Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical Studies

Linea Lofthus Meldahl

A clean hydrogen market in the making

Comparing Norway's and the Netherland's roles in the European hydrogen transition

Master's thesis in European Studies
Supervisor: Dr. Carine Germond
May 2021

NTNU
Kunnskap for en bedre verden

Linea Lofthus Meldahl

A clean hydrogen market in the making

Comparing Norway's and the Netherland's roles in the European hydrogen transition

Master’s thesis in European Studies
Supervisor: Dr. Carine Germond
May 2021

Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical Studies

NTNU
Norwegian University of
Science and Technology

Abstract

The EU intends to become a climate-neutral continent by 2050. Clean hydrogen will be a crucial component to decarbonizing several sectors and creating an entirely new and prospering market. This master's thesis addresses how and to what extent Norway and the Netherlands can play a role in the clean hydrogen market in the EU and their path towards a low-carbon society. It uses qualitative comparative research design with an actor-centric approach at the government and business levels. Furthermore, the study address similarities and differences in the national hydrogen transitions by comparing government hydrogen strategies. Comparisons are made of Equinor and Gasunie's approaches to the transition to clean hydrogen production by studying their most prominent hydrogen projects. It also analyses and compares the countries' efforts to impact EU policies on what they consider essential. The thesis concludes that Norway and the Netherlands are well placed to produce blue and green hydrogen and contribute with kickstarting the market. Actors at the government and business level must actively participate in dialogues for their interests to influence EU policy. The Dutch actors have actively contributed at an early stage with clear, proactive measures and active discussions and participation internationally compared to the Norwegian players. This thesis implies that the Norwegian government must be willing to cooperate closely with the Dutch government if Norway is to play a significant role in the European hydrogen market. Equinor's assessments of a new pipeline to the Northern Netherlands could be an excellent opportunity for Norway to join the European Hydrogen Backbone network.

> "We want to make clean hydrogen the best choice in economic terms. The good news is: with enough commitment, we can reach the tipping point, where clean hydrogen becomes more competitive than its alternatives. With the right investment and the right policies, clean hydrogen can go mainstream" (von der Leyen, 2021).

Keywords: hydrogen transition, green versus blue hydrogen, Norway, the Netherlands, EU, qualitative comparative research design, European hydrogen market, energy transition

Acknowledgements

This master's thesis is 30 credits and is the end of the two-year master's program in European Studies at NTNU. This study has been a particularly interesting and educational period in my life. In particular, the work on the master's thesis has presented many exciting and demanding challenges.

In the planning of the master's thesis, it became natural for me to gradually choose something within the topic of energy transition and the green shift in Europe. I gained particular interest in this topic and how Norway and the EU cooperate in the energy field after my traineeship with the EU delegation to Norway spring 2020. I am very grateful that they gave me an informative and educational experience and resulted in a distinctive interest in the European Green Deal and how Norwegian actors are working towards the green shift. It was also natural to learn more about the clean hydrogen transition, as this has been high on the political agenda in Norway and the rest of the EU. It was challenging to gather a lot of information in such a short period of time, as news about hydrogen developments flowed in almost all the time I was working on the thesis.

In the work on the writing of the thesis, there have been many ups and downs, where I have at times felt drained of energy and the lockdown has been impactful. In particular, I would like to give special thanks to my supervisor Carine Germond at NTNU. I am grateful for all her help and patience in the supervision meetings and got me back on the right track with all my thesis drafts. I also want to thank my fellow classmates, friends, family, roommate, and boyfriend for supporting me and providing tips and motivation in the writing process.

Finally, I would like to thank Noé van Hulst, who took the time to participate and contribute with his experiences and opinions in relation to the topic of this thesis. Although it was unfortunate that not everyone that I hoped to interview was able to participate, I am deeply grateful for the effort and contribution van Hulst made to gain greater understanding of the relationship between Norway and the Netherlands in this area.

Table of Contents

List of figures

List of Abbreviations

CCS	Carbon Capture Storage
CCUS	Carbon Capture Utilisation and Storage
CEF	Connecting Europe Facility funding scheme
EEA	European Economic Area
EZK	Ministerie van Economische Zaken en Klimaat (Ministry of Economic Affairs and Climate Policy)
GHG	Greenhouse Gas
GW	Gigawatt
IEA	International Energy Agency
IPCEI	Important Project of Common European Interest
KLD	Klima og miljødepartementet (Ministry of Climate and Environment)
MLG	Multilevel Governance
NCA	National Climate Agreement
NCS	Norwegian Continental Shelf
NSD	Norsk Senter for Forskningsdata (Norwegian Center for Research Data)
OED	Olje og energidepartementet (Ministry of Petroleum and Energy)
RED II	Renewable Energy Directive
VEMW	The Dutch industry organisation for commercial energy users

1. Introduction

> "The European Green Deal launches a new growth strategy for the EU. It supports the transition of the EU to a fair and prosperous society that responds to the challenges posed by climate change and environmental degradation, improving the quality of life of current and future generations" (European Commission, 2019, 23).

Today, we see ambitious international climate legislation moving towards renewable energy and climate-neutral solutions to reach the Paris Agreement targets[1]. An important element of the solution towards a low-emissions society is the transition to clean hydrogen (van Wijk and Chatzimarkakis, 2020, 12). There is an expanding international agreement that clean hydrogen will play a key role in the world's transition to a sustainable energy future. This is because hydrogen is a flexible energy carrier[2] that can be made from a wide span of energy sources and could be a game-changer in its low-carbon form (IEA, 2019).

Clean hydrogen is gaining a central place in the EU's climate strategy. In December 2019, the European Commission presented the "European Green Deal", a comprehensive climate change restructuring plan for the European Union (EU). The EU desires to improve its own emission reduction targets and to cut 50 or 55 per cent of emissions compared to 1990 levels by 2030 and by 2050 have net zero emissions (European Commission, 2019, 4). The EU industry needs 'climate and resource frontrunners' to develop the first commercial applications of breakthrough technologies in key industrial sectors by 2030 (Ibid, 8). Here, clean hydrogen is one of the priority areas and is high on the political agenda. This study focuses on two forms of clean hydrogen. The first is blue hydrogen, which is produced by fossil fuels such as natural gas but with carbon, capture and storage (CCS). The second form green hydrogen, which is produced by renewable energy.

Many nations developed hydrogen strategies and roadmaps the last year. Among these are Norway and the Netherlands. The Norwegian government presented its hydrogen strategy in 2020 and set the course for encouraging the development of clean hydrogen technologies. The government wants to ensure that blue hydrogen can compete on equal terms with green hydrogen in the European energy market (OED and KLD, 2020, 48). The Dutch Hydrogen Strategy was also published in 2020 and, although it focuses mostly on green hydrogen, it also has an interest in creating a blue and green hydrogen market (EZK, 2020a, 4). Nonetheless, there are some challenges for the Netherlands and Norway with getting both blue and green hydrogen competitive in the developing hydrogen market in Europe. The last years has seen heated debates between the EU Member States on whether there are any regulatory consequences for producing blue or green hydrogen (OED and KLD, 2020, 47). Blue hydrogen is somewhat of a quandary for the EU and some of its Member States. Given that Norway has a particular advantage in the production of blue hydrogen, it is problematic that the EU and the hydrogen

---

[1] The Paris Agreement sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. https://ec.europa.eu/clima/policies/international/negotiations/paris_en

[2] Energy carriers can exist in a variety of forms and can be converted from one to another, as opposed to energy sources that are the original resource from which an energy carrier is produced. Retrieved 11.03.21 from: http://www.eolss.net/sample-chapters/c08/E3-03-05-01.pdf

strategies of several Member States focus only on green hydrogen (Riekeles & Seland, 2020, 17). This can also hinder the impact that Norway and the Netherlands can make on the EU level to get blue hydrogen on equal terms as green hydrogen.

The unprecedented year of 2020 with the coronavirus (COVID-19) caused significant financial setbacks, but its damaging impacts have also been a blessing in disguise for the environment. The considerable decline in pollution levels during the lockdown (Muhibbudin, 2020, 1) has also given a unique opportunity for the EU to uphold the priority on the Green Deal and creating a hydrogen market. Market interest in clean hydrogen has skyrocketed and is now the hottest topic in the global energy conversation (IEA, 2019: OED and KLD, 2020, 47: Equinor, 2020a, 41). In addition, the EU's Green Deal to decrease carbon emission can result in a faster scaling up of hydrogen networks across Europe than what the case was before the pandemic (Li et.al, 2020, 15). Recovering from COVID-19, the EU desires that investments in developing a hydrogen economy can create a clean and affordable energy system. In addition, the EU anticipates it can increase an innovative new hydrogen manufacturing industry and a hydrogen market, creating new green jobs and economic growth (Hydrogen Europe, 2020, 1).

This thesis has a focal point on the developments in the hydrogen transition in Norway and the Netherlands and their possible closer bilateral hydrogen cooperation. They have a unique potential and opportunity to give the new European hydrogen market both blue and green hydrogen. Their approach may function as a roadmap for other European countries who depend heavily on fossil fuels. This study intends to examine the roles of the Norwegian and Dutch governments in the development of hydrogen in a low emission society. The only full-scale CCS projects under development in Europe are all in Norway, the Netherlands, and the UK (OED, 2020, 17). The Netherlands and Norway are considered front runners in Northwest Europe in terms of the application of hydrogen and of European efforts to achieve their domestic emissions reduction goals (EZK, 2020b, 13).

The Northern Lights project and the Port of Rotterdam CO_2 transport hub and offshore storage (Porthos) are the most progressive blue hydrogen projects under development. Regarding green hydrogen, the NortH2 project in the Netherlands is Europe's largest green hydrogen project today. Therefore, it is important to study the roles that Norway and the Netherlands can play in creating a successful hydrogen market in Europe. In addition, the study explores the companies Gasunie and Equinor, which are set to play a significant role nationally and/or internationally. They are also mentioned in the national strategies and can be a great example to show the Norwegian and Dutch cooperation on hydrogen. Gasunie is set to play a crucial role nationally for the Dutch hydrogen backbone and internationally in the European hydrogen backbone (EHB), which will be the largest network in the clean hydrogen market in Europe. Although there is not a national hydrogen backbone for Norway, Equinor has the potential to play a significant part for Norway to join the EHB.

1.1. Research Question and Justification of the Study

This study explores the newest developments in the creation of a hydrogen market in Norway, the Netherlands, and their market opportunities for bilateral cooperation in the EU. The method of qualitative comparative analysis is chosen because it provides a comprehensive perspective of the two countries that will be studied and fits well with the topic and research questions. With the chosen method and the information provided above, the main research question chosen for this study is therefore correspondingly:

How and to what extent can Norway and the Netherlands play a role in the transition and implementation of a European hydrogen market?

To this aim, there are three sub research questions: (1) What are the similarities and differences between the Norwegian and Dutch hydrogen strategies? (2) How are Equinor and Gasunie executing their transition towards hydrogen usage and how can they play a significant part in the new European hydrogen market? (3) To what extent can Norway and the Netherland's approach to blue and green hydrogen impact other EU Member States' hydrogen approach?

The research questions are relevant to this thesis due to its objective to determine the possible essential roles that the national governments and energy companies can play in the new European hydrogen market. In addition, the questions seek to add to the existing literature and compare recent political developments in the hydrogen transition of the Netherlands and Norway. It explores possible closer bilateral cooperation for hydrogen projects between the Netherlands and Norway before moving towards the contested views on blue versus green hydrogen in the EU and how Norway and the Netherlands might have an impact on other Member States' opinions.

The time span of this study focuses on the developments made in 2020 and the spring of 2021, as several key Norwegian and Dutch developments took place in this time span, such as strategy documents outlining future steps towards implementing hydrogen projects. These documents have yet to be analysed and compared and can contribute to finding the extent to which the countries roles can be in the European hydrogen market. The lack of research on political developments signifies the necessity of further investigation on the topic on Norwegian and Dutch comparison of hydrogen strategies and bilateral cooperation.

The study is highly relevant, since clean hydrogen is high on the EU's political agenda. With the current debates taking place on the EU level, this study could provide great value to comprehending a collective EU approach to hydrogen forms. Norway is a major exporter to EU and is climate conscious. Oil and gas as emission-intensive sources must be phased out and there is a need for a more renewable energy. Norway is a safe and predictable state compared to other major fossil fuel exporters. Norway has technology and expertise that is vital for Europe's green transition. The Netherlands is not as major an exporter as Norway, but it is a major actor in sustainable developments. Hydrogen transition is also relevant for Norway and the Netherlands because it is a crucial component for realizing the below 2° Celsius target.

The reason as to why it is important to compare the Norwegian and Dutch hydrogen strategies is to find out to what extent these strategies can play a role for the countries' goals to reach the national climate targets. The comparison can also contribute to finding out to what extent these countries can contribute to the goals in the EU Hydrogen Strategy and European Green Deal. It is also important to compare the companies' efforts to change into a net zero company through clean hydrogen and to compare the various actors' efforts to promote and influence EU policies in the hydrogen field. Finally, it is important to examine the actors' interactions with each other, and all these considerations will assist in filling a gap in the literature.

1.2. Methodology, theoretical framework, and sources

The chosen method in this study is built on a qualitative research design that aims to understand political incidents, and developments over time. Explanations are based on interviews, the analysis of documents, or content and text analysis (Caramani, 2017, 525). Furthermore, the study uses a focused comparative case study analysis. A case study is a method of acquiring a "case" through an empirical analysis of a phenomenon without directly influencing either the phenomenon or the context. The comparative case study is the evaluation of two or more cases (Kaarbo and Beasly, 2002, 372). Comparative case study in politics and in European Studies is to study political institutions, actors, and processes, and identifies differences and similarities between these variables (Caramani, 2017, 3). This study will compare national governments and companies because it helps to interpret new developments and practical and political relationships between the selected states. Norway and the Netherlands were selected for this study because they are two Northern European states with high ambitions for the energy transition and have a geographical advantage with strong connections to the North Sea. Focusing on two comparisons can display how the countries differ in their response to common problems, such as this case with the transition to low carbon society and transition to blue and green hydrogen energy.

This study will use the theoretical approach of governance, as it describes policymaking in the EU and investigates the functioning of an increasingly integrated social and political system. It also covers numerous levels of government and includes a large set of actors (Saurugger, 2014, 102). EU policies are constructed by actors of different origins who share the same objectives on a given topic (Ibid, 110). Multilevel governance (MLG) is a conceptual tool that use an actor-centric approach, which explores relationships between different levels of governments and actors' interests and strategies and how they deal with specific public policies (Pazos-Vidal, 2019, 1). In this case the actor-centric approach can be used throughout this thesis to study how the national governments and companies deal with the hydrogen transition.

An actor-centred approach can assist in answering the main research questions of this thesis. It can assist in displaying and explaining what role Norwegian and Dutch governmental and societal actors are playing in the energy policy field regarding the hydrogen transition in Europe. The research will therefore study the government's approach to the hydrogen transition at the national level, and their efforts at the EU level. An actor-centric approach will contribute comparing the governments and companies and how they use their role in the energy transition and how they work at the EU level. Both government actors and market actors such as Equinor and Gasunie are key for the success of a new and competitive clean hydrogen market in Europe. The study will also look at how these actors collaborate, and whether if there are some tension or contested interests that can hinder the developments. The approach can also explain the third sub-research question on how Equinor and Gasunie works towards realizing the government's strategies through their hydrogen projects and pushing for their interests at the EU level. The chapters from four to six will consistently use the actor-centric perspective to analyse and explain the roles of the various Norwegian and Dutch actors and their efforts to influence at the EU level.

Moreover, this thesis uses sources such as government policy documents, research articles and news articles, official statements, and email interview. Other sources are journal and conference articles which were collected from different scholar databases. Reports from energy and climate correspondents and think tanks were also analysed. These are essential when addressing the latest developments in the Dutch and Norwegian hydrogen transition. Primary sources are the national hydrogen strategies in Norway and Netherlands, along with official government and ministry documents, white papers and Gasunie's and Equinor's reports. These sources scores high in reliability and reveal the content of Norwegian and Dutch policies and signify how politicians justify their actions. Newspaper articles are significant as quotes from people such as Prime Ministers, Ministers, and employees from Gasunie and Equinor can reveal their thoughts and interpretations on the hydrogen topic. However, not all newspapers are correspondingly reliable. This study has therefore tried to focus on valid news outlets and publishers. Regarding interviews, semi-structured interviews were planned[3], but could not be implemented due to the unforeseen difficulty in obtaining relevant contacts in the Energy ministries et the two selected companies. Therefore, the semi-structured interviews were changed into interviews conducted via email.[4]

1.3. Thesis Outline and main claims

The study is divided into seven chapters. The second chapter covers background information on blue and green hydrogen, the EU Hydrogen Strategy and important hydrogen groups and instruments. The third chapter reviews the scholarly literature and states this MA thesis' contribution to the academic field. In the fourth and fifth chapter, the Norwegian and Dutch hydrogen strategies are presented along with the newest hydrogen developments that happened in the countries during 2020 and the spring of 2021. It will also critically analyse to what extent the governments and the companies have tackled the hydrogen transition. This will assist with comparing the similarities and differences with the countries' approach and strategy on clean hydrogen and the companies' approach on how they are adapting to hydrogen production and usage. Chapter six is dedicated to the possible closer bilateral cooperation between the countries regarding hydrogen, the challenge that Norway and the Netherlands must get both blue and green hydrogen competitive and their roles in the implementation of a new European hydrogen market through the European Hydrogen Backbone (EHB). Here, the Norwegian and Dutch government roles and the challenge with the European debate about blue and green hydrogen investment are analysed. The final chapter summarizes the main findings and draws conclusions and discuss limitations of the thesis before providing some suggestions for further research.

---

[3] A notification letter was submitted to and approved by the NSD. Four semi-structured interviews were originally scheduled to gather additional information. Interviewees were critically selected based on their status as people from the relevant Ministries who worked on the national hydrogen strategies and/or experienced staff members from Equinor and Gasunie with knowledge on the firm's hydrogen projects. The plan was to conduct interviews via video call and transcribe the recorded audio. The challenge was that it was very time-consuming with contacting interviewees and for the notification form to be approved by the Norwegian Centre for Research Data (NSD).

[4] This was a major change to the plans and impacts on how many of the planned interviews I could conduct. One out of four participants answered the interview questions. Various attempts to reach Norwegian actors were unsuccessful and one of the Dutch actors did not have time after all. The resulting bias towards the Dutch side will be taken into consideration in the analysis and use of the interview results.

Based on the empirical evidence collected in this study, there are several claims and arguments that can be drawn. The thesis demonstrates that Norway and the Netherlands have both exclusive opportunities to play an important role in the EU hydrogen market. However, the question is to what extent the countries can play a significant role depends on the government actors and market actors in this study. There is a need for active participation on the EU level to get blue hydrogen competitive to kickstart the new market and introduce green hydrogen more effectively. It can be assumed that if the Norwegian government takes the opportunity to act as fast as the Dutch government has done in the hydrogen transition, their approach and developments can be used as an example for other EU Member States and EU institutions on policy-shaping for hydrogen. The thesis demonstrates that from an actor-centric approach, the Netherlands with Gasunie's and Dutch government's efforts will play an important role in the European hydrogen transition. On the other hand, the thesis demonstrates that Equinor has also shown great efforts for closer international hydrogen cooperation, but a successful hydrogen transition depends on the Norwegian government side showing a more active role at the EU level and show more interest in international bilateral cooperation.

2. Understanding Hydrogen as an energy form

This chapter explains what hydrogen as a form of energy is and why hydrogen has sparked international interest as a solution to the transition to a low emissions society. Furthermore, it provides information on the EU Hydrogen Strategy and different hydrogen groups and instruments crucial for hydrogen research and innovation. It is relevant to provide this information because it displays why Norway and the Netherlands created hydrogen strategies. The instruments assist the national governments and market actors with gaining additional funding and investments better chance for success in the hydrogen projects.

2.1. Hydrogen Definitions

Hydrogen is the lightest substance of the elements. It is multi-coloured and can be used as a fuel, a flexible energy carrier, and CO2 storage. It offers a clean and versatile energy path for the decarbonization transition. Today, hydrogen is produced industrially from natural gas steam reforming[5] without capturing CO_2. This process is called *grey hydrogen* and is a high-carbon hydrogen. Around 90 per cent of the hydrogen used in Europe is currently produced from grey hydrogen and is currently the cheapest way to produce hydrogen. To reach the climate goals set in the Paris Agreement and the European Green Deal, grey hydrogen needs be replaced by a cleaner low- and zero-carbon hydrogen type. The first version is low-carbon hydrogen, which is also called *blue hydrogen*. To create blue hydrogen, fossil fuels such as natural gas is combined with carbon emissions that are captured and stored underground. This is also known as CCS. In the CCS process, CO_2 is captured and transported to empty gas fields via pipelines or boats and stored indefinitely underground (IEA, 2019: van Cappellen and Rooijers, 2018, 13), where emissions can be reduced by up to 90-95 per cent (Riekeles & Seland, 2020, 8). Today, blue hydrogen is considered by some states an economically beneficial and feasible method to apply hydrogen in the industry (van Cappellen and Rooijers, 2018, 5).

