CLINGENDAEL
INTERNATIONAL
ENERGY
PROGRAMME

CIEP

HYDROGEN POLICY IN THE NETHERLANDS

LAYING THE FOUNDATIONS FOR A SCALABLE HYDROGEN VALUE CHAIN

In cooperation with

RIFS
POTSDAM

CIEP BRIEFING PAPER 2024 | 01

CLINGENDAEL
INTERNATIONAL
ENERGY
PROGRAMME

CIEP

CIEP acts as an independent forum for governments, non-governmental organizations, the private sector, media, politicians and all others interested in changes and developments in the energy sector.

CIEP organizes lectures, seminars, conferences and roundtable discussions. In addition, CIEP members of staff lecture in a variety of courses and training programmes. CIEP's research, training and activities focus on two themes:

- European energy market developments and policy-making;
- Geopolitics of energy and climate policy-making and energy markets

CIEP is endorsed by The Netherlands Ministry of Economic Affairs and Climate Policy, Ministry of Foreign Affairs, Air Liquide Industrie B.V., BP Nederland, Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A. ('Rabobank'), ENGIE Energie Nederland N.V., Neptune Energy Netherlands B.V., Eneco Holding N.V., EBN B.V., Esso Nederland B.V., Equinor ASA, GasTerra B.V., N.V. Nederlandse Gasunie, ING Wholesale Banking N.V., Nederlandse Aardolie Maatschappij B.V., Vattenfall NL, TenneT TSO B.V., One-Dyas B.V., Havenbedrijf Rotterdam N.V., RWE Generation NL B.V., Shell Nederland B.V., Uniper Benelux N.V., Koninklijke Vopak N.V., Wintershall Dea Nederland B.V.

Find CIEP publications at www.clingendaelenergy.com/publications.

TITLE
Hydrogen Policy in the Netherlands

SUBTITLE
Laying the Foundations for a Scalable Hydrogen Value Chain

AUTHORS
Roelof Stam, Coby van der Linde & Pier Stapersma

NUMBER
2024 I 01 briefing paper

DESIGN
Studio Maartje de Sonnaville

PUBLISHED BY
Clingendael International Energy Programme (CIEP)

ADDRESS
Breitnerlaan 299, 2596 HA The Hague, The Netherlands

TELEPHONE
+31 70 374 67 00

EMAIL
ciep@clingendaelenergy.com

WEBSITE
www.clingendaelenergy.com

BRIEFING PAPER

HYDROGEN POLICY IN THE NETHERLANDS

LAYING THE FOUNDATIONS FOR A SCALABLE HYDROGEN VALUE CHAIN

This paper is an update from a discussion paper published by RIFS, Potsdam in April 2023, and available on the CIEP-website. This updated version is a pre-publication of a Chapter in an upcoming book 'The geopolitics of hydrogen: volume 1: European strategies in global perspective' edited by Rainer Quitzow and Yana Zabanova.

References to this paper should read: Roelof Stam, Coby van der Linde, Pier Stapersma, Hydrogen Policy in the Netherlands, Laying the Foundations for a Scalable Hydrogen Value Chain, in: Quitzow R, Zabanova Y, (eds), The geopolitics of hydrogen: volume 1: European strategies in global perspective, Cham, Springer Nature Switzerland, in press.

ABSTRACT

This chapter delves into the Dutch hydrogen strategy, examining the Netherlands starting position, its national hydrogen strategy, policy initiatives and the international approach adopted by the Dutch government in the low-carbon hydrogen economy.

The Dutch Climate Agreement of 2019 identified low-carbon hydrogen as a key part of the carbon reduction strategy, especially in hard-to-abate sectors. The Netherlands is well-placed to make a substantial contribution to Europe's low-carbon hydrogen market leveraging its current role as a European energy hub, substantial chemical cluster, strategic North Sea location, offshore wind potential, and existing gas and oil infrastructure.

To bolster investment security and scale up the low-carbon hydrogen market by 2030, the Dutch government has opted for a blend of obligations and subsidies. The Dutch government favours hydrogen production through electrolysis from renewable energy, while concurrently allowing for the utilization of hydrogen produced from natural gas with Carbon Capture and Storage (CCS) technology where applicable.

Internationally, the Netherlands aims to position itself as the central hub for hydrogen in Northwest Europe. This involves linking Dutch domestic production at the North Sea and international exporters with users in industrial clusters across Northwest Europe.

