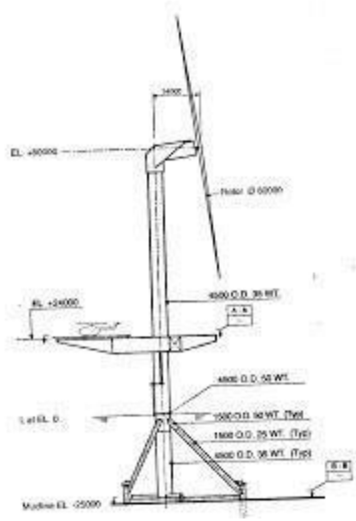

Figure 9. The Netherlands' contribution in EIA research program

In 1984, this collaborative research effort of the EIA resulted in an international ambition for a 1 GW offshore wind energy park (Beurskens, 1985). This ambition was accompanied with a report that concluded that the economic feasibility of offshore wind parks was the main struggle.

However, it also stressed the importance of the general public as catalyst for earlier implementation of offshore wind parks in Denmark and The Netherlands, being both densely populated countries (IEA, 1988).

The Chernobyl accident in 1986 occurred as a result of a defective reactor design that was operated with inadequately trained personnel. The resulting steam explosion and fires released at least 5% of the radioactive reactor core into the environment. As a consequence of this Chernobyl disaster, the Dutch government become hesitant concerning its nuclear ambitions (Verbong, 2001).In parallel to this event, the idea of 'sustainable development' gained an important boost following the publication of the UN Brundtland-report '*Our Common Future'.* These movements led to a policy document titled 'the National Environment Policy Plan' which stressed the carrying capacity of the Earth (Verbong, 2001). As a result, the government set out a target for renewable energy sources with the ambition of '45 PJ of primary fuel savings in 2020'. Furthermore, research on spatial planning concluded that the maximum capacity of onshore wind parks was 1500 MW, and stressed the need for offshore wind parks in order to meet the government target (IEA, 2002)

The second National Research Program Wind Energy was replaced by the Integral Wind Energy Program. The earlier articulated expectation of an onshore wind placement with a capacity 1000 MW in 2020 gained more and more attention and eventually was integrated into a policy goal (Verbong, 2001). The goal was seen as a realistic ambition. Policymakers expected the opinion of the general public not to have changed and started making concrete plans towards implementing wind parks. However, the opposition to wind parks was growing in the form of a movement called 'not in my backyard' (NIMBY). The NIMBY opposition criticized wind turbines for their bird mortality and horizon depletion. However, the NIMBY opposition was less critical on offshore wind parks, as an effect, the general public opinion regarding offshore wind parks was more positive than its onshore counterpart (Verbong, 2001).

Around 1992, the Integral Wind Energy Program program was replaced by the Wind Energy Application Program (Breukers, 2007). The Wind Energy Application Program contained real ambitions concerning offshore wind parks and provided for subsidies for companies that would be willing to invest in offshore wind turbines. Moreover, the Wind Energy Application Program articulated an expectation of 200 MW offshore capacity in 2010 (Verbong, 2005)

The Noord-Holland Province Electricity Company (PEN) was a company that used subsidies of by the Wind Energy Application Program to realize their offshore wind ambition. Because of its advantage of shallow waters, they chose the Ijsselmeer as location for the offshore wind park.

In 1994, the Lely wind park of 2 MW became the world's second offshore wind park, as a runner-up of the first world Danish offshore wind turbine called 'Vindeby'. The Lely wind park is depicted in figure 10.

Figure 10. the first Dutch offshore wind park: the Lely wind park (1994)

The Wind Energy Application Program was succeeded by the second Wind Energy Application Program, which took place around 1996 until 2000. As part of this program, an environmental agency called Novem executed a feasibility study researching the possibilities of a near offshore wind park with a capacity of 100 MW. The feasibility study showed that an offshore wind park with a capacity of 100 MW was feasible in economic and technical terms.

Besides this feasibility study, Novem initiated the actual building of the offshore wind parks that was researched in the feasibility study with a delivery date of 2003 (Energie Onderzoekcentrum Nederland, 2000). They considered this offshore wind park as an 'example' of larger offshore wind parks still to come (WEOM, 2007).

In 1999, Minister of Economic Affairs Jorritsma-Lebbink announced an offshore wind park near Egmond-aan-Zee, called 'NoordzeeWind. The choice for this location was the relatively shallow waters. Learning processes from this park would be considered useful for effective policies for future parks (Verhees et al., 2015)

The following table provides a on overview of the transition processes of SNM and their policy support on offshore wind parks (figure 11

Shielding	Nurturing	Empowering
The first National Research Program Wind Energy (1976) and the second National Development Program Wind Energy (1981) spent some budget to assess the prospects of offshoe wind parks	A particular research group called "Werkgroep Windenergie" was put into place (1971)	The Chernobyl disaster and the Brundtland report gave rise to more interest in renewable energy (1985) and the accompanied ambition of '45 PJ of primary fuel savings in 2020' with 1000 MW installed offshore wind capacity.
The NIMBY opposition was less critical on offshore wind parks, as an effect, the general public opinion regarding offshore wind parks was more positive than its onshore counterpart	IRO report ambition of an offshore wind park with a maximal capacity of 10 MW(1974)	Opening of the fist Dutch offshore wind park named *'Lely' (1994)*
Minister of Economic Affairs Jorritsma-Lebbink announced an offshore wind park near Egmond-aan-Zee, called 'NoordzeeWind (1999)	The difference of 'development' as compared to 'research' between the first National Research Program Wind Energy and the second National Development Program Wind Energy (1981)	
Novem's executed feasibility study concludes that an offshore wind park with a capacity of 100 MW is feasible in economic and technical terms (1996)	The Netherlands' contribution in the EIA study, a design of a 6.5 MW wind energy conversion system (1984)	
	The Wind Energy Application Program ambitions an offshore wind park of 200 MW offshore by 2010 (1992)	

Figure 11. SNM transition processes formation phase

3.2 Growth Phase

Tendering issues and changing political visions on offshore wind parks

Around 2000, the European Union opted for a more liberalized energy market. The Netherlands, as member state, first liberalized the energy market for large users who had a consumption of around 100 MWh per year and for consumers who specifically wanted 'green' electricity (Linderhof, Lise, & Oosterhuis, 2003). In parallel, prospects for offshore wind parks had augmented further, which was recognized by the Fourth National Environmental plan, in which the need for radical innovation and structural changes in the energy as well as the policy regime was expressed (Ministerie van VROM, 2001) This new policy model was named 'transition policy'. In the Fourth National Environmental plan, offshore wind parks were considered a real option in the future Dutch energy system.

In 2001, the cabinet Kok I, consisting of Pvda, VVD, D66 decided that for the planned offshore wind park 'NoordzeeWind', market parties should be included in the development process. As a result, a public tender was issued for the construction and operation in 2001. The Ministry of Economic Affairs spent a subsidy of €27 million for the offshore wind park 'NoordzeeWind', but in exchange requested surveillance over the offshore wind park 'NoordzeeWind'. Finally, a consortium consisting of Shell and Nuon and some smaller companies obtained the subsidy. The cabinet Kok 1 also opened up energy investments and offered tax credits, in purpose of stimulating more investments in sustainable technologies, which would lead to more applications of offshore wind parks (Könings, 2004).