The cleanest form is green hydrogen, produced from electricity and from renewable energy sources such as solar power, wind power and water electrolysis[6] and does not release any CO_2 (IEA, 2019). Blue hydrogen can be the base load of the hydrogen market and paves the way for large-scale integration of green hydrogen and could increase its chances of success (Riekeles & Seland, 2020, 8; van Cappellen and Rooijers, 2018, 43). Clean hydrogen can be used to power cars, heavy transport such as land-based trucks, and maritime transport such as passenger and cargo vessels (Gardarsdottir and Sundseth, 2021).

---

[5] Natural gas reforming is an advanced and mature production process that builds upon the existing natural gas pipeline delivery infrastructure. Retrieved 11.03.21 from: https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming

[6] Water Electrolysis is the process of splitting water molecules (H2O) into oxygen (O2) and hydrogen gas (H2) with electric current passing through the water. Retrieved 08.03.2021 from: https://nelhydrogen.com/glossary/water-electrolysis/

2.2. Hydrogen popularity and considerations

With only thirty years left to reach net zero emissions, it is essential that the large-scale development of clean hydrogen production starts now. The development of a clean hydrogen market requires synchronized development of all sections of the value chain, directed and eased by targeted government policy. Close cooperation between market actors and government bodies is essential (NortH2, 2020a). In the past, interest in hydrogen fluctuated but it almost vanished because clean hydrogen has been too expensive to be widely deployed. Moreover, market interest has been limited and political support has been either lukewarm or absent. What has changed now is the rise the political support across Europe and globally (IEA, 2019: Equinor, 2020a, 41).

Today, the rapidly declining prices of renewable energy, technological developments, and the necessity to drastically downgrade greenhouse gas (GHG) emissions offers new opportunities. Hydrogen is high on the political agenda and a key priority to achieve the European Green Deal and Europe's clean energy transition (European Commission, 2020a, 1). It has also risen in popularity because clean hydrogen allows for large-scale production and is well-fit for storing energy. It can be transported without energy loss and utilize existing infrastructure. This makes hydrogen a key element in the creation of climate-neutral energy value chains. Clean hydrogen has the capability to develop a globally traded product with large-scale imports and exports (Hydrogen Council, 2021, 20). Today, the market for hydrogen is small, but the EU, its Member States and companies are demonstrating a growing interest in hydrogen systems (OED and KLD, 2020, 46). Offensive climate plans in the EU and the world are putting hydrogen on the map and is considered as the only feasible route for at-scale decarbonization (Riekeles & Seland, 2020, 1: Hovland, 2020a: FCH 2 JU, 2019, 22).

Nonetheless, clean hydrogen requires significant investments to ensure developments in technology readiness, cost reduction and financial and political framework conditions (Hydrogen Council, 2021, 20: OED and KLD, 2020, 12). It will take time before it can be produced profitably and on a large scale (Hydrogen Council, 2021, 20). Future market interest is uncertain, but policy support has helped options that were commercially unattractive before to become attractive alternatives now. Increased political will, support and strategy remain a must for a successful hydrogen market to develop. Policy support is important for the actors in this study to promote their interests. Without regulatory financial backing, the volume growth required to lower costs will not happen (Equinor, 2020a, 41). Today, renewable and low-carbon hydrogen are not yet cost competitive compared to fossil-based hydrogen and other energy sources (European Commission, 2020b, 2). This is because the energy shortfalls made by producing hydrogen and the price of storing it make the use of clean hydrogen less beneficial and profitable (OED and KLD, 2020, 8).

Moreover, a policy focused on CO_2 reduction instead of fossil fuel usage reduction is needed for blue hydrogen to succeed. In a feasibility study made by Dutch CE Delft, they state that public support for CCS, fossil fuel usage and hydrogen transport are required for the implementation of blue hydrogen (van Cappellen and Rooijers, 2018, 5). An updated view on CCS is also necessary to meet the Paris agreement goals for blue hydrogen to succeed (Ibid, 15). In addition, green hydrogen only plays a small role in the energy system. To develop the hydrogen economy, completely new value chains will need to be built fast and industries must transform their production methods and business models (NortH2, 2020a). Hydrogen projects will require governmental support, which will therefore also require public support. This can be created by information sharing and dialogues sharing information and dialogues with surrounding inhabitants and municipalities (van Cappellen and Rooijers, 2018, 19). What is important to consider is the possible lock-in effect[7] that blue hydrogen might have in this transition. A lock-in of blue hydrogen for several years can temper implementation of green hydrogen, purely from an economic perspective. Too much optimism and dependence on CCS can however have serious consequences if it is at the expense of other climate measures such as green hydrogen. It is therefore essential that blue hydrogen is used to supplement other measures, not to replace them (Ibid, 43).

2.3. European Hydrogen Strategy

Europe's high aspirations for the transition to a decarbonized energy system are being realized. This energy transition will drastically change how the EU creates, distributes, stores, and utilises energy. Succeeding with the energy transition in the EU requires that clean hydrogen leads the way at a commercial scale. Without it, the EU will fail to reach its decarbonization objective (FCH 2 JU, 2019, 7). 2020 saw several hydrogen developments across Europe, where EU institutions and national governments had important dialogues and published essential documents. On 8 July 2020, "*the EU strategies for energy system integration and hydrogen*" was adopted to pave the way towards a fully decarbonised, more efficient, and unified energy sector. The EU Hydrogen Strategy sets an objective of 40 gigawatt (GW) of renewables in the EU by 2030. This would deliver major gains in terms of decarbonising electricity generation and deliver major benefits regarding jobs and growth (European Commission, 2020b, 2). "Sector linking" and "sector integration" have been two key considerations behind the design of the strategy (Banet, 2020). It will also contribute to the post COVID-19 recovery and positioning the EU as a leader in clean technologies, to the mutual benefit of its climate-neutrality and net zero emissions goals (European Commission, 2020b). Moreover, "The new hydrogen economy could become a growth machine" (Falnes, 2020) said EC Vice President Frans Timmermans who warned that the EU will take global leadership in the development of emission-free hydrogen (Ibid). This is something that government actors had to take into consideration when developing their hydrogen strategies and roadmaps and is why many countries have a strong focus on only green hydrogen. Since Norway is not a member of the EU, it is still affected by these developments and what is happening and considered important in the largest export market for Norway.

The Commission sees hydrogen as "a vital missing piece of the puzzle" and a solution to achieve decarbonisation in several sectors, those which are unable, difficult or expensive to decarbonize (Simon, 2020a: Riekeles & Seland, 2020, 6: Equinor, 2020a, 41: OED and KLD, 2020, 6). Sectoral examples include heavy industry such as steel and coal, aviation, long distance heavy transport, heating, and hydrogen can provide long-term energy storage at scale (IEA, 2019).

> "Boosting demand and supply of hydrogen is likely to require various forms of support, differentiated in line with the vision of this strategy to prioritise the deployment of renewable hydrogen. While in a transition phase, appropriate support will be needed for low

[7] A lock-in is defined as a process that is set out as the creator of a transition but eventually is not replaced but upheld as a valuable technology. A potential lock-in of blue is seen by some stakeholders as a treat while others perceive it as an economic optimization without preference for a technology (van Cappellen and Rooijers, 2018, 42).

carbon hydrogen, this should not lead to stranded assets" (European Commission, 2020a, 10).

This citation from the Commission's Hydrogen Strategy displays a possible challenge for the Norwegian government and Equinor is that the Commission and its EU Member States has made it clear that green hydrogen will be a priority in their hydrogen strategies (Falnes, 2020). Market actors therefore need to adapt accordingly to the new market demands. The Commission is afraid that blue hydrogen might lead to a carbon lock-in, which can cause policy implications for green hydrogen. There are some groups and instruments that can help Norway and the Netherlands in getting blue hydrogen on the same level of investments as green hydrogen, without one excluding the other.

2.4. EU Hydrogen Groups and Instruments

The EU's Hydrogen Strategy also became the starting point for the creation of the special group of the European Clean Hydrogen Alliance (ECHA) as part of the new industrial strategy for Europe. Several Norwegian and Dutch stakeholders are members of ECHA, including Equinor and Gasunie. ECHA brings together industry, national and local public authorities, civil society and aspires for determined deployment of hydrogen technologies by 2030. This creates demand in industry, mobility and other sectors, and also hydrogen transmission and distribution. The objective is to assist with investments in large hydrogen projects. ECHA will ease the creation of a robust pipeline of investments, create an investment agenda, and assist with the scaling up of the European hydrogen value chain. The alliance will play a vital role in easing and realizing the activities set in the European hydrogen strategy, where an industry plan envisages investments of €430 billion until 2030 (European Commission, 2021). The alliance will raise the impact by involving all stakeholders in the hydrogen value chain and by mobilising resources to create an investment agenda to accelerate the roll out of green and blue hydrogen production and usage, and to construct a concrete pipeline of projects. This builds the foundation for a sustainable and competitive industrial hydrogen ecosystem in the EU (ECHA, 2020). Norway and the Netherlands can use this alliance to drive their interest and can help easing Norwegian and Dutch hydrogen projects. It can do so by creating and support new investment agendas for Equinor and Gasunie. This requires that they actively participate in the group to promote their interests and can help with investment agenda for possible closer cooperation with the countries.

Following the Hydrogen Strategy in 2020, the European Council published its conclusions on the path to construct a hydrogen market for Europe. On 17 December, IPCEI was presented with respect to hydrogen, and involves 23 countries (Parola et.al, 2021). Important Projects of Common European Interest (IPCEI) is a European instrument and state aid tool that could approve public support for the rolling out of projects with great value to society. With IPCEI, governments can offer more support than within the usual frameworks (EZK, 2020a, 12). Norway also joined in 2020 and the IPCEI instrument may provide vital support for new, large-scale hydrogen projects (Ibid). The projects can be aided by IPCEI for up to 100 per cent of the funding gap based on a large set of eligible costs (Hydrogen for Climate Action). However, a challenge here is that hydrogen in IPCEIs needs to be green, because blue and grey hydrogen is not complying with the IPCEI rules (Philibert, 2020, 12). IPCEI is important instrument for Norway and the Netherlands and the companies generating blue and green hydrogen. It will be important to look at developments in this study to see how the two countries and the companies operate with this EU instrument (IEA, 2020).

3. Literature Review and Gaps

This chapter examines previous research relevant for the thesis and identifies the literature trends. The literature review explores two academic trends within the existing scholarship. The first trend explores research on the hydrogen transition in Europe. This is to give a perspective on what Norway and the Netherlands need to consider when creating a national hydrogen market. The second trend explores previous country specific research with a focus on the hydrogen transition in Norway and the Netherlands. It can be argued that limited research exists on the political aspect of the hydrogen transition, yet there is a large amount of literature on the technical standpoint. As a result, some of the literature used in this study include technical aspects that are not directly relevant for this thesis, but it also provides some important information on the political aspects. This study will use technical aspects only to explain some important technical words used in the government strategies and the companies hydrogen approach.

3.1. The Hydrogen and energy transition in Europe

The main characteristics of research studies in this strand is an exploration of the drivers and challenges for a developing a successful energy transition and a clean hydrogen market in the EU. These studies focus on comparing a broader number of countries in the EU or globally, rather than in-depth of a few nations. van de Graaf et.al. (2020) argues that international governance and investments to increase hydrogen value chains could reduce the risk of market fragmentation, carbon lock-in, and intensified geo-economic rivalry. He also argues that certification is crucial if hydrogen is to become carbon–neutral or feasibly cause negative CO_2 emissions. A few scholars (Noussan et.al., 2020: Mete and Reins, 2020: Kokulaika, 2020: Newborough and Cooley, 2020) have analysed the EU Hydrogen Strategy. Noussan et.al (2020) argue that the comparison of green and blue hydrogen pathways should be addressed by considering the potential contribution of both solutions to support a low-carbon energy system. Mete & Reins (2020) claim that without tariffs, cost-effective support schemes, demand creation, increased access to the grid or discounts, congestion management, guarantees of origins, hydrogen with CCS and renewable gases may not develop into a successful market. Kakoulakia et al. (2020) argue that most European regions have adequately high potential to be self-reliant using renewable energy. On the other hand, Newborough and Cooley (2020) claim that continuing the current focus on renewable electricity production alone is counterproductive, as it results in an increasing mismatch between electricity supply and demand.

There are some gaps in the examined literature. First and foremost, the existing literature does not analyse in-depth differing views and approaches between countries towards hydrogen. It also neglects the most recent information on developments in the political debate in the EU on whether to invest in blue and/or green hydrogen. Moreover, it does not compare the roles of public authorities and efforts to develop a successful hydrogen market. Furthermore, there is a lack of the most recent and significant developments made in some of the most prominent hydrogen projects, such as the CCS Northern Lights/Longship, Porthos and NortH2. Those are important to analyse, since it is possible that those developments can contribute to a better transition to hydrogen. Finally, it does not cover bilateral cooperation on hydrogen, nor does it cover an analysis and up-to date information on market developments in the European Hydrogen Backbone.

3.2. Hydrogen transition in Norway and the Netherlands

Regarding the strands on national hydrogen transitions, most of the literature on the hydrogen transition in Norway and the Netherlands focus on either one of the two countries. Consequently, a comparison of the countries' hydrogen transition is still missing. For example, Cheng (2020) and Moradi (2018) study the hydrogen transition Norway. Cheng (2020) reviews Norway's position in the hydrogen transition and concludes that, to maintain Norway's role in EU's energy system, it is critical to phase out blue hydrogen and pave the way for increasing demand of green hydrogen in the EU (Cheng, 2020, 73). This is however not the case with the Norwegian Hydrogen Strategy, as the Norwegian government believe it is more realistic for Norway to invest in blue hydrogen. Moradi (2018) concludes that Norway has the capacity to produce hydrogen energy, and investment in the hydrogen energy market will pay off (Moradi, 2018, 80). Contrary to Cheng, Moradi contends that CCS is helpful to make a more successful hydrogen market. Reviewing literature on the hydrogen transition in the Netherlands, Bakhuis (2020), Mulder (2020), and Janipour (2020) provide useful analysis and information. Bakhuis (2020) analyses and identifies key events within the Dutch hydrogen transition and how this has influenced and hindered the hydrogen transition in the Netherlands. He suggests international collaboration and a concrete focus on knowledge creation will be pivotal and key for the success of the hydrogen transition (Bakhuis, 2020). Mulder et.al (2019) study both blue and green scenarios for a hydrogen market in the Netherlands and concludes that with current market prices, blue hydrogen is way more favourable than green hydrogen. Finally, Janipour et.al. (2021) analyses CCS in the Netherlands and argues that CCS and blue hydrogen is seen as a steppingstone on the way to green hydrogen production.

A major gap in the literature reviewed above is that the absence of any comparative analysis of Norway and the Netherlands. Such a comparison is important because of their positions to produce and export blue and green hydrogen and help kickstarting a competitive hydrogen market. Although most of this literature is recent, it doesn't consider the newer developments of the national hydrogen strategies, which is crucial for facilitating the market. There is also a lack of governance theory with an actor-centric approach at the government and business level on hydrogen transition literature. In addition, the literature does not cover government and market actors' efforts to gain additional IPCEI funding and how their projects can impact EU policies. Linked to the lack of a Norwegian-Dutch comparative approach, none of these studies addresses the strategies, governments' and market actors' efforts at the EU level and roles of bilateral cooperation in the hydrogen transition. They also neglect developments in the international collaboration between Equinor and Gasunie. This is important to address because it analyses political developments and the path towards achieving the goals in the Paris Agreement. It is therefore important to study both the national governments but also the companies' position regarding finalizing the implementation of clean hydrogen, and their work on important hydrogen-projects. This study sets out to contribute to the academic literature on hydrogen transition in Norway, the Netherlands and in Europe by doing a comparative case study between Norway and the Netherlands. It aims to expand on the existing academic literature and unveil the countries' roles in the developments and implementation of a clean European hydrogen market.

4. The Hydrogen Transition in Norway

As one of the world's greatest energy exporters, Norway improves the energy security of supply for the many EU Member States. Also, as an enthusiast for climate change mitigation, Norway has been exceedingly dedicated to environmental sustainability and climate policy. Norway endures operating its significant energy resources and revenues sustainably and continues to be a reliable trading partner for the EU. However, the country must reflect on measures to prepare for a future with lower oil and gas profits, in which the EU will naturally desire to invest less (IEA, 2021a). This is where clean hydrogen comes in. Blue hydrogen is considered a "rescue" for the Norwegian Continental Shelf (NCS), where climate-hostile petroleum production can become a profitable climate solution for Norway (Riekeles & Seland, 2020, 1). Norway is perhaps one of the countries with the greatest potential for green and blue hydrogen production. This is because of its extensive renewable energy resources, large production of gas that can be decarbonized, and has the most comprehensive storage potential for CO2 in Europe. The hydrogen economy is plausible and from a Norwegian perspective. Norway also has leading industries and suppliers working with ships, storage of hydrogen, and users that can benefit and utilise hydrogen in the future (Riekeles & Seland, 2020, 22; Røkke, 2020).

This chapter will study the newest developments in the Norwegian hydrogen transition from 2020 to the spring of 2021. It covers the climate legislation of the Norwegian Climate Cure 2030 to show the climate goals and background for why Norway needs to create a hydrogen strategy. Although the Climate Cure does not delve deep into hydrogen, hydrogen will be a crucial component for many Norwegian sectors to reach the 50 per cent emission reduction by 2030 and nearly net-zero by 2050. The Norwegian hydrogen strategy displays that Norway has extraordinary circumstances to prepare for a successful new market for clean hydrogen and lead to blue hydrogen production. Nonetheless, it shows that the government took a cautious stance and was unsatisfactory to the Norwegian industry. The upcoming hydrogen roadmap planned to be published on 11 June 2021 will have to add a clearer course for market actors not covered in the strategy if Norway is to have a meaningful role in the European hydrogen market. In addition, the study looks at how Equinor is executing its transition to clean hydrogen production and the most prominent hydrogen project. Equinor, on the other hand, has shown a clear commitment to the hydrogen transition, and their interest in the international arena can provide Norway a stronger role at the EU level with their responsibility to be active abroad.

4.1. The Norwegian Climate Cure 2030

In January 2020, Norway submitted an enhanced climate target under the Paris Agreement in their newest climate legislation. A joint assignment was given to a trade group[8] to investigate measures and instruments to reduce 50 per cent of non-quota emissions by 2030 and net-zero by 2050. The 2030 goal can give an overall emission budget for Norway of approx. 194 million tonnes of CO2 equivalents for the period of 2021-2030 (Klimakur 2030, 2020, 11). In addition, there were 60 different measures investigated that show how emissions can be cut to meet the Paris Agreement's target.

[8] Trade group of the Norwegian Environment Agency, Statistics Norway, Enova, the Directorate of Roads, the Norwegian Coastal Administration, the Directorate of Agriculture, and the Norwegian Water Resources and Energy Directorate

Norway will meet the 2030 climate target in cooperation with the EU and be part of the EU climate framework in 2021-2030 (Ibid, 3). The Climate Cure was crucial for many Norwegian sectors, as it was necessary to update measures across the value chains for Norway to meet its climate targets. It was also important for Norway to update its climate policies accordingly to the EU's Green Deal goals. However, the place of hydrogen in this document was not discussed a lot but provided measures that the national government had to take into consideration when creating the hydrogen strategy. It also addressed the challenges that there is no competitive market yet for clean hydrogen to become valuable. The Climate Cure document produced by the trade group covered new measures regarding clean hydrogen. Some of the actions are that 50 per cent of new trucks are electric or hydrogen vehicles by 2030, and 75 per cent of new long-haul buses are electric or hydrogen vehicles by 2030. In the long term, hydrogen operation can become an option for the heaviest trucks, tractors, and long-distance buses (Ibid). The fact that the trade group was covered by several sectors displays how Norway intends to decrease CO2 emissions in several areas across society.

The Climate Cure (Klimakur 2030, 2020) mentioned that traditional fuel could be replaced by energy carriers such as hydrogen and electricity, ammonia, natural gas, or biofuels. However, the report states that hydrogen solutions are not yet available for large-scale implementation, where the barrier is technology readiness and thus cost too much. Nonetheless, a solution is to build down the barriers through various support schemes for technology development and implementation. Furthermore, the group also investigated CCS measures for Fortum Oslo Varme's waste incineration plant at Klemetsrud, the waste incineration plant at Heimdal in Trondheim BIR waste energy in Bergen. If these measures are implemented, they will reduce emissions by 4 million tonnes of CO2 equivalents in 2021-2030. They will together contribute to emission reductions of 0.8 million tonnes of CO2 equivalents a year. The measures are phased in relatively late and therefore have significant potential only after 2030. Regulatory changes may also contribute to an increased focus on CCS outside Norway and is a crucial solution to reach the Paris Agreement target (Klimakur 2030, 2020, 301).