INTRODUCTION

The Dutch government has in recent years taken a more active role in the energy transition and therewith the creation of a low-carbon hydrogen[1] economy in the Netherlands. In the Dutch Climate Act of 2019, the government states that it wants to reduce CO_2 emissions by 49 per cent by 2030, compared to 1990 levels, and aims to achieve a near 100 per cent reduction by 2050 (Government of the Netherlands, 2019). These ambitious climate targets require drastic changes to the energy system, which is currently based largely on fossil fuels (85 per cent of total final energy consumption) (BP, 2022). Hydrogen can potentially fulfil a 'systemic function' in the future energy system, accommodating intermittent renewable electricity (Clingendael International Energy Programme, 2019). As stated in the 'Dutch Government Strategy on Hydrogen (2020)', the government believes hydrogen will play a crucial role in the energy and feedstock transition, especially in hard-to-abate sectors (Ministry of Economic Affairs and Climate, 2020). The Netherlands prefer hydrogen produced via electrolysis from renewable energy but additionally there is also room for hydrogen produced from natural gas and/or residual gases with Carbon Capture and Storage (CCS) technology where applicable.

To achieve the Netherlands' climate targets while preventing carbon leakage and maintaining its current energy hub function, the Dutch government is working together with the private sector to realize the development of a low-carbon hydrogen market. Industry, NGOs, research institutions and government are cooperating on a large array of projects aimed at realizing a low-carbon hydrogen economy in the Netherlands. Often these projects are of an international character, connecting neighbouring countries, stakeholders in the North Sea region and global industry (Topsector energy, 2020).

1 Low-carbon hydrogen is defined as all hydrogen produced with a significant carbon footprint reduction compared to unabated hydrogen production. This includes hydrogen produced via electrolysis from renewable electricity (green), hydrogen produced from natural gas or residual gases with CCS (blue) and various other 'low-carbon' hydrogen production methods. The Netherlands is an active member of IPHE (International Partnership for Hydrogen and Fuel Cells in the Economy). IPHE is involved in the certification of the carbon footprint of hydrogen produced from different sources and with different technologies to facilitate the development of international trade in low-carbon hydrogen. See their publication 'Methodology for Determining the Greenhouse Gas Emissions Associated with the Production of Hydrogen (2022) Available at: https://www.iphe.net/_files/ugd/45185a_48960ad9b26045c7a082bceb3a192bc7.pdf.

In this chapter the Dutch hydrogen policy strategy will be discussed.[2] First the starting position of the Netherlands in the emerging low-carbon hydrogen economy is illustrated, after which a broad overview of the national hydrogen strategy and policy initiatives is given. The last section describes the international approach the Dutch government takes in the emerging low-carbon hydrogen economy.

2 The Dutch hydrogen strategy and policy approach outlined in the following chapter is predominantly based on the Dutch Climate Act (2019), the National Hydrogen Programme (2022), the National Plan Energy System (NPE) (2023) and various letters to parliament (e.g. Government Strategy on Hydrogen (2020), Development Transport System for Hydrogen (2022) and Organization and Development of the Hydrogen Market (2022)).

1 THE POSITION OF THE NETHERLANDS IN THE EMERGING LOW-CARBON HYDROGEN ECONOMY

The Netherlands is in a strong position to make a significant contribution to Europe's low-carbon hydrogen market thanks to its current role as a European energy hub, substantial chemical industry, favourable geographical location at the North Sea, offshore wind potential, and existing gas and oil infrastructure.

ENERGY HUB

The Netherlands is home to Europe's largest seaport, the Port of Rotterdam, located at the North Sea and in the Rhine-Meuse-Scheldt delta. With its relatively deep-water port and convenient location, connecting international waters with Northwest Europe, the port of Rotterdam functions as a global hub for international energy trade. The Port of Rotterdam plays an important part and is embedded in the Antwerp-Rotterdam-Rhine-Ruhr-Area (ARRRA), a petrochemical cluster that generates 40 per cent of the total petrochemical output in the EU (Port of Rotterdam, n.d.-b). Significant quantities of energy, among others in the form of crude oil, oil products, coal and gas are imported through Rotterdam daily, and transported via river barges and pipelines to industrial clusters located in Northwest Europe (van der Linde & Stapersma, 2018).

The Dutch government seeks to maintain this hub function in a future renewable energy system. As hydrogen potentially becomes a globally traded commodity and industrial demand for low-carbon hydrogen in Northwest Europe increases, the Netherlands is in a unique position to contribute to the hydrogen supply chain by both producing and importing low-carbon hydrogen and providing a gateway to Northwest Europe (Ministry of Economic Affairs and Climate, 2020; Port of Rotterdam, N.D.-a). The offshore wind potential in the Dutch part of the North Sea is also an important incentive for the development of a low-carbon hydrogen economy. In addition, facilities at Groningen Seaport in the north of the country are developing into a landing point for offshore wind and conversion into hydrogen. These facilities are closely located to similar German plans to develop their side of the Ems Delta, creating a potential new conversion cluster. A similar development is ongoing in the south of the country, on the banks of the river Scheldt and along the canal from Terneuzen to Ghent in Belgium.