In 2002, the government granted permission to multiple other requests for offshore wind parks on the North Sea. The design for these upcoming offshore wind parks was based upon the learning processes that were accompanied by the first 'NoordzeeWind' offshore wind park. These learning processes were mainly technical (wind turbine placement, offshore grid connection etc.). New requests for other offshore wind parks by parties such as but not limited to Nuon, Greenpeace, Evelop and E-connection were then confronted with a suspension on their requests. The reason for the suspension was that a 'concession system' would shortly be put into place that would advance the development phase of offshore wind parks better (Energie Onderzoekcentrum Nederland, 2005). This concession system followed the Danish example of tendering strategic locations for offshore wind parks to market parties, which proved to be very useful, because in 2001 Denmark had the highest proportion of offshore wind power in the world (CEESA, 2010).

Within the concession system, strategic zones would be designated by the government, within which interested parties could request a concession.

Later in 2002, a new cabinet rose to power, Balkenende I. The cabinet consisted of a centre-right coalition of VVD, LPF and CDA. In the coalition agreement, the cabinet decreased subsidies for renewable energy subsidies (Köper, 2012). As a result, the prospects of offshore wind parks were impacted also. The new Minister of Economic Affairs, Hans Hoogervorst was less optimistic about the ambition of a capacity of 6000 MW of offshore wind parks in 2020. Consequently, Hoogervorst executed a social-cost benefit analysis of offshore wind parks by the Central Planning Agency which concluded offshore wind parks to be economically inviable (Verhees et al., 2015).

In 2003, the cabinet was replaced by new cabinet, Balkenende II consisting of VVD, D66 and CDA. In their coalition agreement, renewable energy was again disregarded as an important topic. Alternatively, there was a lot of attention for the full liberalization of the energy market in 2004, which gave households the freedom to choose their own electricity supplier. As a result, the new Minister of Economic Affairs, Gerrit Zalm delegated renewable energy to the State Secretary, who failed making it a priority (Köper, 2012).

In 2003, a consortium called 'We@Sea' was formed. The consortium consisted of some 30 parties including parties such as but not limited to offshore companies Fugro, Ballast Nedam, energy companies like Shell, Eneco, Nuon, Delta and Tennet, research institutes ECN, TU Delft, and multiple NGOs like Greenpeace and Stichting De Noordzee. With the vision of a capacity of 6000 MW of offshore wind parks in 2020, the consortium gained funding for exploring more offshore wind parks (Köper, 2012).

The concession system that would be put into practice, faced some issues. First and foremost, the Council of State overruled the implementation of the concession system because 'it favored the bigger companies over the smaller ones'. Later In 2004, the concession system was adapted to tendering parties on a first-come first-serve basis. This meant that parties who filed a complete application would get the grant for building the planned offshore wind parks (Köper, 2012).

Around 2005, the first real offshore wind park built near the coast of Egmond aan Zee, named 'NoordzeeWind' was opened and spread energy to the Dutch electrical grid. An interesting note here is that the eventual opening date was three years later than expected, due to tendering issues (Windenergie Ontwikkelingsmaatschappij, 2007).

In the beginning of 2007, a new cabinet rose to power, Balkenende III, consisting of the Christen Unie, PvdA and CDA. Surprisingly, renewable energy got an important part in the coalition agreement (Duyvendak, 2008). It presented a policy goal of a 30% CO2 reduction in 2020. Keeping in mind the issues around subsidizing renewable energy, a new subsidy system, abbreviated as SDE was put into place. This subsidy would also be beneficial for offshore wind parks, as the SDE would be given to the companies that gained the grant for building offshore wind parks. This also altered the concession system. From then onwards, grants for offshore wind parks sites were awarded through a dedicated call for tender under the SDE. Under this scheme, producers received financial compensation for the electricity they generate for a fixed number of years (15 years for wind farms). The lowest bidder would be awarded. The bid must be equal or lower than the maximum amount (in €/kWh) set for the specific wind farm site. The lowest bidder would be rewarded with both the grant and the consent to build and operate a wind farm according to the wind farm site regulations (Netherlands Enterprise Agency, 2015). A fist example of this concession system was around 2008, when a second offshore wind parks on the North Sea was opened and was named ‘Princess Amalia’. Because of trouble finding investors, the construction of the offshore wind park was delayed and opened much later. Eventually, the building of the ‘Princess Amelia’ was done by the responsible turbine supplier named Vestas and followed the new concession system (Verhees et al., 2015).

Later in 2008 the cabinet drafted the National Water Plan, in which two specific wind offshore park locations were designated. These are the areas "Borssele" covering 344 km^2 and "IJmuiden Ver" covering 1,170 km^2. Building would take place between 2015 and 2020. The choice of these locations was because the areas were "conflict-free", insofar as it did not bother the shipping, the marine ecosystem, oil and gas, defense and aviation sectors. In addition, the cabinet was striving for a spatial distribution of wind offshore wind parks across the North Sea. To this end, the cabinet had designated two search areas in the National Water Plan, namely "Hollandse Kust" and " Ten noorden van de Waddeneilanden". The objective as formulated in the National Water Plan for the Hollandse Kust search area was to find space for one or more larger wind energy areas with a total area of 500 km2 for 3,000 MW. ‘’Ten noorden van de Waddeneilanden’’ had been designated in the National Water Plan as a search area within which a social assessment would be made between different locations. (Ministerie van I&M & Ministerie van EZ., 2014)

In the National Water Plan, new locations were laid down on which public tenders started for new offshore wind parks. In the beginning of 2010, the winner for this public tender became Bard Gruppe, which had designed three adjacent offshore wind parks north of the island of Schiermonnikoog. The main reason for the choice of Bard Gruppe were the relative maintenance costs that Bard Gruppe could offer. However, Bard Gruppe was financially struggling and eventually was replaced by Eneco who renamed it 'Luchterduinen'. (Verhees et al., 2015)

In 2009, the European Commission implemented the 'Renewable Energy Directive 2009/28/EC', with the vision of promoting the use of energy from renewable sources. This directive required all member states to obtain at least 20% of their total energy needs from sustainable, renewable resources by 2020. Member states were to achieve this objective by individual national targets (European Commission, 2009). In the Netherlands, this target gave rise to the Offshore Wind Energy Law (Wet Windenergie op Zee), which will later be explained in more detail.

In 2010 a new cabinet rose to power, Rutte I, consisting of conservative parties VVD and CDA with 'gedoogsteun' from the PVV. Prime Minister Rutte (VVD) set the stage concerning wind energy by stating that "wind turbines do not run on wind, but on subsidies" (Köper, 2012).

The current subsidy system for renewable energy, SDE was changed considerably and renamed as SDE+. The difference between SDE and SDE+ is that with SDE+, all renewable energy technologies must compete for a single (limited) budget, but in SDE, each technology has its own (limited) budget. As a result, given the current circumstances, offshore wind must compete with lower cost renewable energy technologies. Consequently, offshore wind parks were outcompeted by cheaper alternatives (Verhees et al., 2015).