Since the government does not see it profitable until after 2030, this is a lot later than other countries in Europe, which seeks to have several projects done in the 2020s. Furthermore, the Climate Cure does not delve deep into hydrogen solutions and technology, which is why there was a strong need for a strategy that focuses specifically on how Norway will tackle the hydrogen transition. Nonetheless, an increased focus on hydrogen-related research and technology development is crucial to reach the Climate Cure's 50 per cent goal of emissions reduction by 2030.

4.2. The Norwegian Hydrogen Strategy and upcoming developments

The government's national hydrogen strategy is recognised as a result of Norway's need to adapt to the changes in climate legislation in the EU. It is also vital to ensure internationally competitive business in a changing EU energy market. In 2019, the Norwegian industry, businesses, and organizations were invited by the government to share their input for the hydrogen strategy (OED and KLD, 2019). The Ministry of Petroleum and Energy (OED) and Ministry of Environment and Climate (KLD) collaborated on the strategy formulation and was published on 3 June 2020. The government regarded the strategy as a "contribution to the process of developing new low emission technologies and solutions" (OED and KLD, 2020, 5). It highlighted the potential of hydrogen from both a national and export market perspective, the importance of blue and green hydrogen, and the unique position that the Norwegian industry could take in a growing market (Gardarsdottir and Sundseth, 2021). Hydrogen presents exciting opportunities for Norway, both as an energy nation and a technology nation (OED and KLD, 2020, 5). Norway has excellent conditions for research, development, implementation, production, and use of new technology. It will also continue to be an attractive country for the future industry to invest in (Ibid, 39). Moreover, the government wants to focus on energy and petroleum research to advance long-term value creation and safeguard safe, cost-effective, and sustainable energy resources (Ibid, 44).

Something that differs from past strategies is that the government reveals its position and views on blue and green hydrogen, as different colours of hydrogen have not been discussed before. Hydrogen was discussed by the OED back in 2004[9], but has not been mentioned before 2020. Norway has years of experience with CCS technology and hydrogen, where the NCS and the North Sea could store CO2 underground and produce blue hydrogen at a commercial scale. Moreover, Norway also has large gas reserves and has excellent capacity to upsurge energy production from renewable energy. Several companies and technology communities are already creating tools and services to produce, distribute, store, and use hydrogen for several sectors (OED and KLD, 2020, 7). The government shows in the strategy that they want to focus on blue hydrogen mainly and stress the importance of reducing the costs of green hydrogen. Also, the government wishes to contribute to developing CCS technology. It has ambitions to build cost-effective solutions for full-scale CCS plants in Norway since this can create technology development from an international perspective (Ibid, 9). In large-scale production, the Norwegian government also argues that blue hydrogen with CCS will cost less than green hydrogen (Ibid, 47). This opinion might be because of Norway's particular advantage point in blue hydrogen and to keep natural gas infrastructure competitive in a low emission society (Damman et al., 2020, 33).

Although Norway has not shown any plans of creating a connected national hydrogen backbone with the existing natural gas pipeline network, the government wants to increase the quantity of pilot and demonstration projects (OED and KLD, 2020, 25). Several projects are already developing. For instance, TiZir Titanium and Iron AS is to replace coal with hydrogen in Tyssedal, and received funding amounting to NOK 127 million (Ibid, 40). Norled AS shipping company wants a hydrogen-electric ferry for the Hjelmeland – Nesvik – Skipavik route from 2021. There is also an EU-funded hydrogen project on one of the ferries on the Finnøy route outside Stavanger (Ibid, 33). ASKO started using the world's first hydrogen-powered trucks, which will deliver groceries to stores and will operate in Trondheim (Ibid, 35). This shows how the pilots and demonstration projects cover several sectors, and the projects mostly are at local levels but where also EU funding is involved. However, these were projects that were already in development. The strategy did not provide much on newer hydrogen projects and display how the projects rely and depend on governmental support schemes and additional EU funding to succeed.

[9] OED did not mention opinions on blue and green hydrogen in the NOU 2004:11. Read more here: https://www.regjeringen.no/no/dokumenter/NOU-2004-11/id149967/?ch=1

Regarding the EU context, the strategy displayed how crucial international collaboration is to establish a functioning European hydrogen market. The collaboration includes harmonisation of information-exchange of value chains experience and speeds up participation on a broad commercial breakthrough for hydrogen. It is also essential to design common standards and regulations on blue hydrogen at the EU level (OED and KLD, 2020, 50). Moreover, Norway is also in front internationally to develop technologies, demonstrations, and analysis of hydrogen systems and value chains for hydrogen (Ibid, 44). Most of the technology growth and upcoming demand for hydrogen solutions will come from the EU. The Norwegian authorities need to participate at the EU level to profit from what is happening internationally and to participate by providing knowledge and technology (Ibid, 11). The government must ease participation in relevant international fora that contribute to support and create sustainable technologies and markets for clean hydrogen (Ibid, 11). Here, the strategy mentions forums such as establishing the ECHA but did not delve deep into how active they intend to be here and what they want to focus on. Moreover, since there is a competition to speed up hydrogen among EU countries, and if Norway does not take more ambitious measures, they might fall behind and not be one of the frontrunners in the hydrogen transition at an early stage (Hovland, 2020b).

Significant research and development activity is required before large-scale clean hydrogen can be used to become profitable. Moreover, developing technology is expensive and risky, and its implementation relies heavily on public funding (OED and KLD, 2020, 41). The government argues that the technology must advance and mature first if clean hydrogen becomes a competitive alternative. The government considers that Norway's contribution must be through pilot and demonstration projects, and as the technology gradually matures, they can speed up its introduction and growth on the market (Ibid, 34).

However, the strategy seems to be missing a clear course and the government's approach on hoping the market will take the responsibility alone to decide if exporting to the EU will be profitable. This can lead to a lost opportunity for Norway (NTB, 2020a). But the strategy elaborates that large-scale blue hydrogen export from Norway is not currently seen as a realistic option. However, it can be possible if there is a demand and the willingness to pay for blue hydrogen are present (OED and KLD, 2020, 48). The fact that the government considers hydrogen export only realistic in the long term might impact the acceleration speed on the developments. With this, it seems like the Norwegian government is stepping cautiously and giving the market responsibility on the international level. This, however, can be a lost opportunity for Norway to be one of the frontrunners in Europe at an early phase. It also makes the new market uncertain for companies, and it might be an even more challenging transition. Although it might be risky to make enormous investments at an early phase, the government needs to dare and take a chance.

Although Norway is not an EU Member State, it is part of the European Economic Area (EEA). As a result, it needs a more coherent strategy compatible with the EU's new objectives in the European Green Deal and the green shift. Europe is Norway's most important market and will soon begin to phase out gas. Norwegian gas accounts for 25 per cent of the EU's total gas demand. Although Norwegian authorities and oil companies consider gas a climate-friendly bridge to renewables (Riekeles & Seland, 2020, 9), this is not the case in the EU. They want a phase-out of fossil fuels and natural gas. Last year we saw presentations of new legislation covering hydrogen and debates around them.

The strategy was met with disappointment from the industry, market actors, and the opposition parties. This is partly because it was without any money promises and no quantified targets for how much hydrogen is to be produced in Norway or how large the Norwegian hydrogen market can be (NTB, 2020b). Also, Minister of Petroleum and Energy Tina Bru expressed that "those who had expected large sums of money from the government will probably be disappointed. […] people must understand what a strategy is. It is not a grant document" (NTB, 2020a). Nonetheless, this contradicts several other ambitious national hydrogen strategies across Europe, which shows evident numbers of government funding in hydrogen projects. However, the government later in 2020 provided 13 hydrogen projects to receive NOK 150 million to develop hydrogen-based technology (Norsk Hydrogen Forum, 2020). Distributions of funds for hydrogen projects show that the government follows up on the hydrogen strategy and is determined to provide more funding for projects.

Moreover, there were several developments made in the hydrogen transition after the hydrogen strategy. One of the most important developments was that Norway joined the IPCEI for Hydrogen in December 2020. Norwegian participation in IPCEI allows Norwegian companies to participate in this European initiative (KLD, 2020). There were as many as 25 projects in Norwegian industry, transport, and hydrogen production that announced their interest in IPCEI. Nonetheless, not all types of projects qualify for IPCEI in Norway and may lead to Norwegian companies missing out on an important opportunity to participate in many European projects. Only five projects qualified to receive additional funding (Norsk Hydrogen Forum, 2021). This is a fundamental problem that the government must make sure that more projects qualify through interacting more with Hydrogen Groups at the EU level, such as ECHA.

Minister of Petroleum and Energy, Tina Bru, was assigned to create a new and ambitious hydrogen roadmap that is now under development, which will set a more concrete plan to achieve the hydrogen strategy (Gardarsdottir and Sundseth, 2021). The roadmap is planned to be presented in spring 2021 and will discuss Nordic cooperation, the use of public procurement, export opportunities, and the interaction between energy carriers and various types of infrastructure (Hirth, 2020a). Several stakeholders participated in the input and recommendations for the roadmap.

For instance, from the input letter from Equinor, there are several issues that the government must consider. The Norwegian authorities must work to ensure that blue hydrogen qualifies as an emission-free energy solution. The roadmap must facilitate further announcements of licenses for CCS (Equinor, 2020b, 1) and should be based on Norway's role as an exporter of energy and the need to decarbonize the Norwegian energy system. Furthermore, Equinor argues that the government must consider large-scale hydrogen for the Norwegian processing industry in the context of the export of hydrogen through a new pipeline to Europe. In the design of large-scale hydrogen infrastructure, it is primarily necessary to rely on blue hydrogen. However, it must simultaneously facilitate the phasing in green hydrogen produced when the conditions are favourable. It is crucial to demonstrate to Europe that Norway can produce hydrogen from natural gas with very low emissions (Ibid, 2).

With the strategy's lack of clear actions of what the government intends to participate internationally in and how large the market will be, the roadmap must thoroughly cover. In addition, Prime Minister Erna Solberg articulated an interest in a bigger hub function in Norway and use public proposals to speed up hydrogen transition (Hirth, 2020a). Also, the roadmap should include how Norway can have a hydrogen hub function. The roadmap should also consider creating a hub function in Norway or the NCS to attract more foreign investments in the country and serve as a connection point in the Norwegian market. IPCEI will be crucial for the roadmap, as stated by Bru:

> “Norwegian participation in the IPCEI for hydrogen will be an important piece in the government's roadmap for hydrogen. The link to the EU's hydrogen investment could also be important for Longship, which enables large-scale hydrogen production from Norwegian natural gas with carbon capture and storage” (KLD, 2020).

It is important that if Norway is to meet its 95 per cent emissions reductions in 2050, it needs to grab opportunities fast and dare to take chances, as it will most likely pay off significantly. With this, the government should aspire to show clearer and less cautious actions in the roadmap, and how large the hydrogen market can be for market actors.

4.3. Equinor’s approach to the hydrogen transition

Equinor is a Norwegian oil and gas-based energy company. Since the petroleum sector is a large part of the problem with climate change with a high carbon footprint, Equinor is interested in being part of the climate solution. Equinor is diversifying its energy resources to more renewable energy and energy carriers such as clean hydrogen with blue and green hydrogen. This way, Equinor can continue to use their fossil-based natural gas but with the CCS and blue hydrogen technology. Equinor is at risk of the natural declining demand for fossil-fuels resources from the EU because of the interest in climate-neutral solutions in the European Green Deal. As a market actor, it must consider the interest and demand for the developing new markets. If Equinor only focuses on fossil-based fuels, it risks falling behind the energy transition. Equinor is unique in making a difference in the global climate-neutral energy future and considers itself ready to seize this opportunity.

Equinor seeks early-stage opportunities for converting natural gas to clean hydrogen. It is still in the early days, but Equinor considers this as an exciting opportunity for natural gas in the future. They realize that “business as usual” is no longer an option, where society moves faster towards a net-zero future. There are five paths where Equinor can contribute to this net-zero society. One is to be committed to decreasing emissions from their oil and gas production. The second is to speed up their investments in renewable energy and develop a valuable renewable business. Third, Equinor intends to invest in new technology to create and build new low-carbon markets, value chains, and industries, such as clean hydrogen. Fourth is to invest in nature-based solutions and, lastly, Equinor wants to use its voice to support the goals of the Paris Agreement and policies supporting net-zero technologies(Equinor, 2021).

> “As we rebuild Europe’s economy after the pandemic, we do indeed need to build back better. We simply cannot afford not to. But to succeed, we must bring together every tool that is available: eliminating coal, accelerating renewables, investing in hydrogen. Companies need to work with governments. Blue hydrogen needs to work with green. Suppliers need to work with consumers. We all need to work together, and we need to start now” wrote Al Cook, Executive Vice President, Global Strategy & Business Development, and UK Country Manager for Equinor (Cook, 2020).

If they can achieve all these paths, the company is set to play a significant part in the Norwegian transition and be one of the frontrunners in a sector that is one of the largest carbon-intensive emitters. Cook’s citation (2020) above displays the short time the company has to accelerate the transition towards a net-zero society by 2050 and, therefore, act fast.

In Equinor's Climate Roadmap, they stress the importance that reaching the well below 2°C target will require substantial growth in electrification, renewables, and new value chains and business such as CCUS and hydrogen (Equinor, 2020c, 9). Equinor expects to meet this ambition primarily through a unique focus on renewables and changes in the scale and arrangement of the oil and gas portfolio. With this new approach, Equinor wishes to play a substantial part in Norway's decarbonization transition while also building a resilient, flexible business for a low-carbon future (Ibid, 11). Combined with Equinor's strong position in natural gas, Equinor is prepared for future growth in hydrogen. They can produce emission-free hydrogen that can be used in industrial settings, such as power generation and marine fuels and heating (Ibid, 33). This shows that Equinor is willing to follow along with adapting to stringent climate legislation. They realize the petroleum sector must join the growing market of low and zero-carbon hydrogen that is happening across Europe. They are making several preparations to transition the company with more diverse resources and focus on technology developments.

For Equinor, it is crucial to ensure a future market for natural gas, so they prioritize CCS with blue hydrogen to ensure they can still use natural gas infrastructure (Damman et al., 2020, 33). Equinor is, therefore, actively involved in several projects in the EU and focuses on the possibilities for converting coal or gas-fired powerplants into blue hydrogen production, with Equinor's role being mainly in gas reforming and CCS (Ibid, 27). Various options of supplying blue hydrogen are being evaluated, including producing hydrogen close to the end-user and transporting CO2 to a store in the North Sea (OED and KLD, 2020, 48).

Equinor also realizes that growing and expanding CCUS and blue hydrogen can only be recognized in close collaboration with governments and customers to establish a commercial framework and build new markets. They also need strategic partnerships with industrial players to ensure safe, reliable, and cost-effective implementation. Equinor considers itself a leader in CCUS and is working to build a European value chain, through, for example, waste management facilities and cement producers (Equinor, 2020c, 31). As one of the largest polluters in the economy, the Norwegian maritime sector is a crucial sector for Equinor to partner up with to develop low-carbon solutions. Clean hydrogen fuels can significantly reduce emissions in long-distance transport and cargo ships transported to Equinor's platforms in the North Sea. Equinor has a unique position here, being involved in the entire value chain as both a buyer of maritime services and a producer and seller of marine fuels. Equinor believes new technologies and innovation will provide future solutions to energy and climate challenges. This is why Equinor's research and development projects are essential, and they have the ambition to invest 25 per cent of research and development funds in low-carbon solutions, renewables, and energy efficiency in 2020 (Ibid, 33).

Compared to the Norwegian government, Equinor is more motivated to contribute early with its robust experience and knowledge of CCS technology. Nonetheless, the hydrogen projects Equinor participates in are still not full-scale production and will therefore not contribute much to reducing carbon intensity. Suppose the company is serious about the targets of cuts in carbon intensity while looking for fossil fuels. In that case, they will have to be motivated to invest on a larger scale (Riekeles & Seland, 2020, 11). Looking at Equinor's developments in 2020 and 2021, it seems they are more motivated and show a readiness to transition towards clean hydrogen usage. However, they still focus mainly on blue hydrogen, as they consider it crucial for kickstarting the hydrogen market. This might be because Equinor believes that the development of blue and green hydrogen will occur at different speeds and estimates that blue hydrogen will be able to be produced on a large scale and introduced faster than what green hydrogen can (Equinor, 2020b). Equinor must push for more international collaboration from the Norwegian side if Norway is to play a significant role in the hydrogen transition.

4.4. Longship CCS project

The most promising CCS project on the NCS is the Northern Lights project and is considered Europe's first CCS project on a commercial scale. It received the official name Longship when the Parliament approved the project's financing in December 2020 with a total investment plan of 25.1 billion NOK. With Longship, Norway has taken a great step forward in providing commercially profitable and safe storage of extensive volumes of CO2. In Norway, Equinor and its partners began construction in January 2021 on Northern Lights. The first operational phase is expected to start already in 2024. The project reflects the Norwegian government's aim to develop a full-scale CCS value chain in Norway. Equinor has the responsibility of transportation and permanent storage of CO_2 in a safe reservoir in the North Sea (Northern Lights, 2020: Equinor, 2020c, 31). Longship stands apart from most other CCS projects currently in operation in Norway and internationally. The project intends to contribute to learning and greater efficiency, provide experience and technology developments, and reduce costs and investment barriers for future CCS projects. In addition, it is a flexible transport and storage solution that can receive CO2 from many energy sources and is a commercial framework that provides incentives for further development of CCS in Europe (OED, 2020, 16).

> "In January, the Parliament endorsed Longship, which is the largest climate project in Norwegian industry ever. The project will cut emissions, while facilitating value creation and new jobs. The goal is that it also contributes to increased use of CO_2 capture and storage internationally. With the approval of the development plan for the storage part of the project, Northern Lights, a new milestone for Longship has passed", says Bru (OED, 2021).

Northern Lights is in charge of developing and running CO2 transport and storage components. It will be the first cross-border, open-source CO2 transport and storage infrastructure network. It also offers European third-party companies the opportunity to store their CO2 safely and permanently underground. It demonstrates the potential of this decarbonization approach to Europe and the world. Since governmental support is crucial for this project to succeed, it is positive that the Norwegian government has demonstrated robust and long-standing leadership in realizing full-scale CCS. With this, the project can provide realistic decarbonization opportunities for Norwegian and European industries (Northern Lights, 2020).

Figure 1: Northern Lights project map.

Source: https://www.dnv.com/expert-story/maritime-impact/Northern-Lights-shows-the-way-to-seaborne-CCS-solutions.html

Figure 1 above shows a map of the Northern Lights project, which is part of the full-scale Longship project. Longship includes capturing CO2 from industrial sources in the Oslo-fjord region (Norcem cement factory and Fortum Oslo Varme waste-to-energy plant) and shipping CO2 from these capture sites to an onshore facility terminal at Naturgassparken near Bergen. From there, the CO2 is transported by pipeline to an offshore storage location subsea in the North Sea for permanent storage (Northern Lights, 2020).

Moreover, the licensee has estimated total investments in the development plan to just under NOK 6 billion and the annual operating expenses of approximately NOK 370 million. The approved plan can store 1.5 million tonnes of CO2 annually and a planned working period of 25 years. The warehouse intends to hold more CO2 than will be captured through the Longship project. Northern Lights is in dialogue with several European players about the possible use of the warehouse. An essential objective of the Government's efforts is to lower the cost of CCS and that several projects follow Longship. "The outlook is good. Northern Lights has already entered into a letter of intent with eight companies, and I believe that more people want to connect to the warehouse now that the project has been approved," says Bru (OED, 2021). The agreement with Northern Lights was signed on 5 March 2021. To have revenue, the capture companies must efficiently capture CO2, and Northern Lights must sell another capacity to other customers (Ibid).

The Northern Lights project can both play a crucial part in the national hydrogen transition and where Equinor can play a role more in the international arena in the North Sea with capturing the CO2. Northern Lights is one of the very few projects that can develop extensive infrastructure for CCS in Europe (OED, 2020, 18). The EU has the

Connecting Europe Facility (CEF) funding scheme for trans-European infrastructure projects. The EU partly funds the project through CEF for studies regarding phase 2 of Northern Lights. The EU also provides funding for research projects through the EU Framework Programme for Research and Innovation Horizon 2020, and from 2021, its successor Horizon Europe (Ibid, 19).

However, the project faces technological barriers, market challenges, and regulatory barriers. Since CCS is not an established solution in a functioning market, and today's incentives are not sufficient to make projects profitable, the explored measures are subject to support. As there are technologically mature solutions for CCS in functioning markets, the need for help will decline. Future projects can be driven by general instruments – such as fees – if these are strong and accurate enough (Klimakur 2030, 2020, 302). Also, a challenge is that Fortum Oslo Varme did not receive full funding and received 3 billion NOK and got the responsibility to get additional funding from the EU (OED, 2020, 7). It is crucial that blue and green hydrogen projects can receive the necessary funding and qualify for IPCEI funding. If not, it can slow down and delay developments in the project and, therefore, international developments in CCS. The government must ensure that there are no more postponements to safeguard that blue hydrogen, in particular, can be as competitive and combined with green hydrogen in the new market.

5. The Hydrogen Transition in the Netherlands

As the study has in the previous chapter examined the Norwegian government and Equinor's approach to the hydrogen transition, we now move onwards to investigate the second country in this comparative study. With its open market and integrated supply chains, the Netherlands functions as an energy hub for global energy trade. Nevertheless, the stance for Europe's second-largest producer of natural gas is challenging due to diminishing production and unclear forecasts for alternative gas. Despite successful withdrawing of GHG emissions from economic growth, the Netherlands remains one of the most fossil fuel and CO2-intensive economies. In the Netherlands, strong research, demonstration, and development efforts are being made in blue and green hydrogen production and continued cost reduction of offshore wind and other renewable technologies. In addition, the Netherlands also encourages energy efficiency and innovation in energy-intensive industries along the whole supply chain and contributes to industrial competitiveness (IEA, 2021b).

This chapter provides empirical information on what the Dutch actors of this study, the government, and Gasunie, have done the last year on the path to playing a leading role in the clean hydrogen economy. It will do so by looking at the ambitious climate legislation of National Climate Agreement (NCA), which covers clearer and realistic measures on hydrogen compared to the Norwegian Climate Cure. The Dutch hydrogen strategy is covered in section 5.2. and the Dutch government has continued with determined goals for creating a functional market. In addition, the government is committed to playing a leading role in hydrogen developments in Northwest Europe. The chapter also examines Gasunie's approach to hydrogen and the most prominent hydrogen projects. The chapter demonstrates that the Dutch government and Gasunie have been early with developments compared to Norway and other European countries. The country has excellent preconditions for large-scale production for both blue and green hydrogen, with proactive actions made by both the Dutch government and Gasunie at the EU level.

5.1. The National Climate Agreement

In 2019, the Dutch government presented its climate legislation with well-defined and realistic measures on hydrogen goals with the National Climate Agreement (NCA). With the strict Dutch climate legislation, regarding 49 per cent less GHG by 2030 and approximately 100 per cent by 2050, requires drastic changes to the energy system (EZK, 2019, 179). Just as the Norwegian Climate Cure, it is a crucial plan for the Netherlands and for Dutch sectors to adapt correspondingly to EU climate legislation and to the Green Deal and Paris Agreement. In the NCA, the Dutch industry and government presented several measures and agreements on hydrogen with key concepts on upscaling, cost reduction, and innovation*.* The realization of the NCA measures would lead to at least 70 per cent of electricity production coming from renewables in 2030 (IEA, 2020). The NCA shows that both politicians and market actors recognise the importance of hydrogen for the Netherlands' future energy supply and the importance of integrating the energy systems for clean hydrogen (Gasunie, 2021c, 9). The Netherlands will take a leading position in this field if the country can take the lead in developments (EZK, 2019, 181).

The Netherlands has an extensive processing industry, geographical advantages for offshore wind energy in the North Sea, with a knowledge position and gas expertise and infrastructure. With this, the Netherlands has an excellent and unique starting position to produce and use hydrogen. It can build a clean-tech industry, providing lasting value creation to the Dutch economy, by tackling this transition in a proactive way (EZK, 2019, 179). The Netherlands also intends to start the green transition sooner than other countries. In terms of technological potential, this can be achieved, in part since the Netherlands has solid regional clusters with significant potential where CCS can be applied relatively easily (Ibid, 94). The Dutch industry is expected to shape the transition through process efficiency, energy savings, CCS, electrification, blue and green hydrogen, and speeding up circularity (Ibid, 89). The NCA states that clean hydrogen will provide the Netherlands with an opportunity to integrate large volumes of sustainable energy into the system in a cost-effective way (Ibid, 180).

The main objective is to focus on green hydrogen. However, NCA also claims that an outstanding contribution to developing a broader hydrogen system using blue hydrogen via CCS must be safeguarded without it obstructing the growth of other cost-effective alternative technologies such as green hydrogen (EZK, 2019, 181). It also argues that blue hydrogen will be needed for a proper infrastructure for hydrogen to grow, allowing green hydrogen to be implemented directly (Ibid, 98). To accelerate the development of green hydrogen production in the Netherlands, the national government will explore the options available for an offshore wind energy tender. Additional green energy capacity will be directly used to accelerate green hydrogen production and cost reduction. The ultimate goal of the overall Dutch hydrogen ambition is to meet the demand for clean hydrogen with green hydrogen only (Ibid, 98).

However, they also express that CCS may not obstruct the critical development of alternative climate-neutral technologies in the NCA. There were concerns regarding the lock-in of CCS and the extent to which CCS projects would dominate the available SDE+ budget. To ensure that CCS would not be at the cost of necessary technologies for the long-term transition, the funding of blue hydrogen was restricted. In the future, in combination with green hydrogen, CCS may contribute to realize negative emissions (EZK, 2019, 112). Furthermore, the Dutch hydrogen roadmap, "Waterstof voor de energietransitie" (Gigler et al., 2020), presents that the use of blue hydrogen should serve as a kickstart for hydrogen, which will eventually require a switch to green hydrogen (Gigler et al., 2020, 115). Moreover, if hydrogen is produced on a large scale, the realization of a hydrogen infrastructure is necessary to supply the various production and usage clusters with green and blue hydrogen (Ibid, 93).

As the Norwegian Climate Cure did not delve deep into clean hydrogen, this shows that the Dutch government was early out with clear targets for hydrogen production, investments and outlines realistic aims for the country to start the transition at an early phase. This is something that differs compared to the Norwegian government's more cautious approach. The Climate Cure only argued the challenges of the lack of a market for clean hydrogen and did not elaborate further on creating this market at an early stage. In addition, Norway does not consider the lock-in effect that CCS might cause, as the Dutch approach covers how CCS will not result in a carbon lock-in, not obstructing green hydrogen developments. Both countries, however, see the importance of harmonizing both blue and green hydrogen. As a result, the NCA is considered as the for how the energy sector must shift towards clean hydrogen and for the national hydrogen strategy to assist reaching the goals in the NCA.

5.2. The Dutch Hydrogen Strategy and upcoming developments

The Dutch Ministry of Economic Affairs and Climate Policy (EZK) received the responsibility of the Government's Hydrogen Strategy that was announced on March 30, 2020. Although the Dutch strategy is relatively short, with 14 pages, compared to Norway's covering over 50 pages, it has set clear, ambitious, and realistic new measures and define plans to accelerate large-scale production and use of clean hydrogen. The strategy shows that the Dutch commitment to clean hydrogen will create new green jobs, better air quality, and energy transition. It is the first step in a series of initiatives to realise the country's hydrogen ambitions, which were earlier announced in the NCA (EZK, 2020a, 1). The government needs to guide discussions with the industrial clusters regarding the precise locations of electrolysers. The second priority is contributing to the realisation of cost reduction of green hydrogen (Ibid, 6).

Regions across the country are currently developing hydrogen clusters. The Northern Netherlands region is recognised as the first Hydrogen Valley[10] in Europe (Ibid, 4). The government wishes to send a clear signal. It will do so by distinctly declaring the importance of green hydrogen, presenting an ambitious policy agenda, and taking necessary steps to realise the infrastructure. This is important for all Dutch and foreign companies who have announced projects in the country and will allow companies to make the transition towards the use of clean hydrogen (EZK, 2020a, 1). The Norwegian strategy does not, on the other hand, show a clear course for international companies wishing to join the hydrogen project in Norway. As green hydrogen is not seen as possible on a large-scale in Norway, we can see where Norway and the Netherlands differ the most. The Norwegian strategy focuses on blue hydrogen. The Netherlands strongly shows how green hydrogen is the most critical goal to upscale and will use CCS to ease and accelerate this process. The Dutch focus on green hydrogen enables the regions and industry clusters to initiate their energy strategies and the initial pilot and demonstration projects. The high degree of enthusiasm in the Netherlands is also recognised globally and is already boosting the Dutch business climate. Together, hydrogen imports will also take up a vital role as a global market begins to emerge (Ibid).

The scaling up of the production of green hydrogen is essential. There are limits to what can be achieved in the Netherlands in terms of technology, systemic costs, and space. They must introduce zero-carbon hydrogen soon to allow themselves to continue to integrate wind and solar energy into the energy supply (EZK, 2020a, 2). The Netherlands has great experience with the handling hydrogen safely and responsibly. The large existing industrial market must become more sustainable. This can also serve as a foundation for the transition to clean hydrogen. Production in the Netherlands can occur using large electrolysers or production with CCS in the coastal regions. The transport of hydrogen across the country and Europe through pipeline is considered the cheapest option (Ibid, 4).

[10] A Hydrogen Valley is a defined geographical area, city, region or industrial area where several hydrogen applications are combined together and integrated. Read more here: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/fch-03-1-2019

Gas is expected to still represent 30-50 per cent of final energy use in 2050, although in decarbonised form. It considers that the industry can handle hydrogen safely and responsibly, and its geographical location at the heart of Europe's industrial North. The strategy reveals the Netherlands' outsized ambitions for hydrogen. It can export the Dutch knowledge and skills and clearly outlines the appeal of the Netherlands for companies in the hydrogen value chain. The country's harbours, notably the Port of Rotterdam, are seen as a strategic advantage for the Netherlands to fulfil such a "hub function". The Netherlands can then import, transport, and export hydrogen between supply and demand hotspots. They also consider the existing pipeline network as a natural monopoly. The Dutch government also sees a role for regional network operators, saying it contemplates giving them the legal and regulatory "freedom to gain experience in transporting and distributing hydrogen" (Janssen, 2020).

The Strategy intends to support flexible energy systems by developing hydrogen production, transport, and storage to support the integration of variable renewables and seasonal energy storage. The Dutch government plans to drive commercial-scale blue hydrogen development in the near term by facilitating investment decisions and creating an adequate support scheme for scaling up electrolysis, CCUS, and supporting infrastructure (IEA, 2020). Several Dutch industries have ambitious targets to match the measures in the NCA. For example, for the transport sector, hydrogen is crucial to achieving zero emissions transport. The transport sector is vital for the Dutch economy with its Dutch ports for shipping, public transport for long-distance transportations and are a large part of the targets set out in the NCA[11]. The agricultural sector, being one of the most labour intensives globally, has acknowledged opportunities to produce hydrogen and its use. The government must meet the required prerequisites, while businesses and knowledge and research institutions such as CE Delft and TNO (the Netherlands Organisation for applied scientific research) must invest in scalable applications and innovation (EZK, 2020a, 1).

When there are well-defined rules for the market, and successful steps are taken in scaling up production, this will give a stronger picture for potential customers. It can also provide an outlook as to what degree hydrogen could be profitable to them to attain sustainability improvements. Initiatives aimed at kickstarting the market for clean hydrogen are already underway. The Dutch mobility and industry sectors are at the forefront of this endeavour. Preparations for the first pilot projects are currently ongoing in the built environment and electricity sector. Finally, there are also several unique opportunities in the agricultural sector. A wide range of policy instruments can support initiatives and stimulate and facilitate market development. An essential process is the implementation of the Renewable Energy Directive (RED II)[12]. The national government is committed to ensuring that the future effects of RED II are helpful and stimulating for hydrogen (EZK, 2020a, 9).

The strategy supports low-carbon gases and seeks to increase Dutch expertise in low-carbon gases as the country moves away from natural gas. The government is supporting the accelerated deployment of low-carbon gases through dedicated research

[11] The NCA targets aims to have 50 refueling stations, 15,000 vehicles and 3000 heavy duty vehicles by 2025 and 300,000 vehicles by 2030.

[12] As part of the Clean energy for all Europeans package, RED II aims at keeping the EU a global leader in renewables and, more broadly, helping the EU to meet its emissions reduction commitments under the Paris Agreement. Read more here: https://ec.europa.eu/energy/topics/renewable-energy/renewable-energy-directive/overview_en#the-recast-directive-2018-2001-eu

and demonstration funding with EUR 10 million in 2021 and from 2021. Blue hydrogen and projects are also qualified for SDE++ funding[13] (IEA, 2020). The government will present a new, temporary support scheme for operating costs related to the scaling up and cost reduction process for green hydrogen (EZK, 2020a, 7).

The government intends to facilitate the scaling-up process by using the existing Climate Budget funds accessible for temporary operating cost support as of 2021. They will distribute around € 35 million per year for this reason by rearranging part of the existing funds for hydrogen pilot projects within the DEI+[14]. The government aspires to achieve a substantial cost reduction for green hydrogen in the most cost-effective manner. Furthermore, projects will be able to rely on existing subsidy schemes. The possible extension of the state aid for IPCEI may be an option. The aim is to accelerate cost reductions so that a cost-effective roll-out of green hydrogen can occur sooner to ensure a reduction in CO2. To produce blue hydrogen, CCS will compete in the SDE++ through the CCS category (EZK, 2020a, 8). This shows the government's efforts to make it possible for blue hydrogen to compete. On the supply side, both green hydrogen and blue hydrogen will be necessary to achieve scale. Both production types are therefore urged to use existing subsidy schemes. Apart from scale-up, innovation is also an essential component for bringing down costs (Janssen, 2020). At present, the process surrounding the structure of IPCEI is still ongoing, with the Netherlands intensely involved (EZK, 2020a, 12).

Regardless of their great ambitions, the Dutch minister acknowledges that an international strategy is necessary to support its hydrogen strategy. This approach can realise bigger cost reductions, and the government therefore aspires for coordinated action at the EU level. It includes guarantees of origin and standardisation of definitions, for instance, when it comes to green and blue hydrogen (Janssen, 2020). The government realize that if hydrogen is to make a significant contribution to the energy transition and climate policy and legislation as soon as possible, the Dutch commitment to scaling up and rolling out must be part of a North-Western European approach (EZK, 2020a, 2). The government's systemic role envisaged for hydrogen must be parallel with the decisions and developments in countries and regions that are part of the Northwest European energy market. The policy agenda is set to provide an active international strategy (Ibid, 3). To remain at the forefront in Europe and thus appeal to the associated economic activity, the country must work on the technological frontier of the upscaling process. This will be donewith a range of instruments and a policy framework that can ease the ambitious plans (Ibid, 5). International Hydrogen Advisor for Gasunie, Noé van Hulst, stated that "the Netherlands has identified early that international cooperation is key to accelerate the scale-up and get the cost down of clean hydrogen. That is why it has been a priority to work towards creating an integrated European clean hydrogen market from the early days," as they already started with developments in fall 2018 (Interview, 2021).

The development of infrastructure will also consider the development of the North-Western European hydrogen market, which is relevant with a view of the Netherlands' potential hub function. The government studies the regulation of the future hydrogen

[13] Stimulation of sustainable energy production and climate transition (SDE++) https://english.rvo.nl/subsidies-programmes/sde

[14] Demonstration Energy and climate Innovation (DEI+) is a subsidy on pilot projects and demonstration projects https://www.topsectorenergie.nl/en/tki-wind-op-zee/grants-and-subsidy-program-offshore-wind/demonstration-energy-and-climate

market, including the operation of a future transport network, which involves examining the future role of Gasunie as a market actor. This review will focus on potential temporary positions to kickstart the hydrogen market and on more structural functions once this market matures in terms of transport, storage, and conversion. The principal approach will be to safeguard security of supply, keeping the social costs of the hydrogen supply chain low and give the market space to mature (EZK, 2020a, 5). To achieve a 50-60 per cent reduction of cost, a significant scaling up of green hydrogen production is required in an international context (Ibid, 7). Moreover, it is clear and positive that the strategy also provides an international method, as an international strategy has long been part of the Dutch approach. The principal focus is on Europe, with the Netherlands also actively taking part in global partnership initiatives. The Netherlands' European strategy consists of several paths. One is to have direct contact with the Commission at every possible level. The key goal is to clarify what the Netherlands considers as desirable EU hydrogen policy (Ibid, 12). These are common standards for sustainability, safety, quality, blending of hydrogen in gas grids to boost demand, flexible market regulations, and adequate innovation support.

The Netherlands is more precise than Norway with their own EU strategy on the hydrogen field, while Norway only mentions that cooperation will mostly happen in the EU. Furthermore, the Netherlands initiated the work on hydrogen in the Pentalateral Energy Forum[15], and has taken the initiative to develop common approaches to critical issues such as standards, market incentives, and market regulations ahead of the discussions in an EU context. “We [the Netherlands] like to think [the Forum] also influenced the later EU Hydrogen Strategy. This was accomplished through active dialogue and consultations with the European Commission, at all levels, to neighbouring countries, to industry, by presenting at symposia and conferences” (EZK, 2020a, 12: Interview, 2021). Moreover, dialogue and consultations with North Sea countries are crucial. As the significant potential of offshore wind energy will become a key source to produce green hydrogen beyond 2030, the government wishes to ensure that hydrogen is similarly given a prominent place on the agenda. Furthermore, the government wants more bilateral cooperation with neighbouring states. The Netherlands will be focusing on a solid role for green hydrogen in Europe’s competitive position regarding other parts of the world. The IPCEI instrument may provide vital support for new, large-scale hydrogen projects in the Netherlands. At present, the process surrounding the structure of IPCEI is still ongoing, with the Netherlands closely involved. In the second half of 2020, the Dutch government held an open call to identify which Dutch projects would be able to make a substantial contribution to a so-called quantum leap in a European context (EZK, 2020a, 12).

Trade policy will explicitly consider the opportunities to export Dutch hydrogen knowledge and skills. A policy aimed at drawing foreign investment will clearly showcase the attractiveness of the Netherlands as a location for companies in the hydrogen value chain to set up shop. The significant interest of foreign companies in hydrogen projects in the Netherlands highlights that their favourable starting position is already recognised. Bilateral foreign policy will create potential import relationships with countries that emerge as potential net exporters of clean hydrogen (Ibid, 13). This is something that

[15] The Pentalateral Energy Forum is the framework for regional cooperation in Central Western Europe (AT-BE-DE-FR-LU-NL-CH) towards improved electricity market integration and security of supply. Retrieved 08.04.21 from: https://www.benelux.int/nl/kernthemas/holder/energie/pentalateral-energy-forum/

the Norwegian government must consider also. It is a vital strength that the strategy provides a clear and active international hydrogen strategy. The Norwegian strategy does not give clear views on temporary roles by markets, nor straightforward international measures. There has not been much activity for foreign companies to start or join projects in Norway than the vast activity and investments in the Netherlands.

Nevertheless, there is still a lot to be done in infrastructure, cost reduction, certification, safety, etc. The government recognizes this, including the need for support from the government. The hydrogen vision is also realistic. To get a hydrogen market off the ground, the cabinet recognizes that government support is necessary. Current instruments such as SDE ++ do not provide enough for this. A new - temporary - instrument is needed for upscaling and cost reduction of green hydrogen". The market organization for hydrogen is the same as that for electricity and natural gas. The consequences of this concerning the role of the network operators and the protection of consumers remain insufficiently clear (VEMW, 2020). With this, both strategies cover the importance of both blue and green hydrogen, and both have excellent conditions for being frontrunners in both the national and international transition. Nevertheless, the Netherlands has taken a stronger stance to work proactively on the EU level and nationally, with a clear course, investments and measures. On the other hand, the Norwegian government has taken a more cautious stance but slowly and steadily take more active participation to keep up with other countries. Both countries have been committed to accelerating the developments nationally. However, there is a lack of foreign investments in Norwegian projects still, while international companies are eager to participate in the hydrogen transition in the Netherlands.

5.3. Gasunie's approach to hydrogen transition

Gasunie is a Dutch and European gas infrastructure company whose primary energy source experience is natural gas. To follow the demand for more renewable energy, just as Equinor, Gasunie is determined to work a lot in executing their transition towards hydrogen usage. Gasunie assumes that the role of natural gas will somewhat be replaced with clean hydrogen and are committed to taking a prominent part in the hydrogen transition in the Netherlands and Europe. The company sees many opportunities and a key role for itself in the energy transition, as it has decades worth of knowledge, expertise, and experience in natural gas transportation. They will also use part of their existing infrastructure for hydrogen (Gasunie, 2021c, 8). In Gasunie's annual report for 2020, it was presented that blue hydrogen can stimulate the development of the hydrogen market in the short term. However, for the somewhat longer term, in agreement with the Dutch government, green hydrogen is the ultimate goal (Ibid, 60). This differs from Equinor and the Norwegian government, who only elaborated and focused on how crucial blue hydrogen is in the transition to a clean hydrogen market.

Gasunie is ambitious in its energy transition plans. For the next ten years, they intend to invest billions in the energy transition, both on their own and with partners. Not all of the plans are confirmed, but Gasunie is part of the solution as a public open-access service provider (Gasunie, 2021c, 7). The energy transition will be the fastest, most effective, and cost-efficient it can be if Gasunie interconnects systems for electricity and gases in an intelligent way (Ibid, 9).