After the first offshore wind parks were installed in the Netherland and designated locations for further offshore wind parks were analyzed, societal concerns by NGOs started taking place. International NGOs like Greenpace and more national NGOs like Natuurmonumenten mentioned that there were ecological risks for the North Sea nature when offshore wind parks would be installed (Vrooman etal. 2018).

The ecological risks are manifold. Wind turbines can hit birds and bats and therefore birds and bats can lose some of their habitats. Underwater life also experiences negative effects during the construction of the wind farms, due to the noise during pile driving. Good mitigation measures exist for some risks, but not for others. NGOs expressed that further research and innovations were needed to better identify the risks of the large-scale rollout of "offshore wind" and to keep them within acceptable limits (Vrooman etal. 2018)

In addition to risks, the construction of wind farms also offers opportunities, for example for underwater nature. Because 'soil disturbing activities' are prohibited at the wind farms after construction, there is room for the development of the seabed and the characteristic North Sea fauna. Specific species can settle on the hard substrate of the turbines.

By actively promoting nature recovery in the wind farms, oyster reefs, for example, can recover. Making the most of the opportunities also requires research, experiments with innovations therefore is important.

Many knowledge questions still need to be answered in order to properly manage the ecological aspect of the large-scale development of offshore wind parks. Some questions relate to the long-term effects of large-scale offshore wind, such as effects on wind fields and sea currents. Other knowledge questions are much more acute and concern the protection of species that are already under pressure from wind at sea or other causes (Vrooman etal., 2018)

The following figure 12 provides a on overview of the transition processes of SNM and their policy support on offshore wind parks.

Shielding	Nurturing	Enpowering
Opened up energy investment tax credits for investors, in purpose of stimulating more investments in sustainable technologies (2001)	Fourth National Environmental plan addresses need for policy and long-term commitment (2001)	New concession sytem for public tendering put into place, which later was adapted to tendering parties on a first-come first-serve basis. (2004)
Many developers (Nuon, Greenpeace, Evelop and E-connection) unexpectedly applied for tendering constracts to develop offshore wind parks (2002)	Consoritum *We@Sea* is founded with the vision of a capacity of 6000 MW of offshore wind parks in 2020 (2003)	Full liberalization of energy market (2004) and 'Renewable Energy Directive 2009/28/EC' (2009)
Government proposal for concession-based tendering system overruled by council of state (2004).	Balkenende II ambitions a 30% CO_2 reduction by 2020 (2007)	New subsidy scheme put into practice (SDE), which was beneficial for offshore wind parks (2007), which was later altered to SDE+ (2010)
The *National Water Plan was drafted n* in which two specific wind offshore park locations were designated: "Borssele" and "IJmuiden Ver		'NoordzeeWind' (2005) and 'Princess Amalia' (2008) opened and spread energy to the Dutch electrical grid

Figure 12. SNM processes in the growth phase

3.3 Stabilisation Phase

Offshore wind parks gain momentum

Following the new coalition agreement, renewable energy implementation '*was to be realized by innovation rather than subsidy*', as expressed by president Mark Rutte. In this regard, innovation became an important pillar and even was taken up by the Ministry of Economic Affairs in its name: Ministry of Economic Affairs, Agriculture and Innovation. In line with this new focus on innovation, the cabinet fostered many 'green deals' with organizations and companies in purpose of "*making renewable energy and sustainability more economic*" (Ministerie van EZ., 2010)

The green deals were aimed at bringing parties together and minimize policy barriers. A green deal related to offshore wind parks was named 'Green Deal Offshore Wind' represented by the Dutch Wind Energy Association (NWEA). The NWEA promotes the development of wind energy to achieve a sustainable Dutch energy supply. With the promise of reducing cost up to 40% in the offshore wind park placement, the deal had an ambition of increasing offshore wind deployment from a current total 2200 to 11,000 in 2020. The favourable offshore conditions of the Netherlands were recalled as well as the Dutch offshore wind industries that were internationally very strong (Verhees et al., 2015).

The green deals also gave rise to the Top Consortia for Knowledge and Innovation (TKI's). These consortia consisted of knowledge institutes and companies to address societal problems and aim to come up with solutions for these through knowledge and innovation. As part of the TKI's, an offshore wind innovation contract was signed in 2012. With the vision of achieving 5000 MW of installed offshore wind capacity in 2020, the contract aimed at a revenue of 6 billion euro to be attained via at cost reduction (Topteam Energie, 2012).

Around September 2012, a new cabinet rose to power, Rutte II consisting of the liberal-conservative VVD and labour party PvdA. In their coalition agreement, offshore wind parks were considered a crucial component for achieving future sustainability goals. The coalition agreement in particular requested a National Energy Agreement (Verhees et al., 2015).

In 2013, the National Energy Agreement was published. It contained an ambition of 16% of renewable energy by 2023. Offshore wind parks were considered an important instrument for achieving this target. It further was agreed that a total capacity of 4,450 MW of offshore wind parks had to be realized by 2023 (Sociaal Economische Raad, 2013).

In 2014, a 'Rijksstructuurvisie Windenergie op Zee' was presented by the government. Besides a roadmap to new strategic locations for offshore wind parks, this paper concluded that offshore wind parks within the 12-mile zone were cheaper than further from the coast. Next to this, five possible areas for offshore wind parks were presented. The locations designated were near Ameland , above the northern Dutch coast, near the South Holland coast, near the Maasvlakte and near the Zeeland coast (Ministerie van I&M & Ministerie van EZ., 2014).

Furthermore, the 'Rijksstructuurvisie Windenergie op Zee' took into consideration important topics such as ecology, fisheries, marine radar disruption, effects on housing prices and recreation and tourism. The suitability of the potential areas for offshore wind parks is assessed based on various aspects, such as nature, landscape, recreation, coastal security and the various user functions. For the suitable locations also a strategic environmental assessment (planMER) was done. Concerning the fisheries, a shipping risk analysis was performed. The results of these studies is integrated in the decisionmaking about the boundaries of the designated wind energy areas. The North Sea is one of the busiest navigated seas in the world. So, in consultation with the directly involved parties, like fisheries and environmentalists, a proposal was developed to change the shipping navigation routes near the Dutch coast. A modification of the routes was necessary for the safety of the ship traffic to ensure the accessibility of the main ports. In November 2012 this proposal was approved by the International Maritime Organization (IMO). The modified shipping navigation routes formed the starting point for the further designation of the area for wind energy within the search area Dutchcoast (Ministerie van I&M & Ministerie van EZ., 2014) On figure 13, the *'Structuurvisiekaart'* is visible with new shipping navigation routes, including precautionary areas and clearways.

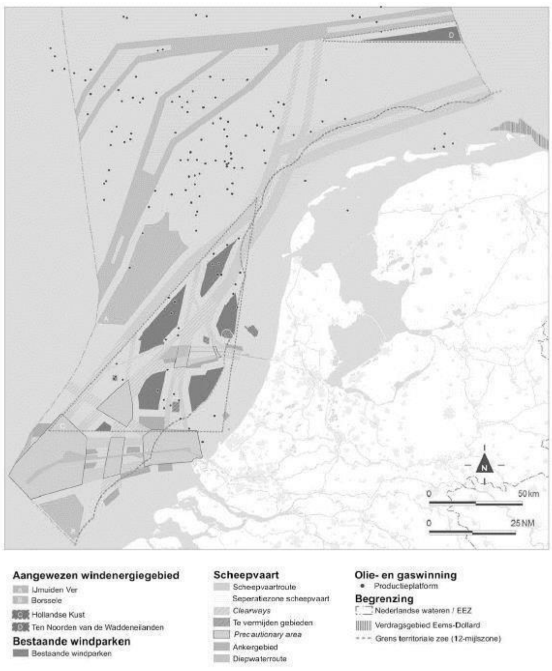

Figure 13. 'Structuurvisiekaart' with new shipping navigation routes, including precautionary areas and clearways

In light of the Energy Agreement it was agreed that offshore wind parks would be connected to a national high-voltage grid instead of a direct connection, this would give rise to the idea of an 'offshore grid', to which TenneT would officially receive the responsibility. The decision for Tennet as offshore grid operator was because Tennet was also the onshore grid operator. The cabinet considered it important that the net grid was in public hands, as it wanted to guarantee a reliable, affordable and sustainable energy supply. An advantage of a national high-voltage grid instead of a direct connection was that it reduced costs. Also, the choice for TenneT as the sole operator of the sea provided a cost saving of 3 billion euro over a time of 15 years. (Ministerie van EZ, 2014)

In 2014, the cabinet selected three areas where offshore wind parks would be developed in the coming years: near the coast of Zeeland, near the coast of NoordHolland and Zuid- Holland. This was stipulated in a letter to the Second Chamber, in the so-called roadmap 'Windenergie op zee' which runs until 2023. In the period of 2015 until 2019, five public tenders were organized for the construction of offshore wind parks in the above-mentioned areas in the period 2019-2023 (Ministerie van EZ., 2018)

Following the 'Renewable Energy Directive 2009/28/EC' and the 'Rijksstructuurvisie Windenergie op Zee', a bill named the 'Offshore Wind Energy Law' was put into place at the start of 2015. The bill provided an integral legal framework for the large-scale realization of offshore wind parks. The bill was intended to lead to cost reductions in the planning and construction of offshore wind parks and shorter construction times. Project developers would get more certainty that a predicated offshore location was suitable for wind parks and the conditions under which the offshore wind park could be developed. Furthermore, the law reduced the number of decision moments in the tendering process in order to prevent an accumulation of objections and appeals (Ministerie van EZ, 2015).

In addition, the offshore wind park 'Luchterduinen' was opened in 2015. The offshore wind park, owned by Eneco and Mitsubishi Corporation, comprised 43 Vestas 3 MW turbines located 23 km off the coast (Eneco, 2015).

Meanwhile, a very important climate conference was taking place. During the twenty-first climate conference of the United Nations in Paris in late 2015, nearly 200 participating nations reached an agreement on a binding climate agreement. This Paris Climate Agreement stated that global warming had to be limited to less than two degrees Celsius above pre industrial levels. This called upon drastic reductions of fossil fuels, upon which the Netherlands promised to act (United Nations, 2015).

In 2016, the fourth Dutch offshore wind park was installed, named 'Gemini', comprising 150 Siemens 4 MW turbines on the twin locations Buitengaats and ZeeEnergie, 85 km off the coast. Gemini is owned by Northland Power, Siemens, Van Oord and HVC (Brasseur & Kirkwood, 2015).

The first sites in the Borssele Wind Farm Zone were tendered in 2016. The intense competition among firms in the public tender to obtain the permission and related subsidy to build and manage the wind parks(38 offers) resulted in a far lower than expected price (max. 0.12 euro per kWh), making the project the cheapest in the world at the time. Dong Energy (currently Ørsted) received the tender and corresponding subsidy for the Borssele 1 and 2 offshore wind park with a winning offer of 0.07 euro per kilowatt hour. The offshore wind park began supplying power to TenneT's offshore system in November 2020 and was officially opened in September 2021. Norges Bank Investment is the largest owner, possessing 50% of all shares of Borssele 1 & 2 (Golroodbari et al., 2021)

The Blauwwind consortium, comprised of Partners Group (45%), Shell (20%), Diamond Generation Europe (full subsidiary of Mitsubishi Corporation, 15%), Eneco Group (10%), and Van Oord (10%, also the BP contractor), won the second permit and subsidy to build and operate the Borssele 3 & 4 offshore wind farm sites in late 2016. The subsidy reductions for Borssele III and IV were even greater than for the Borssele I and II projects, which were projected to be the world's cheapest offshore wind parkat the time. The second Borssele offshore wind farm is anticipated to be built and managed with a subsidy of just 300 million euros, meaning that it will be run without subsidies after 7.5 years. The initial estimate for the subsidies was 5 billion euros. The offshore wind parks Borssele III & IV were installed in November 2020 and roughly generate around 3 TWh of energy each year, which is enough to power the equivalent of 825,000 Dutch households or up to 2.3 percent of total Dutch electricity consumption (van der Loos, 2020)

In 2018, the Two Towers consortium, comprised of Van Oord, Investri Offshore, and Green Giraffe, won the Borssele WFZ V site, which was designated as a small-scale demonstration site for offshore wind technology. Borssele V is located in Site III of the Borssele Wind Farm Zone and contains two Vestas 9.5-MW turbines as well as various innovations, one of which is a submerged Slip Joint. DNV GL validated the Slip Joint's design and production in the autumn of 2019. Thermally Sprayed Aluminum (TSA), Impressed Current Cathodic Protection (ICCP) optimization, and oval cable entrance holes are among the other improvements. Finally, the seabed around the two Borssele WFZ V wind turbines is equipped with environmentally appropriate scour protection. This technology is being used to investigate how nature and renewable energy sources might benefit one other. Oysters will be planted on the seabed's protective layer of rock to increase erosion protection, biodiversity, and the natural habitat for aquatic species (Jansen et al., 2022).

In October 2017, the cabinet Rutte III rose to power consisting of VVD, CDA, D66 and ChristenUnie. In their coalition agreement, named ‘Vertrouwen in de toekomst’, the cabinet announced a National Climate Agreement in aspiration of meeting the climate goals set out in the Paris Climate Agreement.

They gave a prominent role to offshore wind parks in decreasing greenhouse gas emissions. Concerning the fisheries, they made a specific promise that no more fisheries would be closed and that the interest of this sector was to be taken into consideration when assignng new offshore wind park locations (Rutte, Van Haersma Buma, Pechtold, & Segers, 2017)

The Dutch National Climate Agreement aimed to decrease carbon dioxide emissions in the Netherlands by 49% in 2030 compared to 1990. Many measures had to be implemented across multiple sectors of the Built Environment, Mobility, Industry, Agriculture and Electricity. In every sector, a ‘climate table’ was set up, in which involved companies, organizations had meeting and made agreements on how to achieve the ambitions as outlined in the National Climate Agreement (Rijksoverheid, 2019).

In the Electricity ‘climate table’, offshore wind parks were considered as one of the main technologies in the upcoming energy transition required to reach decarbonisation targets. The ambition regarding offshore wind parks was high: in 2030, offshore wind parks would have to deliver a total target capacity of 11.5GW, generating around 49TWh of energy (Rijksoverheid, 2019).