Last year, Gasunie worked a great deal with their transition towards hydrogen usage. Their most ambitious project with the future national hydrogen backbone transport network[16], the Hydrogen Valley project in the Northern Netherlands, and future hydrogen infrastructure financing (Gasunie, 2021c, 59). Gasunie strives to gradually build a large-scale and cost-effectively hydrogen transport and storage infrastructure with nationwide coverage. Most of this backbone will be made up of modified natural gas pipelines (Ibid, 8). This backbone can offer storage capacity in hydrogen salt caverns (Ibid, 21). All of the Netherlands' major industrial clusters can be connected to this national hydrogen backbone by 2027, which will also branch off to Dutch neighboring countries and be part of a European hydrogen Backbone (EHB) in 2030 (Ibid, 60). The earliest regions where hydrogen transport infrastructure can be constructed are the Rotterdam-Rijnmond region (2024) and the Northern Netherlands region (2025) (Ibid, 61).

This backbone has many advantages. First of all, both green and blue hydrogen can be fed into this backbone hydrogen infrastructure. Blue hydrogen can create the necessary large volumes of hydrogen to respond to the large demand centres. It would also initiate the fast conversion of the natural gas infrastructure into a hydrogen infrastructure (van Wijk and Chatzimarkakis, 2020, 15). Without a doubt, being at the heart of Northern European' industry clusters that this backbone will enable the Netherlands to play the leading European role in the global hydrogen market. Large companies can get rid of natural gas and reduce vast amounts of CO2 emissions, and will retain employment, export power, and innovation capacity for the Dutch economy (Gasunie, 2021a). Moreover, third parties have open access to this network, eventually connecting important Dutch hydrogen locations (EZK, 2020c, 16). In June 2020, the HyWay27 study started and was named for the year when the national backbone is supposed to be ready. The first results of this study will be available throughout 2021 to make investment decisions in time (Gasunie, 2021c, 71). Gasunie assists nationally with connecting hydrogen clusters through this transportation backbone, providing a fast integration of clean hydrogen for the Dutch transition and the company. In addition, it is easier for the Netherlands to build a national hydrogen backbone than Norway because of the geographical landscape.

Gasunie has explored various ways to make the backbone financially feasible. In 2020, the Dutch government revealed the National Growth Fund (Nationaal Groeifonds), offering knowledge development, research & development, and infrastructure innovation. The Dutch National Growth Fund could be a source of financing for developing the backbone (Gasunie, 2021c, 61). While Gasunie is in good financial health and has resources, their investment criteria mean that they still need grants and government support. Funds will also come from consortium partners and part from Gasunie itself, but European support funds are also becoming available (Ibid, 9). Moreover, the existing gas infrastructure can be relatively easily and quickly converted to accommodate hydrogen at a modest cost. In 2021, the backbone received investment funding of a total of € 1.5 billion (Gasunie, 2021a). Gasunie has also assisted with turning the Northern Netherlands into a Hydrogen Valley. The Northern Netherlands was the first region in Europe to be win an EU grant of € 20 million, and € 70 million was raised in public-private co-financing (Gasunie, 2021c, 61). Gasunie has also been active with placing several conversion, transport, and storage projects ahead that could potentially be part of IPCEI for hydrogen. Acquiring IPCEI status for the Dutch national hydrogen infrastructure is another opportunity to gain state aid (Ibid, 63). With this, Gasunie is determined to play

[16] By making maximum use of Gasunie's existing natural gas transport infrastructure, the national hydrogen backbone can have a capacity of approximately 10-15GW by 2030. 10GW is a quarter of the total annual energy usage by all industrial users in the Netherlands.

a significant role in the national hydrogen transition, the company's hydrogen transition, and the EU.

With this, it seems that both Equinor and Gasunie are determined to play a significant role in the national hydrogen transition and intend to provide their skills and knowledge to accelerate the technology developments and assist with maturing the market. Equinor is more determined to decarbonise natural gas with blue hydrogen to help at the early stage at the transition, as green hydrogen can not be scaled up fast enough, according to the Norwegian actors. On the other hand, Gasunie is committed to green hydrogen while also assisting with blue hydrogen being competitive with one of the most significant CCUS projects in Europe.

5.4. Porthos and the NortH$_2$ project

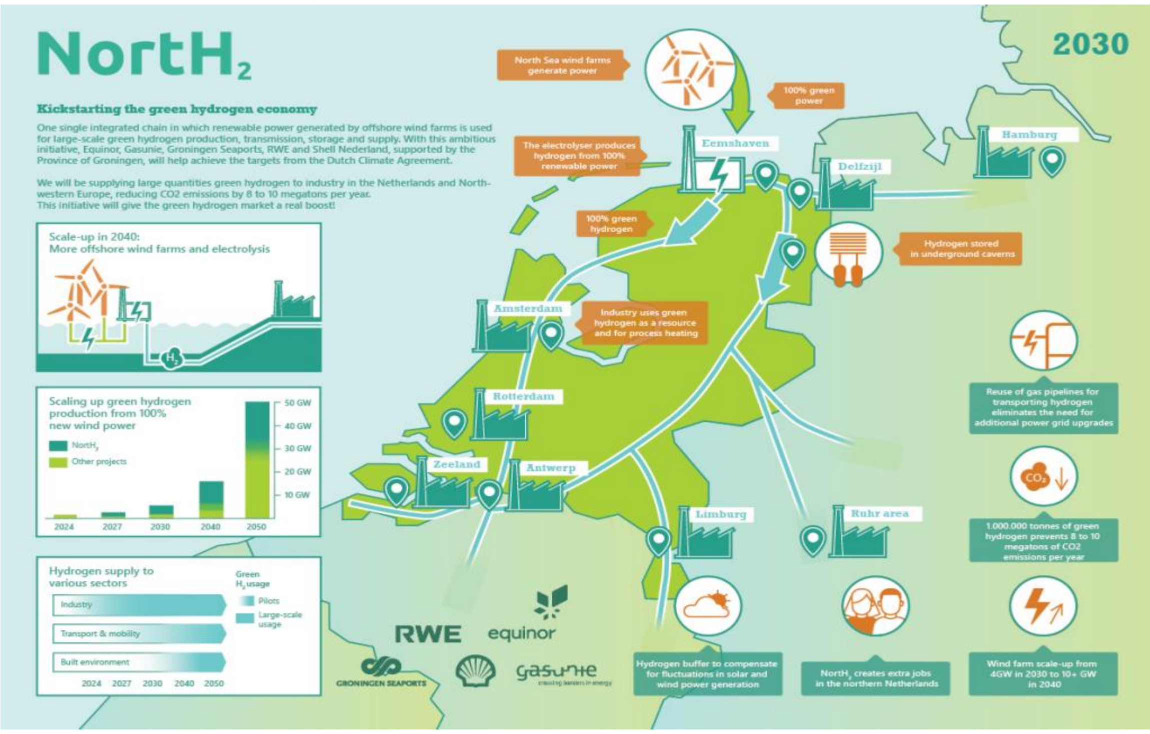
Gasunie is committed to facilitating and accelerating the energy transition by developing both CCUS/CCS and green hydrogen with partners from across the supply chain (Gasunie, 2021c, 68). The most promising and advanced blue hydrogen project is the Port of Rotterdam CO_2 Transport Hub and Offshore Storage (Porthos) project. The project aims to transport CO_2 from industry in the Port of Rotterdam and store this in empty gas fields underneath the North Sea, shown in Figure 2 below (Porthos, 2020). The project is a joint venture of Energie Beheer Nederland (EBN), Gasunie and the Port of Rotterdam Authority. With the construction of Porthos, blue hydrogen will contribute to reducing CO2 emissions very soon (EZK, 2020a, 10). The project is a joint project of Energie Beheer Nederland (EBN), Gasunie and the Port of Rotterdam Authority (EZK, 2020a, 10). Porthos will be storing around 2.5 Mt of CO2 per year and supplied by the Rotterdam locations of Air Liquide, Air Products, ExxonMobil, and Shell. This is equivalent to 10 per cent of the total emissions produced by Rotterdam's industrial sector. As such, the Porthos project will significantly contribute to the Netherlands's achievement of its climate targets (Porthos, 2020).

The project received funding from the Commission and was awarded £102 million Porthos project and wants to financially support the creation of Porthos, where parts will build a future-proof CO2 pipeline through the port area and will contribute to the overall project budget. The public funding comes from the budget of CEF. The European grant means that the Dutch state can scale down its funding support. Moreover, the Dutch government is prepared to cover the difference between the companies' total costs and savings via the SDE++ scheme. The Porthos system is constructed between 2022 and 2023 and taken into operation in 2024 (Gasunie, 2020b). The fact that the project will be in operation as early as 2024 will help kickstart the hydrogen market and economy, putting the Netherlands as one of the frontrunners in the transition. In addition, CCUS projects can also attract more investments as they focus more on utilizing the stored CO2 compared to only storing permanently, as is the case with Longship. Although Norway realises both blue and green hydrogen is essential, they argue that green will not be profitable until later when the market has matured. However, the Netherlands, on the other hand, shows that both blue and green at a commercial scale can be realistic and possible within 2030.

As the most significant green hydrogen project in Europe, NorthH2 will initially be produced in Eemshaven in the province of Groningen and eventually offshore too. The project will cut carbon emissions by over eight to ten megatons a year (NorthH2, 2020b). In early 2020, Gasunie, Groningen Seaports, and Shell Nederland united with the Groningen provincial authority to initiate the project (Gasunie, 2021c, 61). NorthH2 will enable large-scale generation, storage, and transport of green hydrogen for industries that are difficult to electrify or where electrification is not even an option. Gasunie's focus is on the storage and transport of green hydrogen through the hydrogen backbone to the Netherlands' key industrial hubs. A feasibility study covering the period through to 2030 displayed optimistic outcomes. The second phase of the feasibility study is underway, which will look at the period beyond 2030. In addition, the partners anticipate European and domestic energy decarbonisation grants is required during the early project stages. The partners wish to make their individual investment decisions in 2024 (Ibid, 62).

The goal for the project in 2030 is to produce 4GW of green hydrogen, meaning that NorthH2 contributes significantly to the achievement of the Dutch NCA objectives. Moreover, NorthH2 wants to reduce the production costs of green hydrogen through scaling up and integration. The goal for 2040 is to deploy offshore green hydrogen on a large scale to utilize the wind potential of more remote parts of the North Sea. With more than 10GW of green hydrogen, NorthH2 will significantly contribute to the green hydrogen market. By 2050, the goal is to be an essential commodity in a fully operative hydrogen market (NorthH2, 2020a). The North Sea is an excellent location for wind turbines and is considered one of the best spots for these in the world. Northern Netherlands is home to numerous knowledge centers and companies that know a lot about gas and hydrogen. Examples are centers of expertise and learning like the University of Groningen, Hanze University of Applied Sciences, EnTranCe, and Gasunie and NAM. With this concentration of knowledge, a hydrogen cluster can be developed, one where the highest quality, safety, and environmental standards will be observed (NorthH2, 2021). The project will complete a preliminary study in 2021 to start engineering in the second half of 2021 (Skarsgård, 2020).

Figure 2: NortH2 project map.



Source: https://www.equinor.com/en/news/20201207-hydrogen-project-north2.html

Figure 2 above shows the single integrated chain where renewable power produced by offshore wind farms in the North Sea is used for large-scale green hydrogen production in Eemshaven in Northern Netherlands. Here, 100 per cent green hydrogen is transferred across the national backbone and stored in underground salt caverns, where the industry can use the green hydrogen as a resource. This is considered a crucial component for the success of the national hydrogen backbone, the cost-reduction, and the large-scale production of green hydrogen. It can be regarded as one of the pioneers and innovators in green hydrogen developments in the Netherlands. It is also crucial for the Netherlands to reach the goals set in the NCA, giving the green hydrogen market the lift, it needs to succeed. As both the Norwegian government and Equinor have not yet focused much on specific green hydrogen projects, it is necessary to collaborate with green hydrogen projects abroad and to accelerate green hydrogen projects. It can also be argued then that the Netherlands is in a better place than Norway with the realization of such a large green hydrogen project that will benefit Northwest Europe immensely.

6. Bilateral Hydrogen Cooperation

The previous chapters have looked, with an actor-centric approach, at both case studies of the Norwegian and Dutch hydrogen transition developments for the last year. There are several similarities with the transitions in the countries and between the actors. They all see the importance of blue and green hydrogen and have excellent conditions to start production soon. Nevertheless, while Norway is hopeful for the success of mid-and long-term value chains of blue hydrogen, the Netherlands focuses on easing the developments and cost reductions on green hydrogen through blue hydrogen. The Netherlands has more international companies investing in hydrogen supply and usage than Norway.

This chapter examines more on the possibility of bilateral cooperation between the actors in this study. Closer collaboration between Norway and the Netherlands can ensure the chances of success in the hydrogen projects, as the countries share mutual interests in this field. The chapter compares the market actors and the governments' level of interaction and whether there is a need for more interaction. Section 6.2 presents the challenges at the EU level that might hinder investments in blue hydrogen projects that are crucial for Norway's and Netherlands' hydrogen transition. With this, the chapter analyses and compares the actors' efforts to impact EU policy to allow the countries to ensure their interest in clean hydrogen. The last section compares the Dutch and Norway's approach to the developing EHB that is crucial to find out the potential roles of the countries and consequently contributes to answering the main research question. It can be argued that the Norwegian and Dutch blue hydrogen projects can provide fast integration of a clean hydrogen market in the EU, and Equinor's and Gasunie's expertise and knowledge can cause more enthusiasm to invest in their projects. The success of these projects depends on the actors in this study taking offensive actions and involvement on the EU level and in hydrogen groups such as ECHA.

6.1. Closer Norwegian and Dutch cooperation

Norway and the Netherlands already cooperate on several hydrogen projects. However, most of them are in the Netherlands, and currently, there seems to be less cooperation on the NCS. Both strategies see that international cooperation, and in particular with North Sea countries is vital for the hydrogen projects and transition to succeed.

Looking first at the cooperation between Gasunie and Equinor, Equinor has shown interest in building close collaboration with the Netherlands on the hydrogen field. This may be to ensure their plan to make strategic partnerships, and with a lot happening in the Netherlands with both blue and green hydrogen, it would be a strategic move to strengthen the relationship. Gasunie and the Dutch government are optimistic about the bilateral hydrogen cooperation with Equinor. They are considered very good at all levels, both at the company level and with the Dutch government (Interview, 2021). Without a doubt, this cooperation is a strategic move for Equinor, with the Netherlands' unique starting position and location to the North Sea, which can contribute to the essential projects in Europe. Equinor joined the NortH2-project in 2020 along with German RWE as new partners. "NortH2 fits well with Equinor's experience and position as one of the world's leading offshore wind operators" (Skarsgård, 2020), said Pål Eitrheim, Executive Vice President for New Energy Solutions in Equinor. It will be a crucial part of creating competitiveness for renewable energy through increased value and market options.

Moreover, the CEO of Equinor, Anders Opedal, elaborated that "the project can be an important part in our efforts to build a competitive position in hydrogen, creating future value and industrial possibilities. We aim to be a net-zero energy company by 2050, and developing a profitable low carbon value chain for hydrogen will be an essential part of our transition to becoming a broad energy company […]" (Equinor, 2020e).

"The transition away from fossil energy will go faster than we thought after the corona crisis. A faster transition also means that there is more urgency for Norway to reduce our dependence on fossil energy exports," says Espen Barth Eide (Hovland, 2020c). The NorthH2 might be an opportunity to gain experience with offshore wind power that Norway can benefit significantly from with its large coast. This cooperation can assist with exchanging knowledge and expertise for both countries, which is a crucial step forward in realising the goals in the hydrogen strategies for closer cooperation with North Sea countries. With Equinor joining this large green hydrogen project, Equinor can gain a competitive position and contribute with green hydrogen instead of only focusing on blue hydrogen. This may be an opportunity for Norway to join more green hydrogen projects and possibly push for more green hydrogen in Norway. NortH2 also contributes to Equinor's transition to a broad energy company by positioning the company towards a significant green hydrogen value chain, balancing existing renewable and blue hydrogen projects.

In addition, Equinor has been a partner in the first phase of the H-vision project, which is an associated part of the ambitious Porthos project and focuses on blue hydrogen production. The hydrogen can be used in industrial processes to generate high temperatures or to produce electricity. Thus, H-vision can help develop Rotterdam as a hydrogen hub for import, production, marketing, and export (Equinor, 2020d). It also sets an example of how Norway needs to cooperate more with countries with mutual blue and green hydrogen interests. There have yet to be any discussions on the Netherlands joining the Longship project. Still, since both Longship and Porthos are considered the largest and most advanced blue hydrogen projects in Europe, they can benefit from each other's developments. This also relies on eagerness for closer cooperation for Gasunie to join the Longship project and the government's willingness to support with investment. The closer collaboration between the market actors on blue hydrogen can also cause a possible future where blue hydrogen can prosper and thrive in combination with green hydrogen.

Regarding hydrogen cooperation between the Norwegian and Dutch governments, there has been less interaction and dialogues than Equinor and Gasunie. Noé van Hulst expressed that when he was Hydrogen Envoy for the EZK, he visited the Norwegian government in 2019 but did not find great enthusiasm for closer bilateral cooperation on the hydrogen field. The Netherlands would be ready to work more closely, but there has not been much momentum yet on the Norwegian side. As a result, the challenge is for the Norwegian government to show more interest in closer cooperation, such as Equinor has done with Gasunie. The Netherlands has a "Memorandum of Understanding" on hydrogen with Germany, Portugal, Denmark, and others, but not with Norway (Interview, 2021).

The Norwegian uncertainty of cooperation might have been because of the lack of or low market interest for clean hydrogen in 2019. However, the Norwegian government has still shown a very cautious approach compared to the Netherlands and other ambitious countries. As previously mentioned, they are waiting for the market to mature instead of actively assisting in growing it. Norway's uncertainty can delay and make the transition more expensive at a later stage. Norway must therefore grab the opportunity to find more ways to cooperate with countries that allow both blue and green hydrogen. Naturally, the Netherlands would be a strategic country to collaborate more within the European hydrogen transition. Due to the rapid developments made across Europe, the Norwegian government has shown more interest in hydrogen transition than what they were in 2019. There might be more enthusiasm from the Norwegian government today on closer bilateral cooperation with the Netherlands. This will ensure that Norway can join the hydrogen transition at the heart of Northern Europe's industrial clusters. The government actors and market actors can benefit from each other's blue and green hydrogen projects. Nonetheless, their cooperation and developments can also impact other EU Member States' views and interests in blue and green hydrogen.

6.2. Norwegian and Dutch impact on the Green versus Blue hydrogen debate

If there is a market for both blue and green hydrogen in Europe, the Norwegian and Dutch actors must make significant efforts at the EU level to make both competitive for investments. There are several obstacles for Norway and the Netherlands regarding the blue and green hydrogen market. First, EU Member States disagree over which type of hydrogen to support. In Europe, there has been little interest in blue hydrogen as a climate solution (Riekeles & Seland, 2020, 22). There are two opposing teams among the EU Member States that are facing off each other. Those supporting green hydrogen and those favouring a broader "low-carbon" definition of blue hydrogen from natural gas and nuclear (Simon, 2020a). Those who are pro-blue hydrogen include Czechia, Finland, France, Hungary, the Netherlands, Poland, and Romania. The opposing group is Austria, Denmark, Ireland, Latvia, Luxembourg, Portugal, and Spain, which exclusively support green hydrogen (Simon, 2020b). Moreover, some countries perceive CCS as unsafe. For example, in Germany, land-based CCS is prohibited (Klimakur 2030, 2020, 306). The largest potential customers for hydrogen production for Norway and the Netherlands, such as Germany, mainly want to invest in green hydrogen. Therefore, it may be unlikely that they will make significant investments in the production of blue hydrogen (Riekeles & Seland, 2020, 15) from the Porthos and the Longship project.

In addition, five Member States (Denmark, Spain, Portugal, Austria, and Luxembourg) have sent a letter to the Commission stating that they are part of IPCEI Hydrogen on the condition that only projects related to green hydrogen will receive support. The five countries will also work for this view of green hydrogen in forthcoming legislative alterations, including the RED II (Stortinget, 2021). This can be a problem if there is going to be future IPCEI funding on blue hydrogen projects in Norway and the Netherlands. This is illustrated in the number of Norwegian hydrogen projects, with only 5 out of 25 projects that met the IPCEI criteria for additional funding. Furthermore, this green versus blue hydrogen debate also applies to the EU taxonomy for green investments. A list of economic activities is classified based on their contribution to EU sustainability-related policy objectives, which is vital for attracting capital and influencing political framework conditions. This taxonomy aims to encourage private investment in sustainable growth and contribute to a climate-neutral economy. In the EU taxonomy, the production of green hydrogen is explicitly mentioned as a low-carbon technology, but blue hydrogen is not (Philibert, 2020, 13: Riekeles & Seland, 2020, 17). Thus, the taxonomy favours green hydrogen and may make producers less interested in investing in production based on blue hydrogen (Riekeles & Seland, 2020, 18).