The ‘Ontwikkelkader Windenergie Op Zee’, which was published by the cabinet in September 2018, contained the functional requirements and the technical concept of the offshore net grid to which the offshore wind parks are connected, in purpose of minimizing the offshore wind parks and the offshore net grid. Based on calculations by ECN (Ministerie van EZ., 2018), it had been determined in which locations offshore wind parks could be realized at the lowest costs. These locations were mostly areas near to the Dutch coast, as depicted in figure 14. The main argument that the offshore wind parks were placed near the Dutch coast was that in this way it had a short connection to the offshore net grid (Rijksoverheid, 2019).

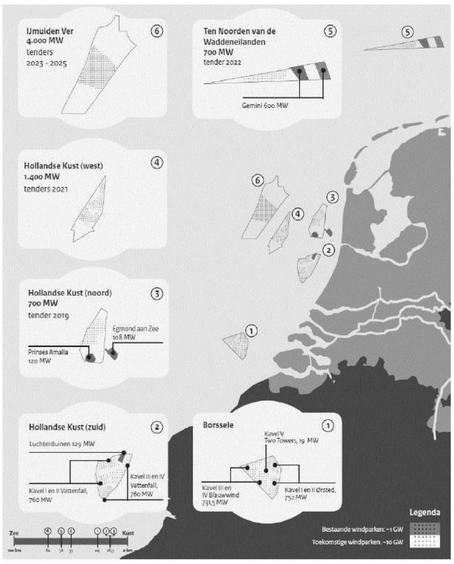

Figure 14. planned offshore wind parks Ontwikkelkader Windenergie Op Zee’

In 2018 and 2019, the first-ever non-subsidized tender for offshore wind parks took place. By means of a non-subsidy bid, Vatenfall won two tenders for the sites in Hollandse Kust (zuid). Furthermore, because some of the wind parks will be positioned within territorial waters (12-mile zone, 22 kilometers off the Dutch coast), Vattenfall will pay an additional sum of almost € 2 million per year for the right of superficies. The wind farms at Hollandse Kust (zuid), located 18.5 kilometers off the coast of The Hague, will begin construction towards the end of 2022 (Netherlands Enterprise Agency, 2022).

In 2020, the CrossWind partnership, comprised of Shell (80%) and Eneco (20%), was awarded the competition to build and manage the last par of the Hollandse Kust in the Dutch region of the North Sea. The 760-MW Hollandse Kust (noord) wind park, like the other offshore wind park in Hollandse Kust (zuid), was tendered under zero-subsidy terms. Similarly to Hollandse Kust (zuid), around 25% of Hollandse Kust (noord) is located inside the Dutch territories' twelve-mile zone. This implies that a seabed lease and an infield cabling rental agreement will be negotiated between the wind farm operator, The Central Government Real Estate Agency, and TSO TenneT. The consortium plans to have the Hollandse Kust (noord) operational by 2023 with an installed capacity of 760 MW, generating at least 3.3 TWh per year. Aside from building and operating the wind farm, the CrossWind consortium deploys a number of innovations (technology demonstrations), including a floating solar farm, short-term battery storage, turbines that are'tuned' to minimize the wake effect that turbines can have on one another, green hydrogen produced through electrolysis, and the combination of these individual measures to ensure a continuous power supply regardless of the variance of the wind (Knol & Coolen, 2020).

Wind energy costs have dropped far quicker than expected. The Energieakkoord from 2013 set a target of 40% cost reduction by 2020 compared to 2010 in pricing levels. The 2020 target price was established at 100 €/MWh. However, the pricing level for Borssele I & II was already significantly lower in 2016 than the plan for 2020. The most recent auctions for the Hollandse Kust Zuid and Noord resulted in pricing that were even without subsidies, with just the cost of grid connection being subsidized/publicly supported. The independent Netherlands Court of Audit discovered that the prices for offshore had fallen by 80% in a review of the Energieakkoord 2023, thereby two times as much as was initially planned (Jansen et al., 2022).

The National Energy Agreement was integrated in 2019 to establish a more comprehensive Climate Agreement, which is still operational today in the Nethelrands. The Climate Agreement intended to cut CO2 emissions by 49% by 2030, as compared to 1992. In terms of overall power generation, the current goal is to produce 70% of electricity from renewable energy sources (wind and solar) by 2030, and a 100% renewable energy system by 2050. This meant the phasing out of coal-fired power plants and biomass units. Related to offshore wind parks in the Netherlands , the Climate Agreement contains a promise to build an additional 7 GW of offshore wind farm capacity in the Dutch section of the North Sea between 2023 and 2030 (Jansen et al., 2022).

To keep pace with the ambitions of the Paris Climate Change Agreement at European level, the EU's Fit for 55 package was signed in 2020. The goal of this agreement is to cut greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Offshore wind will become the EU's primary source of power under this policy, taking full advantage of the potential in Europe's oceans - from the North Sea and Baltic to the Black Sea, and from the Atlantic to the Mediterranean. The objective of 300 GW by 2050, representing a 25-fold growth in offshore wind capacity, indicates a major shift in size for the industry at an unprecedented rate. This goes beyond only national ambition, and requires a nation-wide commitment towards realizing a European offshore wind energy system. Efforts are already pursued, for example by means of cross-border interconenctions such as the 'WindConnector'. Following the developments at the North Seas Energy Forum, TenneT, the Dutch TSO, and the United Kingdom's real estate business and seabed manager, joined forces to investigate potential opportunities for further cost reduction in offshore wind through alternative grid connection infrastructure solutions. This resulted in a jointly commissioned research activity examining the potential benefits of merging cross-border electricity transmission and infrastructure for offshore wind parks, called a 'WindConnector.' (Netherlands Enterprise Agency, 2022).

The following figure 15 provides an overview of the transition processes of SNM and their policy support on offshore wind parks.

Shielding	**Nurturing**	**Empowering**
'Rijksstructuurvisies Windenergie op Zee' was presented for new offshore wind parks (2014)	*Green Deal Offshore Wind between the government and the offshore wind industry for more job deployment (2011)*	Cabinet's focus shifted from 'subsidizing renewable energy' to 'stimulating innovation' (2011)
Cabinet selected three locations where offshore wind parks would be developed in the roadmap 'Windenergie op zee' (2014)	*Wind Innovation Contract* signed and ambitions over 5000 MW in 2020 (2012)	Tennet was formally chosen as an offshore grid operator
The 'Ontwikkelkader Windenegrie Op zee containing functional requirements of offshore wind parks (2016)	The National Energy Agreement contained an ambition of 16% of renewable energy by 2023	Luchterduinen (2015) and 'Gemini' (2016) opened and spread energy to the Dutch electrical grid.
	The Dutch National Climate Agreement ambitions offshore wind parks with a capacity of 49 TWh in 2030 (2017)	During the twenty-first climate conference of the United Nations, nearly 200 participating nations reached an agreement on the Paris Climate Agreement (2015)
	The EU's Fit for 55 packages was signed (2020)	Offshore wind farm sites Borselle (2018) and Hollandse kust (2020) are tendered

Figure 15. SNM processes in the stabilisation phase

4. Discussion

'It is fundamentally crazy to build wind farms out at sea. But it works!'