Some countries are also concerned about the lock-in effect of blue hydrogen and will stay longer than just short to mid-term. It is primarily Norway in Europe who have the most interest in the long-term production of blue hydrogen. This is something the Norwegian government and Equinor aspire to promote and, therefore must provide dialogues, information sharing, and risk analysis to get more support and influence views on blue hydrogen. It is crucial to enable blue hydrogen investments while reassuring renewable integration is not obstructed. This is something that the Dutch actors have already worked with (Riekeles & Seland, 2020, 15).

The EU will also rely on fossil-based hydrogen with CCS/CCUS as a stepping stone to grow the market in the early stages. Given the ambitious visions for hydrogen in Europe, there will still not be enough renewable energy to rely solely on production from surplus power. It will take time for green hydrogen to turn completely green; there should be room to produce blue hydrogen as a climate solution for many years. It is uncertain whether there will be enough renewable energy left over to produce large amounts of green hydrogen in the EU. If so, the EU will become dependent on imports to meet all the demand for hydrogen they want to create (Riekeles & Seland, 2020, 14).

Thus, the critical issue in hydrogen production should be the level of CO2 emissions, not the specific technology (Simon, 2021a). It will not be possible to reduce emissions sufficiently only by building more renewable energy. The most realistic way to reduce carbon intensity may be through blue hydrogen, as CCS allows companies to continue producing gas, while delivering a near emission-free product (Ibid, 11). Both blue and green hydrogen can become profitable, and betting on one technology does not have to exclude the other (Ibid, 12). As mentioned in the Dutch strategy (EZK, 2020a), a combination of both blue and green hydrogen can lead to negative emissions. If the debate shifts from a focus on renewables towards a focus on climate change mitigation, blue hydrogen has a comparable CO2 footprint compared to hydrogen from wind (van Cappellen and Rooijers, 2018, 41). Moreover, both green and blue hydrogen is needed if hydrogen is to have a chance to compete with other competitive energy sources (Andersen, 2020). Executive Vice President Sustainability for SINTEF Energy, Nils Røkke, stated the following:

> "It is not effective to choose between […] green and blue hydrogen. It's a distinction we have to erase. […] We must do both. We need to get a bigger market for hydrogen, then discussing whether we should have green or blue hydrogen is useless. If we do not put CO_2 storage in place, hydrogen from natural gas is not the future. […] To get large volumes of hydrogen quickly, natural gas with CCS can play a big role. […] There will be a large variation in the use of hydrogen in different countries, even within Europe. There are already very different energy infrastructures, and thus the needs will be different" (Andersen, 2020).

Moreover, regarding Equinor's position on the green versus blue debate, they realize that some places want to avoid blue hydrogen and only use green hydrogen production. However, this would make the challenge of decarbonizing Europe far more difficult, as blue hydrogen allows societies to act faster and prepare the infrastructure, which can then be used for green hydrogen. The cost of green hydrogen will decline over time, and when it is more affordable, the pipelines and consumers will be ready to integrate it fast

(Cook, 2020). In addition, Noé van Hulst addressed back in 2019 how CCS and CCUS will help scale up the clean hydrogen market. Colour does not matter at an early stage because the volume for large-scale production is still too small. He stated that "we (Netherlands) are pushing both green and blue hydrogen. […] If you start to calculate the volumes that are needed over the next ten years, you will not get there only with green hydrogen" (Simon, 2019).

Therefore, the Norwegian and Dutch actors must advocate for blue hydrogen to be classified as environmentally sustainable. This is will then attract necessary investments from the EU and impact the IPCEI criteria. Norwegian and Dutch authorities should signal clearly that they can offer large amounts of near emission-free hydrogen to the EU. They will have to ensure that blue hydrogen is paralleled with green hydrogen in EU strategies and the EU taxonomy for green investments and IPCEI, by active dialogue and information exchange. They should ensure that blue hydrogen has better conditions in Europe's hydrogen initiative and that blue hydrogen and green hydrogen are treated equally in all parts of the EU taxonomy for green investments. This way, it is the emissions that are essential to whether hydrogen is considered sustainable or not.

Furthermore, it is essential to safeguard energy security and create the basis for meeting economic needs where EU legislation is not discriminating against different types of hydrogen. Not every EU country has a surplus of renewable electricity in the system. To achieve emission reductions cost-effectively and to avoid making enduring disproportions between Member States, hydrogen should be produced from all possible low-emission sources in the beginning. The EU policy needs to consider these regional specificities when creating the support instruments for the energy transition (Simon, 2021a).

In addition, during the research of this thesis, activity has increased significantly from the Norwegian government. For instance, in March 2021, when Norwegian ministers met EU commissioners. They agreed to strengthen cooperation on how to promote the transition to a modern and competitive low-carbon economy. The Commission and the Norwegian government ministers discussed CSS technology and hydrogen as a potential long-term solution for decarbonizing the energy sector (UD, KED, OED & SD, 2021). This shows that the government moves in the right direction to promote its interests at the EU level. However, they should do this at a faster pace to keep up with the international developments. The EU has also shown more interest in the Longship project. Tina Bru has elaborated that "Closer European cooperation on CCS is vital for this climate technology is to become an international success. Therefore, we must make it clear to our European neighbours that the carbon storage facility on the Norwegian continental shelf also holds potential for the European industry. We have also noted that the EU is showing great interest in offshore wind power, especially floating wind farms, and following developments in Norway. These are good examples of the impact that the green transition in progress here in Norway is having outside our borders" (UD, KED, OED & SD, 2021). This can show the impact that hydrogen developments in Norway can have in the EU, and it displays that Norway intends to take more active involvement in ensuring blue hydrogen gets a place in the new market in Europe.

Norway and the Netherlands must play actively to ensure a criteria terminology for blue hydrogen. With this criteria terminology, it can help Norway and the Netherlands with future investments in blue hydrogen. It is, therefore, essential that strategic decisions are made today and that it is actively working at the government level to ensure that blue hydrogen has a place in Europe's energy mix (Riekeles & Seland, 2020, 2). It is uncertain to what extent the Netherlands and Norway have and can push for a more accepting EU position of the need and importance of blue hydrogen to meet the common national and European climate goals. Norway and the Netherlands can provide CCS technology exchange, where Longship and Porthos can serve as a way for other countries to store their CO2 and result in a push for a somewhat of a domino effect on other states that depend heavily on fossil fuels.

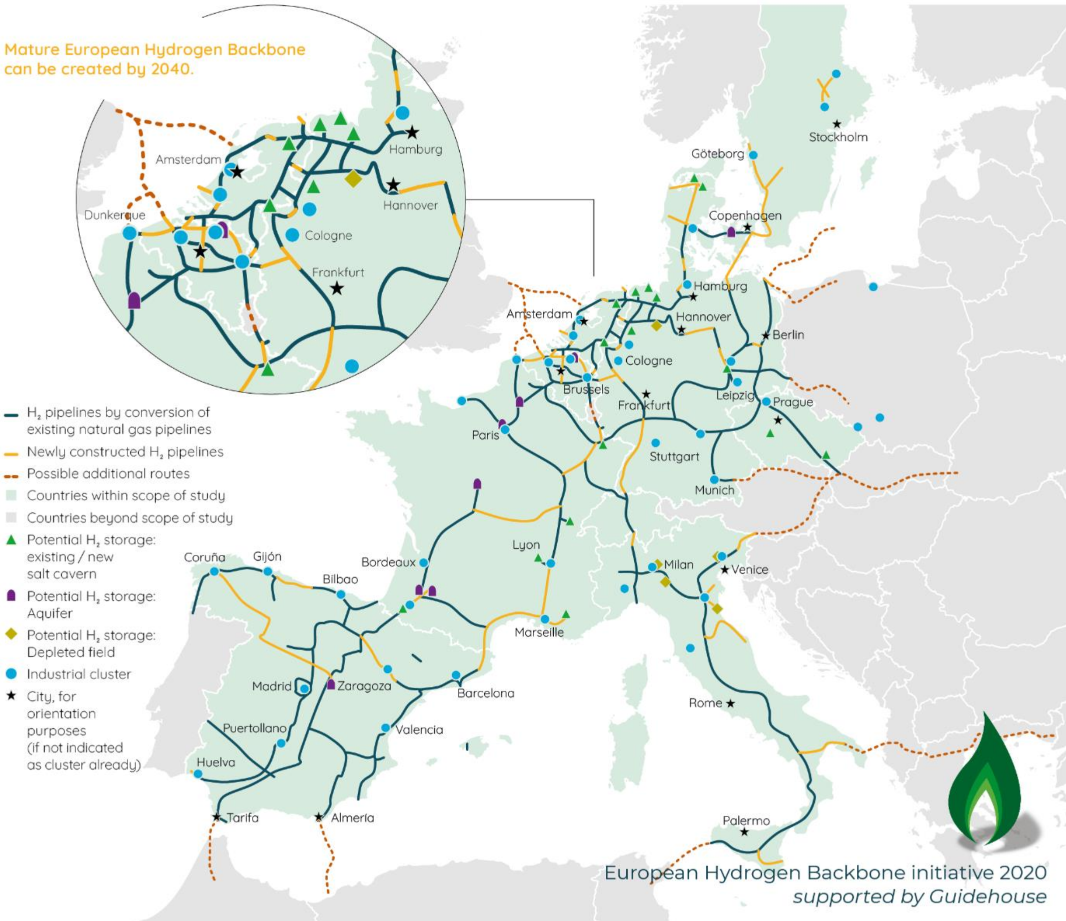
Porthos, along with Longship, can showcase both safe and profitable blue hydrogen for the other EU Member States. The success of CCS projects such as Longship and Porthos can also be a driver for more support for blue hydrogen technology in the other EU Member States. All projects that succeed in showing CCS can be done safely and cost-effectively can help impact and cause more comprehensive support. Longship and Porthos are therefore crucial since as they will be able to meet those criteria. If these projects become successful, they can, in the longer term, also helps in bringing along the other EU Member States. The countries may still have a strong preference for green hydrogen and only support green hydrogen projects in their own country. This should not block the other Member States from including blue hydrogen, and they still allow some EU funding to go to blue hydrogen projects (Interview, 2021). The Longship full-scale project can help reduce the green versus blue hydrogen barriers in other countries by showing that capture, transport, and storage can be safely carried out. It can perhaps even trigger CCS/CCUS projects in Europe and serve as an additional positive effect of future projects. With this, the success of the hydrogen developments in the countries can make it easier for the other Member States to utilize blue and green hydrogen if those against blue hydrogen allow investments to go to blue hydrogen.

6.3. Norwegian and Dutch roles in the European Hydrogen Backbone

As mentioned in Gasunie's approach in section 5.3., Gasunie is making a national hydrogen backbone that will ultimately connect to a European Hydrogen Backbone that will be the largest cross-border and creates a European hydrogen market. Gasunie, along with several other European gas infrastructure companies, is part of the Gas for Climate group and has worked actively to complete the EHB (Interview, 2021). This will allow trade of green and blue hydrogen across the EU. The EHB report was published in July 2020 and displayed a European hydrogen market and infrastructure required for Europe to achieve the Green Deal and Paris Agreement objectives (Wang et al., 2020, iii). Moreover, the cost of an EHB can be very modest compared to the forecasted scope of the hydrogen markets. The companies in the Gas for Climate group are ready to lead and invest in hydrogen transport to facilitate a scale-up of hydrogen. Thereby, they will be part of the solution to create a European hydrogen market (Ibid, iv).

It proves that a European hydrogen market can be achieved based on repurposing existing gas infrastructure, conjoined with targeted investments in new dedicated hydrogen pipelines. The goal is an intersected, dedicated hydrogen transport infrastructure spreading across Europe by 2040. The report explains that before cheap green hydrogen has sufficiently scaled up, blue hydrogen will be helpful to quicken decarbonization. There were ten European countries for the EHB report in 2020 (Germany, France, Italy, Spain, the Netherlands, Belgium, Czech Republic, Denmark, Sweden, and Switzerland). In this report, they state that a network will gradually emerge from the mid-2020s and onwards, with a 6,800 km pipeline network by 2030. The goal is to connect hydrogen valleys with the Northern Netherlands, the first valley in Europe. The backbone will then grow by 2035 and 2040, with almost 23,000 km (Ibid, iii). Figure 3 below shows the map of the EHB that can be realized in 2040. This map shows that in northwest Europe, blue lines on the map offer hydrogen pipelines by converting existing natural gas pipelines.

Figure 3: European Hydrogen Backbone map 1.



Source: https://gasforclimate2050.eu/ehb/

Domestic hydrogen production can also be blue hydrogen produced at locations with good transport links to carbon storage locations (Wang et al., 2020, 1). In this case, the Netherlands has excellent transport links and storage potential through Porthos. An interconnected cluster will likely emerge in the North of the continent, including parts of Belgium, The Netherlands, and North-West Germany. A dedicated backbone here can enhance the benefits of various hydrogen initiatives, including collected electrolysis-plus-wind farms and blue hydrogen plants on the supply-side and fuelling station deployments and industrial sites on the demand-side (Ibid, 5). With the Netherlands being in the middle of Belgium and Germany, it can set the connection point in the Northwest European backbone. Northern Netherlands will be the first valley and naturally become one of the quickest to adapt to the transition in Europe. They will have to take great advantage of their unique starting position. With their developments in 2020 and 2021, they are actively using their position to be one of the frontrunners and leading in blue hydrogen technology among the EU Member States.

Without a doubt, through the ambitious and realistic measures set in the national hydrogen strategy and climate legislation with the NCA, the Netherlands and Gasunie will play an essential role in the new and emerging market for clean hydrogen trade across Northern Europe. With the government and Gasunie's active participation, they can share and promote the value of both blue and green hydrogen. Also, they can participate to some extent to influence views through Porthos. With the crucial role of a hydrogen hub in Northern Netherlands and possibly Rotterdam, and its beneficial location close to Germany, Belgium, Denmark, France, UK, and Norway in terms of the North Sea, the Netherlands has a very central role to play in the EHB in Northern Europe region. First of all, not only is it attractive to continue trade business with the UK after Brexit, but its strategy also is open for other international companies to get access to the backbone network.

The Netherlands plays a vital role in the European hydrogen market because of several facts. They have great offshore wind potential and can be an import hub for importing clean hydrogen to Europe, including cross-border to Germany, Belgium and France. In addition, the Netherlands has a considerable capacity available for this, and sooner than any other countries, with possibly 10-15 GW in 2030 (Interview, 2021). NortH2 is a crucial big flagship project that can deliver an early scale-up of 4 GW in 2030 and provide 10 per cent of the EU's 40 GW target in 2030 (Ibid). The Netherlands can secure a competitive position in Europe for hydrogen and innovations relating to hydrogen. The Northern part of the country can have a leading position as the European Hydrogen Valley (NortH2, 2021).

Gasunie is confident that the government, market, and society will enable them to go ahead with a significant part of their intended investments. The more they succeed in doing that, the greater the opportunities to hit Dutch and European climate targets on time and in a cost-effective way. This will also give greater economic benefits to their European region as a result from the energy transition (Gasunie, 2021c, 9).

The backbone also allows access by all interested market parties under equal terms and conditions (Wang et al., 2020, iv). In addition to EU domestic production, there is a promising outlook of largescale imports of hydrogen from countries outside the EU (Ibid, 1). As shown in the report from 2020, Norway and Equinor are not yet part of the EHB, but EHB is open for other European countries is an exciting market opportunity for Norway. Also, although countries such as Denmark, which is closer to Norway, would be less interested in importing Norwegian blue hydrogen for now. However, whether it is cheaper to transport the hydrogen from Norway to Europe or transport gas to Europe and CO_2 back is still uncertain. Norway will depend on the preference of other countries to ease blue hydrogen production (Riekeles & Seland, 2020, 19). In this case, the Netherlands will help facilitate blue hydrogen with its Porthos project compared to others. The Netherlands is also most likely to be ready and eager to cooperate with blue hydrogen and create a new dedicated hydrogen pipeline. The possibility that Norwegian natural gas could play an essential role in a European hydrogen strategy is realistic.

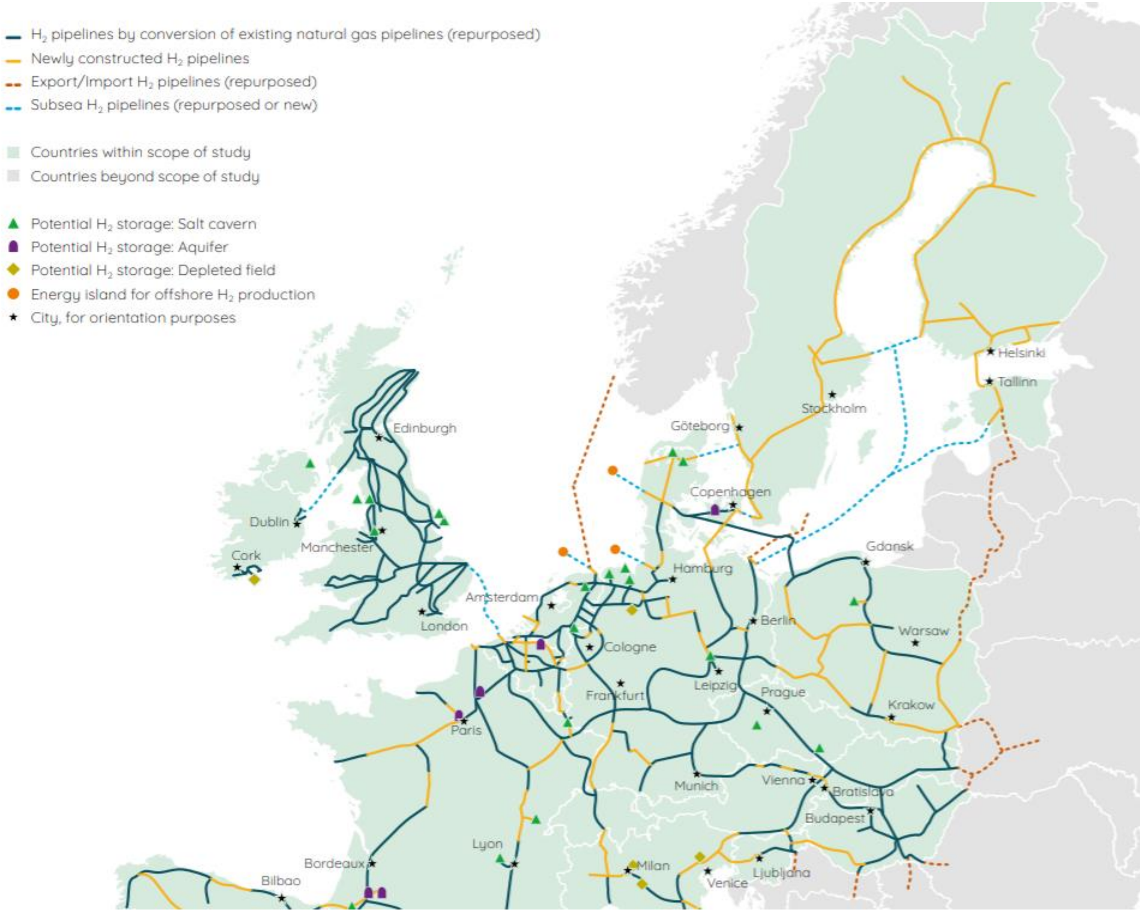
Norway can help as a technology provider for the European hydrogen market (Hirth, 2020b). In addition, gas from the NCS can cover a significant proportion of the EU's hydrogen needs and a scale that is needed (Equinor, 2020b, 1).

Considering possible closer bilateral cooperation with Norway and the Netherlands, Equinor presented in 2021 that it is considering creating a new dedicated hydrogen pipeline exporting blue hydrogen from Norway to Europe. The feasibility study is in the hands of the Vice President for Low Carbon Solutions for Equinor, Steinar Eikaas. He elaborates that if Norway is going to build a dedicated hydrogen pipeline accounting for 10 per cent of what Norway export in natural gas today, it will be an excellent project for Equinor, where they are prepared to invest billions of NOK. "A key question is whether Norway has enough gas left on the shelf to be able to defend the development. A hydrogen plant ready in 2030 must be supplied with sufficient amounts of natural gas 30 years in the future. […] If we put it in Europe, we can use any gas. We have to be confident that we have enough gas", Eikaas stated (NTB, 2021). It is, however, an uncertain project as this hydrogen production will generate four times more CO2 than the Longship project can handle. Nonetheless, there are still no active public discussions in Norway on joining this backbone or creating dedicated hydrogen pipelines from Norway to Europe. There should be an active discussion and public debate, but so far, nothing is happening (Interview, 2021).

Equinor also elaborated in their input letter (Equinor, 2020b) how important it can be for the roadmap to cover the possible establishment of new dedicated pipelines from Norway to the EU. This shows the dedication and commitment for Equinor to play a significant role for both Norway and the EU to maintain Norway's role as an energy exporter in a low emission continent. This is, however, something that Equinor must convince the public and the government to get through. If Equinor is ready to invest, this can be a viable option for Norway to play any role in the EHB. Equinor, along with the Norwegian government, must dare to take a chance at this development. "The easiest and cheapest will be to put hydrogen production on the continent and then bring the CO2 home for storage," admits Eikaas. And until now, these projects for hydrogen production in other European countries Equinor has been working on (NTB, 2021). Where this pipeline might go still uncertain, but there are many advantages for this pipeline to go from Norway to the Netherlands[17]. Groningen in Northern Netherlands is an attractive hot spot as a hydrogen hub and the first hydrogen valley in Europe. The Netherlands would also allow the flow of both blue and green hydrogen.