Tulsi Tanti

4. Discussion

Despite efforts made throughout the entire thesis writing process to increase research quality as much as feasible, this thesis still includes some shortcomings and some noteworthy discussion points. These discussion points relate to how the results from the previous section contrast or resemble with the broader policy and scientific landscape on offshore wind parks. Therefore, some results will be highlighted in this section and compared with findings from other scholars. Furthermore, this paragraph describes the limitations of the chosen metholododgy and discusses how these limitations could be addressed in future research.

The study documented a history of policy support of offshore wind parks in the Netherlands over a period of roughly 50 years. When considering all activities, some trends may be observed. First, offshore wind energy in the Netherlands was introduced by research programs after the oil crises in 1970's that stressed the need for sustainable alternatives. However, these research pilots were not followed up upon, until the societal opposition, in the form of the so-called NIMBY took place and offshore wind parks were again on the table. Funds were made available, which resulted in the first offshore wind parks. This transition period is titled the formation period as experiments happened and a social network was created. In the second period, the so-called growth phase, the momentum of offshore wind parks was slowed down because of clear lack of commitment in policy making. This pointed out that successful offshore wind park implementation required consistency in the energy regime towards the chosen ambitions of offshore wind parks. It also indicated that a socio-technical system such as the (fossil) energy system embodies a lot of inertia and therefore much perseverance and dedication is necessary to change the energy regime. The third and last period, the *stabilisation* phase is marked by a reinvigorated drive for offshore wind parks. Apart from a shift in emphasis , this period is special because of the introduction of numerous regulatory frameworks by the government like the the 'Offshore Wind Energy Law' and the National Climate Agreement. This period mainly shows how modifications in the surroundings of an innovation (by creating a fruitful climate) may affect the outcome and progress of that innovation.

More discussion points can be raised related to the three transition stages. The *'slowing down'* of offshore wind parks in the second period, or the decrease in momentum of a certain technology in general, is explained by other authors as component of a *'hypecycle'*. A hypecycle is a graphical depiction of the stages of a technology's life cycle, from launch through maturity and broad adoption, invented by Gartner (Fenn & Raskino, 2008). The hypecycle describes the progress of a certain technology. Following a first technological trigger, expectations of a technology rise dramatically, creating excitement until what is known as the peak of inflated expectations.

As the peak is completed, disappointment gains the upper hand, and expectations rapidly declines, resulting in the dip of disillusionment. After some time, the technology rebounds and gradually but steadily makes its way to the market (Bakker, 2010). To some extent, the same dynamic of the hype cycle may be applicable to the implementation of offshore wind parks in the Netherlands. The questions however arises to what extent it resembles a hype cycle and which periods relate to which parts of the hype cycle. Literature on hype cycles (related to offshore wind parks) is relatively premature. The scientific literature around *expectations* however is more comprehensive.

Expectations concerning offshore wind parks have started in 1970 and changed significantly over the technology's progress. Partly this can be attributed to changes in ambitions that shape different expectations. Berkhout (2006) describes expectations to be '*bids about what the future might be like, that are offered by agents in the context of other expectation bids'*. In contrast, Van Lente & Spitters (2000) describe expectations to be part of a shared agenda that requires action in itself. Expectations at once indicate a development direction, upon which action is taken (van Lente & Spitters, 2013). Furthermore, Geels and Smit (2000) point out that some expectations might be set unrealistically high in order to create attention for a technology. As Geels and Smit (2000) put it, 's*ome future speculations do not strive for truth or accuracy, but are meant to influence specific social processes in technological developments.*' These statements are all true indeed. The expectations and ambitions set from a political point of view have been unrealistically high for offshore wind parks and as a result never played out as expected. This also happened because the government was not the only one expressing expectations. The actor which establishes the expectation surrounding a certain technology is important. Expectations expressed by some actors (such as the government) potentially have a greater impact on the emerging technological innovation system than expectations from other actors (Berkhout, 2006). The content of expectations is important as well. Berkhout (2006) specifies how the validity of expectations are relevant in discovering which expectations will align with reality. Expectation dynamics often shows a typical pattern where changes occur in the nature of the expectations of a technology throughout time. For example, early, high expectations are substituted by more detailed expectations as a technology matures, thus minimizing the degree of uncertainty related to the technology.

Another noteworthy discussion point relates to the type of policy approach that has been used by the government in the implementation of offshore wind parks in the Netherlands. Offshore wind parks heavily rely on the national government and large industrial players that have monopolized their position (Tennet, e.g. Vestas, Siemens, Vatenfall) for this development. In this way, municipalities or provincial governments have been largely omitted. This type of procedure is quite centralized in which the national government has a steering role. The top-down approach towards implementing wind parks in the Netherlands has led to some opposition. A first example is the onshore wind park that is built near the Wieringermeer. This wind park, the Wieringermeer wind park, is commissioned by Vatenfall, and the generated electricity is transferred to datacentres of Microsoft. Vattenfall will receive a maximum of more than 660 million euros in subsidy from the Dutch government in the coming fifteen years (Rengers & Houtekamer, 2020). Microsoft made a ten-year deal with Vattenfall regarding the supply of green power to the data center. Over the years, the Wieringermeer wind park has become a controversial issue among Dutch citizens. For instance, the issue got major attention in the television series 'Zondag met Lubach' (Lubach, 2020). In their television show, Lubach is skeptical about the allocation of wind energy to Microsoft. In general, it is questioned whether the globalization of the wind park is beneficial for national climate goals. Next to that, at a regional level, locals question whether the distribution of the produced energy is fair (Rengers & Houtekamer, 2020). For instance, Vattenfall makes an indirect promise that the wind energy will be destined for households as Vattenfall expresses its energy production in the number of households that can be powered by the energy. Furthermore, the region and citizens of Wieringermeer have to incur the negative externalities which are imposed by the data centres. For example, due to the intense water consumption of data centres, local residences are likely to suffer from water shortages (NOS, 2021). Related to offshore wind parks in the Netherlands, also more and more discussion is opening to what extent the allocation of the renewable energy is done responsible and fair. For example, recently, wind park owners Eneco and Shell have sold half of the power production of their tendered wind parks (which is yet to be built in 2023) to Amazon. The wind park has 69 wind turbines with a total capacity of 759 megawatts and supplies 3.3 billion kWh of electricity annually, equivalent to an energy consumption of approximately one million households (NOS, 2021). It is therefore critical to ensure that all stakeholders have the opportunity to engage in the process, including local citizens. This connects to literature suggesting that the energy transition requires a shift from an individualistic, market-based strategy to a participative, community-based one. In this way, the energy transition is a responsible transition for everyone, and not only for the multinationals that benefit from it. This is also congruent with the Western paradigm shift from the age of technocracy to the age of participation (Vleuten et al. 2017).