[17] In a Tekna webinar on "Norway as an energy nation: Hydrogen" (11.02.21), Vice President of Low Carbon Solutions at Equinor, Steinar Eikaas, presented that Equinor is considering a new hydrogen pipeline from Norway to Groningen in Northern Netherlands. See the webinar here: https://www.tekna.no/fag-og-nettverk/energi/energibloggen/norge-som-energinasjon-hydrogen/

Figure 4: European Hydrogen Backbone project map 2.



Source: https://gasforclimate2050.eu/publications/

In April 2021, the Gas for Climate group expanded the EHB map with the countries covered by the new members joining the group (Jens et al., 2021). Figure 4 is the updated map from the European Hydrogen Backbone report from 2021. It displays the possible extension of EHB with a repurposed export and import dedicated hydrogen pipeline that Equinor is considering investing in. In this map, the new pipeline might go from the Stavanger region, where Equinor has its headquarters, to the Northern Netherlands. This map shows what might happen in developments in the upcoming years. However, it depends on to what extent and how much Norway can play a role in the European hydrogen market. Therefore, there is a need for more dialogue and discussion with the public and between Equinor and the Norwegian government. They must be open to bilateral cooperation with like-minded countries that share mutual interests and values for blue and green hydrogen. In addition, this can be an opportunity to make use of Longship for transporting both through the new dedicated hydrogen pipeline and by ships. The North Sea can then be even more actively used for transporting Norwegian to the Northern Netherlands, which will consequently give direct access to the national backbone and the first hub in Europe. Therefore, Norway can join the kickstarting of the European hydrogen market.

Norway and the Netherlands can play a role, but they must work actively to drive for more eagerness to allow investments. Blue hydrogen will help kickstart the hydrogen economy and will be available soon with almost zero emissions. Their hydrogen projects can assist with kickstarting the European clean hydrogen market because they will be operational at a very early stage and in particular the Netherlands with NorthH2 at a commercial scale and a functioning national backbone ready before 2030. Time is scarce, and countries are positioning themselves at a fast pace to participate in reaching the goals in the Green Deal and the Paris Agreement. It is therefore crucial that Norway must not fall behind. The EU will become less dependent on third countries by focusing on clean hydrogen transition. Norway must grab this opportunity and will be less dependent on fossil fuels. The green transition is expensive, and uncertainty might hinder the developments and actors investing less in projects. Blue hydrogen production in Norway can also help meet future energy needs to produce clean hydrogen in Europe.

If Norwegian actors invest in the production of blue hydrogen, uncertainty for potential consumers of hydrogen may be less. If blue hydrogen is to be invested, it is urgent. Equinor should take the opportunity to take strategic steps by attempting to enter into long-term agreements with industrial hydrogen customers in Europe. Norway also has a head start with CCS in terms of legislation and has excellent conditions for establishing an industry associated with the production of blue hydrogen (Riekeles & Seland, 2020, 14). If Norway is to persist as a world-leading energy and technology nation, maintaining and building upon this close cooperation the EU throughout the years to come is fundamental. While building a national hydrogen market and infrastructure is the first phase, planning for the production and infrastructure for sizable export to the EU should not be far behind. That is one reason the Longship CSS project is so important. The ability to capture and store CO2 at scale is an essential enabler to produce blue hydrogen in Norway, which can be used to fast-track the development of an export infrastructure. Companies and societies need motivations to restructure their whole infrastructure to use clean hydrogen (Gardarsdottir and Sundseth, 2021).

Prime Minister Erna Solberg has elaborated that there must be a wave of CCS projects in other European countries for the Northern Lights to succeed. Norway hopes to become a European hub for offshore CCS. "Initially, I hope to see more capture projects around the North Sea and in Northern Europe, using the infrastructure we are now establishing," Solberg said. "After that, I hope there will be more CCS projects both in the rest of Europe and globally so that we drive down costs and improve performance. […]. It is still an immature mitigation solution in many ways. […] Our main focus is now on short-term emission reduction, but we believe that CCUS will play a larger role towards 2050" (Hodgson, 2020). It is not long until 2050, and the government's approach to sit and wait for the market to mature only creates uncertainty on investments.

Green shipping is one of the areas where the EU looks to Norway and where the Norwegian government has created a framework that will give Norwegian actors a strong position. The launch of the Norwegian Longship project for CCS has stirred widespread interest in Europe. Norway's goal is to provide a European infrastructure for CCS. Offshore wind power is another area that stands out as a good candidate for future cooperation with the EU and where Norwegian companies can provide a wide range of expertise (UD, KED, OED & SD, 2021). Norway can continue to play an essential role as an energy partner if one plays the cards correctly and thinks long-term regarding the EHB and the European hydrogen market. But competition is sharpened, and Norway must work fast to keep up and not fall behind. Close regional cooperation with neighbouring countries will again be strategically important in this regard. The North Sea is already used as a unique laboratory and hub for a new vision. Norway has all the prerequisites to be part of this vision (Banet, 2020).

If Norwegian hydrogen production is to become a major industry, it must be aimed at a larger market than only Norwegian domestic demand. There may be considerable opportunities for export to Europe. Norway has both extensive gas resources that can be used for blue hydrogen, and large power resources that can be used for green hydrogen. In addition, it is unlikely that the production of hydrogen for a European market based on Norwegian power resources will occur in Norway (Riekeles & Seland, 2020, 17). Long-term strategic thinking is still needed if Norway becomes a vital producer of hydrogen. If Norway does not position itself as a supplier of hydrogen, the result may be that the EU's climate targets will gradually disappear from the market for Norwegian gas.

On the other hand, if Norway can put in place the production of blue hydrogen, Norwegian gas can go from being a climate problem that Europe wants to get rid of, to becoming a climate solution that contributes to zero emissions. However, the Norwegian authorities still have an essential role to play in easing Norwegian hydrogen production. The authorities must contribute to developing transport solutions, further develop the opportunities for CCS on the NCS, and participate to ensure that blue hydrogen gains a place in the EU climate strategies (Ibid, 22).

7. Conclusion

This study has attempted to acquire an understanding on the hydrogen transition in Norway and the Netherlands in the perspective of governments and business companies. This was done by using a qualitative comparative research design with an actor-centric perspective. This final chapter summarizes and concludes the master thesis based on the results and findings from the previous chapters. This final chapter sum up the main findings of the research questions and presents the conclusion of the thesis and the main research question. It also examines the limitations of the study before providing recommendations for what can be interesting to study with follow-up research about the hydrogen transition in Europe, Norway, and the Netherlands.

7.1. Main Findings of the study

This thesis has strived to gain insight on Norway's and the Netherlands' roles in the European clean hydrogen transition. It was conducted on the grounds to fill a gap in the academic literature regarding governments' and companies' roles in the hydrogen transition based on a comparative actor-centric perspective. Recollecting the main research question of this study:

> *How and to what extent can Norway and the Netherlands play a role in the transition and the implementation of a European hydrogen market?*

To answer this, three sub-research questions were covered. The first sub-research question to this study was '*what are the similarities and differences between the Norwegian and Dutch hydrogen strategies*.' Studying the hydrogen strategies, it appears that both countries are determined to contribute significantly to the national climate legislation and international transition and be pioneers in technology developments. With Norway's vital energy sector and the Netherlands as a significant energy hub, the countries have excellent preconditions to prepare for a thriving new market for blue and green hydrogen. However, Norway has a particular advantage in blue hydrogen with significant experience with CCS technology. Therefore, the Norwegian government wishes to safeguard blue hydrogen in the mid-to-long term and ensure that blue hydrogen qualifies as an emission-free solution for EU policies. The Dutch government also favours blue hydrogen but only as an at-scale supplement for accelerating the integration of green hydrogen. The Dutch government also issues the importance of ensuring CCS does not hinder green hydrogen developments, something that the Norwegian government does not address.

Furthermore, the Norwegian government took a more cautious stance with new investments, as the market for clean hydrogen is not competitive and profitable enough yet. In contrast, the Dutch government provided clear and realistic funding for projects. Moreover, the Dutch government has been early with developments compared to Norway and other European countries. The findings also shows that, today, the Netherlands is better positioned than Norway, as the Dutch actors have been proactive and benefitted from their advantage to start early developments. They have ensured that all hydrogen projects will receive the necessary support to accelerate the transition. The Netherlands has a realistic strategy to play a crucial role. Norway, on the other hand, is still a bit behind. With this, it can be determined that while the Netherlands has adopted a hydrogen strategy with established production targets, Norway has executed a strategy without set production targets.

Moving towards the second sub research question on '*how are Equinor and Gasunie executing their transition towards hydrogen usage and how can they play a significant part in the new European hydrogen market*.' Both companies have shown strong determination to change their business model to adapt to the new market demand internationally. They are also ready to play vital parts in reaching the Paris Agreement target and the national climate targets set in the NCA and the Climate Cure. In 2020, the companies displayed that they are committed to play significant parts in transitioning the energy sector and produce clean hydrogen at a commercial scale. While Equinor has worked most on contributing to international hydrogen projects around the EU, Gasunie has worked with the national hydrogen backbone network in the Netherlands. Both promote the importance of CCS technology and blue hydrogen to decarbonize fossil fuel solutions and provide the market with large-scale production at an early stage.

Moreover, Equinor's interest in active participation in the international arena can provide Norway a more assertive role at the EU level with its commitment to be active abroad. They prioritize CCS but see the importance of creating value chains for offshore wind power energy with green hydrogen. Equinor's participation in the Longship CCS project will provide commercially profitable CCS and contribute to learning and greater efficiency, provide experience and technology developments, and reducing investment barriers for future CCS projects. Gasunie is also determined to play an essential role in both the national hydrogen transition and a proactive international approach. Gasunie has shown commitment by also leading the European Hydrogen Backbone on the Northwest of Europe. In addition, Porthos can also reduce GHG emissions very soon, contributing significantly to the Dutch climate targets in the NCA. NorthH2 is Europe's largest green hydrogen project and will without a doubt substantially play a prominent role in providing GHG reductions nationally and at the EU level and reduce the cost of green hydrogen.

Finally, the last sub-research question was '*to what extent can Norway and the Netherlands ' approach to blue and green hydrogen impact other EU Member States' hydrogen approach.'* The controversial debate on green versus blue hydrogen between the EU Member States can affect developments and investments from IPCEI, as blue hydrogen has not been qualified as a sustainable energy solution. For the Longship and Porthos project to succeed, there is a need for foreign investment from other European countries. The Dutch actors have been proactive and made significant efforts to promote their interest on the EU level by participating early with various groups. Equinor has also been active at the EU level, while the Norwegian government has focused chiefly on national applications up until now. Since the EU will lack the necessary volume of clean hydrogen with only green hydrogen, the Norwegian and Dutch approaches might be a possible future approach for the EU and its Member States. Norwegian and Dutch blue hydrogen technology can also be a solution for European countries strongly dependent on producing energy from fossil fuels with no resources for green hydrogen production.

Moreover, Longship and Northern Lights and Porthos project can play a significant part in allowing EU Member States to store CO2 and also display how CCS/CCUS technology can be safe and competitive with green hydrogen in the developing market in Europe without them obstructing each other's investments. The Norwegian and Dutch positions can therefore provide an updated view on CCS. This relies on the upholding of active partaking of the business and government actors at the EU level. The Norwegian government must play an active role here to ensure more pilot and demonstration projects succeed through additional IPCEI funding and participating in ECHA. It is crucial that the actors actively work at the EU level to safeguard policy support for blue and green hydrogen. Therefore, they must continue to make great efforts through dialogues, consultations, information sharing, and position papers by cooperating with countries with mutual interests.

Based on all these findings of the sub-research questions, the study concludes that Norway and the Netherlands can play a crucial part in making a clean hydrogen market for Europe. With two of Europe's most promising CCS/CCUS projects, they can help kickstart the market and help introduce and increase the success of green hydrogen. The projects can also provide the required at-scale clean hydrogen that the European market will demand. Norway and the Netherlands have unique positions and excellent conditions in providing safe blue and green hydrogen technology to the new European hydrogen market for clean hydrogen. With beneficial actions close to the North Sea, they can cooperate on technology developments, information, and sharing know-how in this field. As blue hydrogen also enables a faster and more successful transition towards green hydrogen, Norway and the Netherlands can help to kickstart and introducing the implementation of the European clean hydrogen market. It can be argued that the Norwegian and Dutch blue hydrogen projects can provide fast integration of a clean hydrogen market in the EU, and Equinor's and Gasunie's expertise and knowledge can cause more enthusiasm to invest in their projects. The success of these projects depends on the actors in this study taking offensive actions and involvement on the EU level and in hydrogen groups.

By ensuring closer bilateral cooperation between Norway and the Netherlands, they have a better chance of succeeding with project developments and could lead to accelerated integration of hydrogen markets. Although Equinor and Gasunie cooperate closely with hydrogen projects, there has been a lack of bilateral cooperation and dialogue between the Dutch and Norwegian governments. This must change soon and depends on the Norwegian government showing more enthusiasm for closer collaboration. Norway needs to seize the opportunity to strengthen hydrogen cooperation with the Netherlands. With Equinor considering generating a new hydrogen pipeline to the EU, this pipeline might be profitable to go from Norway to the first European hydrogen valley in Northern Netherlands. Norway would gain access to the Dutch backbone which allows flows of blue and green hydrogen and consequently get connected to the European Hydrogen Backbone. This opportunity can also ensure that Norway can achieve greater bilateral cooperation with the EU Member States. It could lead to a closer integrated energy system between Norway, the Netherlands and the EU and Norway could remain as one of the EU's largest energy exporters. Closer bilateral cooperation will provide the EU Member States blue hydrogen at a commercial scale and therefore might meet the volume demand from the market. Both countries and the EU are highly dependent on securing a functional hydrogen market. Therefore, it is in their interests to work together to facilitate both blue and green hydrogen production.

Still, if Norway make the right decisions and act fast, they can, along with the Netherlands, play a crucial role in the hydrogen transition and implementation of a new European clean hydrogen market. However, the Norwegian government and Equinor must ensure that blue hydrogen investments do not hinder policies on green hydrogen, something that the Dutch government and Gasunie have covered and made clear.

Norway must play the correct cards and make strategic decisions. The upcoming Norwegian hydrogen roadmap, set to be published on 11th June 2021, has several issues it must address. Norway must grab its unique opportunity fast to have a meaningful role in the European hydrogen market together with the Netherlands. The large-scale development of clean hydrogen production must start now if Norway, the Netherlands, and Europe will become a net-zero society by 2050. Therefore, close cooperation between market actors and government actors is essential. Norwegian and Dutch blue hydrogen projects can act as a baseload of the hydrogen market and pave the way for significant integration of green hydrogen and accelerate new value chains. Consequently, Norway and the Netherlands can give an outstanding contribution to Europe’s path towards a low-emission continent and make clean hydrogen the mainstream solution for hard-to-abate sectors.

7.2. Limitations of the study

With the concluding remarks mentioned above, there are however some limitations to this thesis. One of these can be the chosen time period. The main reason for selecting this time period was to account for the more recent debate and developments that have seen significant stride towards the hydrogen transition. One of the objectives of this thesis was to ensure that this research contributed to filling a research gap. However, the thesis did not get to analyse the Norwegian hydrogen roadmap and whether Equinor's hydrogen pipeline will be approved or not. In addition, the rapid speed of the developments throughout this while research process can also mean that some analysed documents might become obsolete. Nonetheless, the period has given a clear overview of how the hydrogen strategies and approaches were discussed during 2020 and 2021 and could thus function as a framework for further research about this topic. To the best of my knowledge, no analysis has yet studied government actors' and market actors' roles in the hydrogen transition and possible closer bilateral cooperation on hydrogen between two European countries. Thus, the thesis contributes to filling a vital research gap about a comparative perspective on the Norwegian and Dutch roles in the European hydrogen market. This particular focus is essential to research more since they are leading countries in the green transition and can set an example for other European countries on how to approach the hydrogen transition with different needs. Also, this country selection reduces the comparison of other European countries, providing additional and perhaps wholly different results.

Another limitation is the result of the participants in the semi-structured interviews. It can be assumed that the Norwegian actors that were invited for interviews would infirm that closer bilateral cooperation with the Netherlands will be beneficial for Norway to maintain its role as an energy exporter. Equinor would provide information on their active participation on the EU level and how they can play a role in the new market. Something that could have been done differently was to expand the selection criteria on the NSD. This way, it could be possible to contact and interview other relevant actors from research centres and institutes if some of the main actors could not participate. This was especially unfortunate for the sake of this study with the case of the Norwegian government, Equinor, and the Dutch government's position and opinions, as it would have been interesting to add examples from these actors to the study. With this, this study could not take these actors' views into consideration, which would have likely impacted the analyses of the actors' roles.

7.3. Recommendations for further research

The study was primarily focused on comparing Norwegian and Dutch actors from a MLG perspective of government level and company level and how they adapt to policies from the EU level. This study can provide the basis of hydrogen transition research in the context of an actor-centric perspective. Future research is needed to investigate the success of the transition and if countries will meet their targets for 2030 and 2050. It could be possible to study whether the Norwegian government will focus on playing a more active role and have closer cooperation with EU countries such as the Netherlands. Another question is whether the upcoming Norwegian hydrogen roadmap will show more straightforward decisions with an EU strategy such as the Dutch hydrogen strategy covered. While the study provides valuable insight into how Norway and the Netherlands can influence EU policies, their actual level of participation needs further investigation. Doing a later analysis of future hydrogen developments of the Norwegian and Dutch transition could further contribute to an even better understanding of the extent of their potential roles.

As the transition to a clean hydrogen market in Europe is still a significant research gap in the academic literature, it is suggested that the results of this thesis should be considered as building blocks for future studies instead of solid answers. This study expands the research horizon to study other actors' approaches to the hydrogen transition. It could also be constructed the same research in a new context, location. Here it would be interesting to include other countries such as Denmark, Germany, Portugal, France, which are also quite ahead of hydrogen developments. There is limited research on the EHB, and it would be interesting to go more in-depth on analysing the developments in other countries. For instance, what can the developments in Central Eastern Europe contribute to the hydrogen field. Are there any challenges they must tackle? It could also be researched more on the EU institution's point of view on the future research and if there are any issues between the institutions that need to be addressed.

List of References

Andersen, I. (2020). *Vi må viske ut skillet mellom grønn og blå hydrogen. Vi trenger begge deler.* Teknisk Ukeblad. Retrieved 19.01.21 from: https://www.tu.no/artikler/vi-ma-viske-ut-skillet-mellom-gronn-og-bla-hydrogen-vi-trenger-begge-deler/487536?key=4JxIZLzs

Bakhuis, J. (2020). *Analysis of the hydrogen transition in The Netherlands using Strategic Niche Management and Event Sequence Analysis*. [MSC Degree, Delft University of Technology]. Accenture.

Banet, C. (2020). *Havvind, hydrogen, CCS: Norge trenger en helhetlig energiplan for Nordsjøen.* Energi og Klima. Retrieved 23.11.20 from: https://energiogklima.no/kommentar/havvind-hydrogen-ccs-norge-trenger-en-helhetlig-energiplan-for-nordsjoen/

Cheng, C. (2020). *The prospects of blue and green hydrogen in Norway for energy export*. [MA Thesis, University of Stavanger]. ResearchGate.

Cook, A. (2020). *Bringing Europe together to reach net zero*. Equinor ASA. Retrieved 19.04.21 from: https://www.equinor.com/no/where-we-are/eu/bringing-europe-together-to-reach-net-zero-.html

Damman, S., Sandberg, E., Rosenberg, E., Pisciella, P., Johansen, U. (2020) *Largescale hydrogen production in Norway - possible transition pathways towards 2050*. SINTEF.

ECHA. (2020). *Mission and Vision*. European Clean Hydrogen Alliance. Retrieved 08.03.21 from: https://www.ech2a.eu/missionandvision

European Commission. (2019). *The European Green Deal*. Brussels. COM/2019/640 final. Retrieved 08.02.21 from: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

European Commission. (2020a) *A hydrogen strategy for a climate-neutral Europe*. Brussels. COM(2020)301 final. Retrieved 15.09.20 from: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

European Commission. (2020b). *An EU Strategy to harness the potential of offshore* *renewable energy for a climate neutral future*. COM/2020/741 final. Retrieved 25.12.20 from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A741%3AFIN&qid=1605792629666

European Commission. (2021). *European Clean Hydrogen Alliance*. Industrial Policy. European Union. Retrieved 08.03.21 from: https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en

Equinor. (2020a). *Energy Perspectives Report 2020: Long-term macro and market outlook.* Equinor ASA. Retrieved 10.12.20 from: https://www.equinor.com/no/how-and-why/energy-perspectives.html

Equinor. (2020b). *Innspill til «Veikart for hydrogen».* Regjeringen. Retrieved 12.02.21 from:https://www.regjeringen.no/contentassets/66de7ddcf7a6494694202b760fa3f50f/equinor-asa.pdf

Equinor. (2020c). *Equinor's Climate Roadmap*. Sustainability. Equinor. Retrieved 27.02.21 from: https://www.equinor.com/content/dam/statoil/documents/climate-and-sustainability/climate-roadmap-2020.pdf

Equinor. (2020d). *Hydrogen vil være et viktig bidrag til energiovergangen. Dette gjør vi*. Equinor ASA. Retrieved 23.11.20 from: https://www.equinor.com/no/what-we-do/hydrogen.html?gclid=Cj0KCQjwmcWDBhCOARIsALgJ2QcQf41SiZKVsWp-XuS4PE1xa6ChVHX0OJH0i7gfYYduxrC-8KP9kWEaArlLEALw_wcB

Equinor. (2020e). *Equinor joins Europe's biggest green hydrogen project, the NorthH2-project*. Equinor ASA. Retrieved 08.12.20 from: https://www.equinor.com/en/news/20201207-hydrogen-project-north2.html

Equinor. (2021). *Our climate ambitions – net-zero by 2050*. Equinor ASA. Retrieved 29.03.21 from: https://www.equinor.com/en/sustainability/climate.html

EZK. (2019). *National Climate Agreement*. Government of the Netherlands. Retrieved 13.09.20 from: https://www.government.nl/documents/reports/2019/06/28/climate-agreement

EZK. (2020a). *Government Strategy on Hydrogen*. Government of the Netherlands. Retrieved 23.11.20 from: https://www.government.nl/documents/publications/2020/04/06/government-strategy-on-hydrogen

EZK. (2020b). *Waterstof in binnenvaart en short sea - Een Inventarisatie van innovatieprojecten*. Retrieved 24.02.21 from: https://www.rijksoverheid.nl/documenten/rapporten/2020/06/30/waterstof-in-binnenvaart-en-short-sea

EZK. (2020c). *Een Waterstofbeurs voor het Klimaat*. Retrieved 24.02.21 from: https://www.rijksoverheid.nl/documenten/rapporten/2020/09/30/een-waterstofbeurs-voor-het-klimaat

Falnes, J. (2020). *EU satser på hydrogen: Vil bli verdensledende*. E24 Nyheter. Retrieved 01.01.21 from: https://e24.no/teknologi/i/kJ29pk/eu-satser-paa-hydrogen-vil-bli-verdensledende

FCH 2 JU. (2019). *Hydrogen Roadmap Europe. A Sustainable Pathway for the European Energy Transition.* Publications Office of the European Union. Retrieved 19.01.21 from: https://op.europa.eu/en/publication-detail/-/publication/0817d60d-332f-11e9-8d04-01aa75ed71a1/language-en

Gardarsdottir, S. and Sundseth, K. (2021). *Building a Hydrogen Future in Norway*. SINTEF. Retrieved 08.04.21 from: https://blog.sintef.com/industry-en/building-a-hydrogen-future-in-norway/

Gasunie. (2020). *102 million euros in funding on the horizon for Porthos carbon storage project*. Gasunie. Retrieved from: https://www.gasunie.nl/en/news/102-million-euros-in-funding-on-the-horizon-for-porthos-carbon-storage-project

Gasunie (2021a). Annual Report 2020. Gasunie AS. Retrieved 29.03.21 from: https://www.gasuniereport2020.nl/en

Gasunie. (2021b). *Gasunie versnelt investeringen voor de energietransitie*. Gasunie AS. Retrieved 05.03.21 from: https://www.gasunie.nl/nieuws/gasunie-versnelt-investeringen-voor-de-energietransitie

Gigler, J., Weeda, M., Hoogma, R. and de Boer, J. (2020). *Waterstof voor de energietransitie. Een programmatische aanpak voor innovaties op het thema waterstof in Nederland voor de periode 2020 – 2030*. TKI NIEUW GAS. Topsector Energie. Retrieved 17.02.21 from: https://www.topsectorenergie.nl/sites/default/files/uploads/TKI%20Gas/publicaties/Waterstof%20voor%20de%20energietransitie%20-%20innovatieroadmap%20(jan%202020).pdf

Hirth, M. L. (2020a). *Tydelig signal om sterkere statlig drahjelp for hydrogen*. Energi og

Klima. Retrieved 25.10.20 from: https://energiogklima.no/kommentar/blogg/et-bedre-grunnlag-for-hydrogenindustrien/

Hirth, M. L. (2020b). *Slik kan Norge bidra best til grønn omstilling*. Energi og Klima.

Retrieved 23.11.20 from: https://energiogklima.no/nyhet/rapporter/slik-kan-norge-bidra-best-til-gronn-omstilling/

Hovland, K. M. (2020a). *E24s hydrogenkart viser satsinger over hele Norge: – Har*

virkelig tatt av. E24. Retrieved 01.01.21 from: https://e24.no/den-groenne-oekonomien/i/zg0oVO/e24s-hydrogenkart-viser-satsinger-over-hele-norge-har-virkelig-tatt-av

Hovland, K. M. (2020b). *Nel-sjefen om Norges hydrogenstrategi: – Dessverre veldig*

tannløst. E24. Retrieved 25.10. 20 from: https://e24.no/olje-og-energi/i/Vbm0x4/nel-sjefen-om-norges-hydrogenstrategi-dessverre-veldig-tannloest

Hovland, K. M. (2020c). *Frykter at hydrogentoget går uten Norge: – Brenner mer under*

føttene våre enn vi har trodd. E24. Retrieved 25.10.20 from: https://e24.no/olje-og-energi/i/3Jye9A/frykter-at-hydrogentoget-gaar-uten-norge-brenner-mer-under-foettene-vaare-enn-vi-har-trodd

Hodgson, R. (2020). *Norway seeks funding for carbon capture as IEA publishes major*

report. ENDS Europe. Retrieved 27.09.20 from: https://www.endseurope.com/article/1695405/norway-seeks-funding-carbon-capture-iea-publishes-major-report

Hydrogen Council. (2021). *Hydrogen Insights 2021. A perspective on hydrogen*

investment, market development and cost competitiveness. McKinsey and Company. Retrieved 09.03.2021 from: https://hydrogencouncil.com/en/hydrogen-insights-2021/

Hydrogen Europe. (2020) *Green Hydrogen Investment and Support Report: Hydrogen*

Europe's input for a post COVID-19 recovery plan. Hydrogen Europe. Brussels. Retrieved 01.02.21 from: https://hydrogeneurope.eu/sites/default/files/Green%20Hydrogen%20Investment%20and%20Support%20Report_FINAL.pdf

IEA. (2019). *The clean hydrogen future has already begun.* IEA. Paris. Retrieved

23.11.20 from: https://www.iea.org/commentaries/the-clean-hydrogen-future-has-already-begun

IEA. (2020). *The Netherlands 2020*. Energy Policy Review. Country Report. Paris.

Retrieved 21.02.21 From: https://www.iea.org/reports/the-netherlands-2020

IEA. (2021a). *Norway*. Country Profile. International Energy Agency. Retrieved 26.02.21 from: https://www.iea.org/countries/norway

IEA. (2021b). *The Netherlands*. Country Profile. International Energy Agency. Retrieved 21.02.21 from: https://www.iea.org/countries/the-netherlands

Janipour, Z., Swennenhuis, F., de Gooyert, V. and de Coninck, H. (2021). Understanding contrasting narratives on carbon dioxide capture and storage for Dutch industry using system dynamics. *International Journal of Greenhouse Gas Control*. Vol. 105.

Janssen, D. (2020). *Dutch outline clean hydrogen 'vision' aim at global market*. Euractiv. Retrieved 11.02.21 from: https://www.euractiv.com/section/energy-environment/news/dutch-outline-clean-hydrogen-vision-aim-at-global-market/

Jens, J., Wang, A., van der Leun, K., Peters, D. and Buseman, M. (2021). *Extending the European Hydrogen Backbone. A European Hydrogen Infrastructure Vision covering 21 countries.* Gas for Climate 2050. Retrieved 13.04.21 from: https://gasforclimate2050.eu/publications/

Kaarbo, J. and Beasly, R. J.K. (2002). A Practical Guide to the Comparative Case Study Method in Political Psychology. *Political Psychology*. Vol. 20, No. 2. Pages 369-391. Wiley Online Library.

Kakoulakia, G., Kougiasa, I., Taylora, N. Dolcib, F., Moyab, J., Jäger-Waldaua, A. (2020). Green hydrogen in Europe – A regional assessment: Substituting existing production with electrolysis powered by renewables. *Energy Conversion and Management*. Vol 228.

Klimakur 2030. (2020). Klimakur 2030 – tiltak og virkemidler mot 2030. Rapport M-1625. Miljødirektoratet, Enova, Vegvesenet, Kystverket, Landbruksdirektoratet, Norges vassdrags- og energidirektorat. Regjeringen. Retrieved 12.03.2020 from: https://www.regjeringen.no/contentassets/1092a287729448e5826b0df5832794bd/klimakur-2030.pdf

KLD. (2020). *Slutter seg til europeisk satsing på hydrogen.* Regjeringen. Retrieved 30.04.21 from: https://www.regjeringen.no/no/aktuelt/slutter-seg-til-europeisk-satsing-pa-hydrogen/id2790732/

Li, Y., Kool, C., & Engelen, P.-J. (2020). *Analyzing the Business Case for Hydrogen-Fuel*

Infrastructure Investments with Endogenous Demand in The Netherlands: A Real Options Approach. Sustainability. Vol.12. Issue 13.

Mete, G. and Reins, L. (2020). Governing New Technologies in the Energy Transition – The Hydrogen Strategy to the Rescue? *Carbon and Climate Law Review*. Vol. 14.

Moradi, M. (2018). *Economic Assessment of Hydrogen Energy Production in Norway. An Economic Analysis of Strategies for Implementation of Hydrogen Fuel Produced by Renewable Energies in Norway*. [Master Thesis, NTNU].

Muhibbudin, I. (2020). Prevalence of COVID -19 Pandemic: A Paradigm Shift to Hydrogen Economy. *Preprints*.

Mulder, M., Perey, P. L., & Moraga , J. L. (2019). Outlook for a Dutch hydrogen market: economic conditions and scenarios. (CEER Policy Papers; No. 5). Groningen: *Centre for Energy Economics Research*. University of Groningen.

Newborough, M. and Cooley, G. (2020). Developments in the global hydrogen market: Electrolyser deployment rationale and renewable hydrogen strategies and policies. *Fuel Cells Bulletin*. Vol 2020, Issue 10, Pages 16-22.

Norsk Hydrogen Forum. (2020). *150 millioner kroner til hydrogenprosjekter i 2020*. Norsk Hydrogen Forum. Retrieved 10.04.21 from: https://www.hydrogen.no/hva-skjer/aktuelt/150-millioner-kroner-til-hydrogenprosjekter-i-2020

Norsk Hydrogen Forum. (2021). *25 søkte: Fem norske prosjekter videre i IPCEI*. Norsk Hydrogenforum. Retrieved 10.04.21 from: https://www.hydrogen.no/hva-skjer/aktuelt/25-sokte-fem-norske-prosjekter-videre-i-ipcei-hydrogen

Noussan, M., Raimondi, P. P., Scita, R., & Hafner, M. (2020). *The Role of Green and Blue Hydrogen in the Energy Transition—A Technological and Geopolitical Perspective*. Sustainability, 2021 13(1), 298.

NorthH2. (2020a). *Why invest heavily in hydrogen now?* NorthH2. Retrieved 14.02.21 from: https://www.north2.eu/en/blog-en/why-invest-in-hydrogen-now/

NorthH2. (2020b). *Large-scale green hydrogen production*. NorthH2. Retrieved 14.02.21 from: https://www.north2.eu/en/

NorthH2. (2021). *The Netherlands as an Energy Hub*. Retrieved 05.03.21 from: https://www.north2.eu/en/blog-en/the-netherlands-as-an-energy-hub/

Northern Lights. (2020). *About the Longship project*. Northern Lights CCS. Retrieved 22.03.21 from: https://northernlightsccs.com/about-the-longship-project/

NTB. (2020a). *Hydrogenstrategi får kritikk: – En tapt mulighet for Norge*. Dagens Næringsliv. Retrieved 17.04.21 from: https://www.dn.no/energi/norge/tina-bru/sveinung-rotevatn/hydrogenstrategi-far-kritikk-en-tapt-mulighet-for-norge/2-1-818893

NTB. (2020b). *Opposisjonspartier: Hydrogen kan bli «game changer» for Norge*. E24. Retrieved 29.03.21 from: https://e24.no/olje-og-energi/i/EWOaX5/opposisjonspartier-hydrogen-kan-bli-game-changer-for-norge

NTB (2021). *Equinor vurderer hydrogenrør til Europa: – Hvis vi gjør dette, så blir det gigantisk*. E24. Retrieved 15.02.21 from: https://e24.no/olje-og-energi/i/M3jaX5/equinor-vurderer-hydrogenroer-til-europa-hvis-vi-gjoer-dette-saa-blir-det-gigantisk

OED. (2020). *Longship – Carbon capture and storage*. Meld. St. 33 (2019–2020) Report to the Storting (white paper). Regjeringen. Retrieved 15.01.21 from: https://www.regjeringen.no/contentassets/943cb244091d4b2fb3782f395d69b05b/en-gb/pdfs/stm201920200033000engpdfs.pdf

OED. (2021). *Godkjenner utbyggingsplan for CO2-lagring*. Regjeringen. Pressemelding. Nr: 014/21. Retrieved 09.03.21 from: https://www.regjeringen.no/no/aktuelt/01421/id2837595/

OED and KLD. (2019). *Invitasjon til innspillsmøte – helhetlig hydrogenstrategi*. Regjeringen. Retrieved 17.04.21 from: https://www.regjeringen.no/no/aktuelt/invitasjon-til-innspillsmote--helhetlig-hydrogenstrategi/id2624196/

OED and KLD. (2020). *The Norwegian Government's hydrogen strategy towards a low emission society.* Strategy. No: 36/2020. Pages 3-53. Y-0127 E. Regjeringen. Retrieved 16.02.21 from: https://www.regjeringen.no/contentassets/8ffd54808d7e42e8bce81340b13b6b7d/hydrogenstrategien-engelsk.pdf

Parola, L., Goldberg, S. and Morra, F. (2021). *EU Commission approves Dutch State Aid for hydrogen production*. Herbert Smith Freehills. Retrieved 10.04.21 from: https://hsfnotes.com/energy/2021/03/04/eu-commission-approves-dutch-state-aid-for-hydrogen-production/

Pazos-Vidal, S. (2019). *Subsidiarity and EU Multilevel Governance: Actors, Networks and*

Agendas. Routledge Studies on Government and the European Union. CRC Press.

Philibert, C. (2020). Perspectives on a hydrogen strategy for the European Union. Center for Energy and Climate. *Ifri*.

Porthos. (2020) *CO2 reduction through storage beneath the North Sea*. Retrieved 06.12.20 from: https://www.porthosco2.nl/en/

Riekeles, H. & Seland, S. (2020). *Hydrogen – muligheter og hindringer for en ny norsk eksportnæring*. CIVITA. Retrieved 31.01.21 from: https://www.civita.no/publikasjon/hydrogen-muligheter-og-hindringer-for-en-ny-norsk-eksportnaering

Røkke, N. (2020). *Hydrogen Economy: Too good to be true for Norway?* SINTEF. Retrieved 06.02.21 from: https://blog.sintef.com/sintefenergy/hydrogen-economy-to-good-to-be-true-for-norway/

Saurugger, S. (2014). Governance. Chapter 5. 102-122. In Saurugger, S. *Theoretical Approaches to European Integration*. The European Union Series. Palgrave Macmillan. London. Red Globe Press.

Simon, F. (2019). *Dutch urge swift EU hydrogen push to cut industry, transport emissions*. Euractiv. Retrieved 07.01.21 from: https://www.euractiv.com/section/energy-environment/news/dutch-urge-swift-eu-hydrogen-push-to-cut-industry-transport-emissions/

Simon, F. (2020a). *Renewable or 'low-carbon'? EU countries face off over hydrogen*. Euractiv. Retrieved 07.01.21 from: https://www.euractiv.com/section/energy-environment/news/renewable-or-low-carbon-eu-countries-face-off-over-hydrogen/1537354/

Simon, F. (2020b). *EU bets on blue hydrogen 'to break chicken-and-egg problem'* Euractiv. Retrieved 07.01.21 from: https://www.euractiv.com/section/energy-environment/news/eu-bets-on-blue-hydrogen-to-break-chicken-and-egg-problem/

Simon, F. (2021). *Polish climate minister: 'It is critical that EU legislation on hydrogen is colour-blind'*. Euractiv. Retrieved 06.03.21 from: https://www.euractiv.com/section/energy/interview/polish-climate-minister-it-is-critical-that-eu-legislation-on-hydrogen-is-colour-blind/

Skarsgård, M. L. (2020). *Equinor inn i Europas største prosjekt for grønn hydrogen*. Finansavisen. Retrieved 07.12.20 from:

https://finansavisen.no/nyheter/energi/2020/12/07/7595656/equinor-inn-i-europas-storste-prosjekt-for-gronn-hydrogen

Stortinget. (2021). *IPCEI Hydrogen: grønn og blå hydrogen*. In EU/EEA News. Retrieved 25.01.21 https://www.stortinget.no/no/Hva-skjer-pa-Stortinget/EU-EOS-informasjon/EU-EOS-nytt/2021/eueos-nytt---13.-januar-2021/ipcei-hydrogen-gronn-og-bla-hydrogen/

UD, KED, OED & SD (2021). *Norway to strengthen green cooperation with EU*. Regjeringen. Retrieved 22.03.21 from: https://www.regjeringen.no/en/aktuelt/green_cooperation/id2836622/

van Cappellen, L. and Rooijers, F. (2018). *Feasibility study into blue hydrogen – Technical, economic & sustainability analysis*. CE Delft. Retrieved 12.01.21 from https://www.cedelft.eu/en/publications/2149/feasibility-study-into-bleu-hydrogen

van de Graaf, T., Overland, I., Scholten, D. & Westphal, K. (2020). *The new oil? The geopolitics and international governance of hydrogen*. Energy Research & Social Science. Vol. 70.

van Wijk, A. and Chatzimarkakis, J. (2020). *Green Hydrogen for a European Green Deal A 2x40 GW Initiative*. Hydrogen Europe. Retrieved 19.01.21 from: https://hydrogeneurope.eu/sites/default/files/Hydrogen%20Europe_2x40%20GW%20Green%20H2%20Initative%20Paper.pdf

von der Leyen, U. (2021). *Speech by President von der Leyen to the Hydrogen Council*. Press Corner. European Commission. Brussels. Retrieved 15.05.21 from: https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_21_158

VEMW. (2020). *Kabinet presenteert ambitieuze waterstofvisie voor Nederland*. Koninklijke VEMW. Retrieved 30.03.21 from: https://www.vemw.nl/Nieuwsoverzicht/2020-03-31-Waterstof-kabinetvisie-marktordening.aspx

Wang, A., van der Leun, K., Peters, D., and Buseman, M. (2020). *European Hydrogen Backbone. How a dedicated hydrogen infrastructure can be created*. Guidehouse. Gas for Climate 2050. Retrieved 18.01.21 from: https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/

Annexes

Interview Questions for Gasunie

Disclaimer: All replies are Noé van Hulst's personal views based on his experience and activities. None of the interview responses and citations used in this thesis are official views of Gasunie or any other institution.

Noé van Hulst is International Hydrogen Adviser for Gasunie, Chair of IPHE, Hydrogen Advisor at International Energy Agency and previous Hydrogen Envoy at the Ministry of Economic Affairs and Climate Policy.

The questions were sent to van Hulst by email on 17.03.21 and were answered by the respondent with a signed consent form via email on 13.04.21.

1. Dutch role internationally

- How are the Netherlands and Gasunie working to play a significant role in the implementation and the transition towards a European hydrogen market, in particular with respect to the European Hydrogen Backbone network?
- To what extent can hydrogen projects such as NortH2 and Porthos contribute to a European hydrogen market?

2. Bilateral hydrogen cooperation between Norway and the Netherlands

- What is Gasunie's approach to and views on the current bilateral hydrogen cooperation with Equinor?
- What benefits do you see in a Norwegian-Dutch hydrogen cooperation, e.g. in terms of information/know how exchange, investments, learning?
- What are the main challenges for a successful Dutch-Norwegian cooperation?
- What are your/Gasunie's views on a possible newer hydrogen projects with Equinor, such as a hydrogen pipeline from Norway to the Northern Netherlands as a solution for Norway to join the European Hydrogen Backbone network?
- What are the Netherlands/Gasunie's views on the potential of storing C02 in the Norwegian Longship CCS project in the North Sea?
- To what extent can the success of CCS projects such as Longship and Porthos push for more support for blue hydrogen technology in other EU Member States which only favours green hydrogen?

NTNU

Kunnskap for en bedre verden