One possible avenue for realizing more responsibility and justice in the Dutch energy transition and in the implementation of offshore wind parks could be by means of the Dutch Regional Energy Strategies (RES). The RES aim to combine regional businesses, local citizens to take action on energy projects like wind parks, where significant attention is devoted to participation and support from the general public. The RES can offer local inhabitants a greater role in how their environment should look, for example, by being more flexible in the destination plans for projects to develop. This method might also help with other energy-related solutions, such as house insulation or asbestos removal. The government might create a plan for these local residents to form an energy cooperative to invest in wind energy and utilise the profits to fund house modifications. Similar projects have sprung up elsewhere in the Netherlands, combining solar panel installation with asbestos removal (Aalbers, 2021). In both instances, the RES assists in the growth of neighbourhood residents' autonomy. In this way, it successfully links the presence of wind parks with the ability to transform their neighbourhoods for the better. This solution also represents the bottom-up implementation method, which Cairney (2012) and Barett and Fudge describe as a negotiating process (1981). It also fits within a more collectivist approach, emphasising the co-creation paradigm, which has received more attention in recent research on energy publics (Pesch et al. 2020).

Besides the above-stated noteworthy discussion points, this discussion also sheds light of the limitations of this research. In discussion of the 3 different transition periods of the analysis, it may be remarked that this periodization is merely a descriptive abstraction that is superimposed on events (Calinescu, 1986). Still, the analysis proves useful in explaining offshore wind park developments and how policy has advanced and constrained these developments. The different periods are identifiable because of certain characteristics that make them unique, such as changes in ambition, an evolution from research to implementation, modifications in the political landscapes and different actor configurations. It may be observed that the first period of the historical analysis covers 30 years and therefore analyses more time than the subsequent two decades discussed in periods 2 and 3. This might suggest '*present bias'*, however, this is the result of increasing developments concerning offshore wind parks like more media coverage, more offshore wind parks installed and more policies and regulatory frameworks put into place by the government.

In discussion of the framework Strategic Niche Management, the following may be noted. First and foremost, the three niche transition processes shielding, nurturing and empowering are only vaguely different from one another. This gave rise to a problem where certain developments could be considered both shielding, nurturing and empowering. For example, in 2003, a consortium called 'We@Sea' was formed, which gained funding for exploring more offshore wind parks. *'Setting up consortia to enhance learning experiences'* is a policy indicator for a nurturing process, whilst *'finance research and development (R&D)'* is a policy indicator for a shielding transition process. The development of the consortium called 'We@Sea' which received funding for research and development thus may be seen as both shielding and nurturing. Therefore, the different transition processes (shielding, nurturing and empowering) were often difficult to identify from one another which made it difficult to use it as an analytical lens. More research should be devoted to the interrelation between the different niche transition processes.

5. Conclusion

‘Als de wind van verandering waait, bouwen sommige mensen muren en anderen windmolens’

Chinees gezegde

5. Conclusion

This thesis investigated how policy can support offshore wind parks in the Netherlands. This research consisted of an analysis outlining the history of the slow development of offshore wind parks in the Netherlands and also gave insights in offshore wind parks as a socio-technical system. First, the problem statement was defined, namely the slow development of offshore wind parks whilst having very high expectations of offshore wind energy towards 2030. Next, relevance of the research was explained, which gave rise to the reason of studying the overall Dutch offshore wind innovation system and how to strengthen it with recommendations. Then, literature contributions to previous academic articles were shared and the main research question was posed: *'How can policy support the facilitation of offshore wind parks in the Netherlands?'*. This question was answered in a structured manner. First, the contextual energy situation and Dutch offshore energy system was explained. Next, a methodological approach was set up, which included a transition theory, namely Strategic Niche Management, whilst lending terminology from Multi-Level Perspective and Transition Management. A chronological literature review was then presented, which compiled a history of policy support over 50 years in the Netherlands, reviewed by the framework of Strategic Niche Management. By doing so, it has presented a chronological review of Dutch offshore wind park developments through the processes of shielding, nurturing and empowering. The three transition periods that were identified in the 5 decades are summarized below.

1. Formation Phase

Research in offshore wind parks: from aimlessness to real ambitions (1970–2000)

The first period is characterized by the emergence of offshore wind parks as a sustainable way of generating energy, as a response to the oil crisis. Research programs were set up to investigate the potential of offshore wind parks. Initially being dismissed as being 'too expensive' in the first and second National Research Programs, expectations concerning offshore wind parks steadily received more and more support, due to societal opposition, in the form of the so-called NIMBY for its onshore counterpart. Funds were made available, which resulted in the first offshore wind park of the Netherlands: the Lely wind park of 2 MW in 1994. After this, real ambitions were expressed by the announcement of an offshore wind park near Egmond-aan-Zee, called 'NoordzeeWind.

2. Growth Phase

Tendering issues and changing political visions on offshore wind parks (2000-2010)

This period is characterised by lack of consistency in policy making. Despite significant efforts of several coalition governments, there were a lot of changing visions on offshore wind parks. This is mainly because since the 2000s, not even one of the successive coalition governments has succeeded in completing its term. As a result, energy policy frequently changed, which negatively influenced the effectiveness of the executed policies. Therefore, political stability and predictability are fundamental to secure the investments required for offshore wind parks. Still two offshore wind parks, ‘NoordzeeWind’ (2005) and ‘Princess Amalia’ (2008) opened.

3. Stabilisation Phase

Offshore wind parks gain momentum (2010–2020)

The third and last period is characterized by a renewed impulse for offshore wind parks. Apart from a shift in focus from ‘subsidizing renewable energy’ to ‘stimulating innovations’, this period is identified by many regulatory frameworks put into place by the government. Following the ‘Renewable Energy Directive 2009/28/EC’, the ‘Offshore Wind Energy Law’ paved the way for a legal framework for the large-scale realization of offshore wind parks. In 2015 the Paris Climate Agreement was agreed upon, which gave rise to the National Climate Agreement ambitioning a capacity of 11.5GW by offshore wind parks in 2030. In line with the National Climate Agreement, the ‘Ontwikkelkader Windenergie Op Zee’ was published by the cabinet in 2018, containing the functional requirements and the technical concept of the offshore net grid. This period is characterized by ‘Luchterduinen’ and ‘Gemini’ which opened in 2015 and 2016 respectively and spread energy to the Dutch electrical grid. Furthermore, the first non-subsidiary tenders started for the wind parks in Borssele and Hollandse Kust Zuid. The Energy Agreement turned out to be a "game changer" for offshore wind energy in the Netherlands. Up until 2013, there was limited activity in offshore wind parks. With the more proactive current policy approach, a total of 3.5 GW was successfully tendered between 2016 and 2019, with an additional 7 GW now scheduled. This demonstrates the importance of a strong public-private process guided by the government.

Lastly, disccusion points were raised related to the different transition stages of the analysis. The discussion points contrasted the results of the analysis in view of the broader scientific landscape. Also, limitations and shortcoming of the methodology were elaborated upon. The following section will provide detailed policy recommendation how to foster the Dutch offshore wind energy system.

6. Policy Recommendations

‘’Vol van realisme en idealisme. Een werkelijkheidszin, die rekening houdt met het bereikbare, doch beseft, dat in de werkelijkheid het ideaal ook mee doet. Anderzijds een idealisme, dat ver vooruitziet, maar daarom niet voorbijgaat aan wat vlak voor ons ligt.’’

Willem Drees, 1946

6. Policy Recommendations

This thesis gave insights in offshore wind parks as a socio-technical system, to which policy recommendations are drawn in this paragraph. On a general note, it is recommended that the Dutch government continues to advocate for more interconnection capacity, remove rules that require integration of energy systems and that the government plays a pioneering role in the further development of the North Sea region.

- This thesis showed that offshore wind parks contain a substantial sector of the economy with and expected value of € 6.5 billion in 2030 in the most optimistic scenario. Crucial for the actual realization are the solutions that will have to be found for the fact that wind power and other renewable sources are not available on demand. Peak-demand management and energy storage for example via batteries in electric transport or via the large-scale application of electrolysis.

- A European approach to the further development of offshore wind energy offers benefits for both the sector and society. European cooperation is an effective way to reduce the costs of the energy transition and to improve stability.

- In view of the strong position of the Dutch offshore cluster on the international market, the Netherlands is benefiting relatively much from the development of wind parks outside the Netherlands. The Netherlands therefore has an interest in this open, accessible market. I recommend that the Dutch government stays committed to removing barriers to trade. Such barriers are, for example, the specific requirements surrounding minimal local involvement that some countries draw up in the wind energy sector, but also the fragmentation of regulations in the field of working time, safety and environmental requirements that operate across borders.

- In the field of turbine construction, there are hardly any Dutch activities. Given the large share of turbine development in the total supply chain, significant potential value is lost with this. The Netherlands does have a favourable location on the North Sea and a good infrastructure, so the government should commit to bringing more activities to the Netherlands. The government may facilitate this, for example through promotion of the Netherlands as a country of residence and through diplomacy behind the screens.

- The allocation mechanism, in which concessions and grants being issued at the same time contributes to a reduction of costs and risks. Given the rapid market developments, it is necessary to update the mechanism to improve and build in flexibility to respond to different market conditions. The new bill *'Offshore Wind Energy Law'* offers guidelines for this.

- There is a shortage of technically trained personnel in the sector. Personnel with technical background of all education levels are missing. This scarcity is not inherent to offshore wind parks but is more widely felt in other energy-related sectors. In addition to ongoing national initiatives, the government can facilitate the development of a specific action plan for the development or retraining of qualified personnel.

- For an ecologically responsible rollout of offshore wind parks and the associated redevelopment of the North Sea, it is recommended that the government invests time and resources in knowledge to be able to limit the ecological risks of offshore wind parks. The government should take advantage of the ecological opportunities of offshore wind parks and apply the precautionary principle.

- The government should change the public perception about offshore wind parks in order to motivate the Dutch people to be supportive about the realization of 11.5 GW of capacity in 2030, as set out in the National Climate Agreement.

- Increasing the costs for normal energy production generated by fossil fuels energy system will lead to more stimulation of new offshore wind parks. The government should impose more taxes on energy from conventional, fossil fuel energy system.

- The implementation of offshore wind parks should be a fair process in which the needs of the local community are taken into consideration. The Dutch offshore wind energy system should be incorporated in the Regional Energy Strategies in the Netherlands (RES). The RES seek to bring together regional enterprises and local communities to take action on energy projects where major emphasis is placed on public engagement and support. The RES has the potential to give local residents a larger role, as extensively explained in the previous chapters.

7. References

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Appendix I: Sequence of developments future offshore wind parks

Capacity (GW)	Offshore wind park	Tender date	Expected opening date
0,7	*Borssele*, kavels I en II	Realized in 2016	2020
0,7	*Borssele*, kavels III, IV en V	Realized in 2016	2020
0,7	*Hollandse Kust (zuid)* kavels I en II	Realized in 2017	2022
0,7	*Hollandse Kust (zuid)* kavels III en IV	Realized 2019	2023
0,7	*Hollandse Kust (noord)* kavel V	Realized 2020	2024
0,7	*Hollandse Kust (west)*, kavel VI	Realized 2021	2025 t/m 2026
0,7	*Hollandse Kust (west)*, kavel VII		2025 t/m 2026
0,7	*Ten noorden van de Waddeneilanden*, kavel I	Fourth quartile 2022	2027
1,0	*IJmuiden Ver*, kavel I	Fourth quartile 2023	2028
1,0	*IJmuiden Ver*, kavel II		2028
1,0	*IJmuiden Ver*, kavel III	Fourth quartile 2024	2029
1,0	*IJmuiden Ver*, kavel IV		2029

Appendix II: Involved actors of offshore wind parks in the Netherlands

Actor	Resource(s)	Targets
European Commission	Directive 2009/28/EC	Promoting renewable energy sources.
Ministry of Economic Affairs & Climate Policy	Energy Policy Making Allocate budget	National Climate Agreement: offshore wind parks with a capacity of 11.5GW in 2030
Ministry of Finance	Subsidy schemes: SDE+	
Ministry of Infrastructure and the Environment	Energy policy making	
Regional governments (e.g. Nord Holland Provinces)	Practical policies on assembly, transportation and construction of offshore wind parks	National Climate Agreement: offshore wind parks with a capacity of 11.5GW in 2030
Wind turbine manufacturers (e.g. Vestas)	Knowledge, technology and skills	
Project developers (Vatenfall, Eneco)	Technology, knowledge and skills	Have a higher share in offshore wind parks
Environmental NGOs (e.g. Natuurmonumenten)	Lobby, campaign and media	Environmental concerns
TenneT	Infrastructure (grid)	High degree of grid reliability

Appendix III: List of offshore wind parks in the Netherlands

Wind park	Capacity	Turbines	Expected life	Km to shore	Depth (m)
Egmond aan Zee (2008)	108 MW	36 (Vestas V903MW)	20 years	13	15-18
Princess Amalia (2008)	120 MW	60 (Vestas V802MW)	-	26	19-24
Eneco Luchterduinen (2015)	129 MW	43 (Vestas V112/3000)	25 years	24	18-24
Gemini (2016)	600 MW	150 (Siemens SWT-4.0130)	20 years	55	28-36

Appendix IV: Turbine models of offshore wind parks in the Netherlands

OWP	Capacity (MW)	Turbine Name	Rated power	Turbine type
Princess Amalia (2008)	120	V80-2.0 MW	2 MW	Variable speed
Egmond aan Zee (2008)	108	V90-3.0 MW Offshore	3 MW	Variable speed
Luchterduinen (2015)	129	V112-3.0 MW Offshore	3 MW	Variable speed
Gemini	600	SWT-4.0-130	4 MW	Variable speed

Appendix V: Foundations of offshore wind parks in the Netherlands

OWP	Grounded	Diameter (meter)	Length (meter)	Weigh (ton)
Princess Amalia (2008)	Monopile	-	-	-
Egmond aan Zee (2008)	Monopile	4.6	-	-
Eneco Luchterduinen (2015)	Monopile	5	70	525
Gemini	Monopile	7m at base, 5.5m at top	59-73	670-916

Appendix VI: Connection facilities of offshore wind parks in the Netherlands

OWP	Array cable length	Transmission type	Nominal voltage
Princess Amalia (2008)	45 km	MVAC	24 kV
Egmond aan Zee (2008)	20.4 km	MVAC	34kV
Luchterduinen (2015)	32 km	MVAC	33 kV
Gemini	105 km	MVAC	33kV