INDUSTRY

The Netherlands has a relatively energy intensive economy due to its large refining and petrochemical sector and other economic activities that benefitted in the past from the availability of abundant natural gas, including greenhouse-based agriculture and horticulture, and fertilizer production. Hydrogen is already a widely used commodity in the chemical, refining and fertilizer industry. It plays a multidimensional role in these industries, as it is a by-product in some processes, while being an essential feedstock or a potential alternative energy carrier in others.

With an estimated 1.5 million tonnes per year, the Netherlands is the second largest hydrogen producer in Europe, after Germany (TNO, 2020). As such, the Netherlands has extensive experience in the safe production, transportation, storage, and consumption of hydrogen in industrial settings. Currently, most hydrogen produced in the Netherlands is created via steam methane reforming using natural gas (862,000 tonnes per year), most of the remaining of hydrogen is produced with oil and residual (refinery) gasses (574,000 tonnes per year) (TNO, 2020). Approximately 10 per cent of the Dutch gas consumption is used to produce hydrogen, emitting significant amounts of CO_2 (Ministry of Economic Affairs and Climate, 2020).

In addition to hydrogen production via electrolysis from renewable energy, hydrogen from natural gas and residual gases with CCS provides a relatively quick solution to decrease emissions considerably and plays a role in the Dutch national carbon reduction strategy (Ministry of Economic Affairs and Climate, 2020). An example of an initiative to reduce carbon emissions in current hydrogen production is the H-vision project in Rotterdam, which aims to produce low-carbon hydrogen from natural gas and residual refinery gasses. In this project, CO_2 would be captured and either stored in empty gas fields under the North Sea or used as feedstock for basic chemicals such as methanol. The hydrogen would be used as input for the refinery process (H-vision, n.d.). The transportation and storage of CO_2 would be facilitated by Porthos, a joint venture of Gasunie, Port of Rotterdam and EBN.

Porthos stands for Port of Rotterdam CO_2 Transport Hub and Offshore Storage and is the flagship CCS project in the Netherlands. However, the Porthos project was delayed due to a lawsuit filed by Mobilisation for the Environment (MOB) against the state, concerning the nitrogen the project is expected to emit during its construction. The Netherlands is currently struggling with a 'nitrogen crisis'. Excessive amounts of nitrogen emissions from agriculture, industry and transportation threaten the country's biodiversity. Although these emissions have decreased significantly over the years, they continue to pose a threat to the environment. In an interim ruling issued on 2 November 2022, the court concluded that the nitrogen construction exemption used for the Porthos project does not comply with European Nature Conservation Law and may not be used for the construction of the project.

Therewith, Porthos was delayed but not off track. An individual assessment of the nitrogen impact had to be made for the project (Raad van State, 2022).

On 9 December 2022, the Ministry of Climate and Energy published a letter to parliament in which it declared that it would temporarily assume liability for financial risks related to this project, pending the final verdict (Ministry of Economic Affairs and Climate, 2022d). The government considers the carbon reduction that Porthos could provide (2.5 million tonnes CO2 per year) to be crucial to its efforts to achieve the 2030 climate goals. To prevent delays or possible cancellations, it was necessary that Porthos continued the tendering procedures already initiated. Therefore, the government aimed to guarantee financial obligations for a maximum amount of 175 million euros up until the end of 2023 (Ministry of Economic Affairs and Climate, 2022d).

The interim ruling had significant implications for the construction industry in general, as it meant that in the future the compliance of individual construction projects with the requirements of the Nature Conservation Act will need to be assessed. This will lead to considerable delays in permitting processes and to delays in the construction of homes, infrastructure, and energy projects, creating a serious obstacle to the energy transition in the Netherlands (Meijer, 2022).

On 16 August 2023, the Council of State (highest legal authority in the Netherlands) ruled that, based on the new assessment, the nitrogen deposition during the construction of Porthos does not pose a threat to neighbouring nature (Raad van State, 2023). On 18 October 2023 a final Investment decision (FID) was taken. Construction will start in 2024, and is facilitating Air Products, Air Liquide, ExxonMobil and Shell to capture and store 2.5 Mton CO2 per year for 15 years. The CO2 will come from their existing SMRs, which is seen as an important first step to realise low-carbon hydrogen supply. Project Aramis, an initiative of Gasunie, EBN, Total and Shell Nederland could be the next CCS project to reach FID, increasing the contribution of blue hydrogen to the energy transition targets (Netherlands Enterprise Agency, 2021c). On 22 June 2023, Belgium and the Netherlands signed an agreement on CCS collaboration and cross border CO2 transport, facilitating also Belgian captured CO2 for storage in depleted Dutch offshore gas fields (Aramis, 2023).

NORTH SEA

The Netherlands' location on the North Sea is well-suited for the production of hydrogen via electrolysis from renewable energy. The Dutch part of the North Sea covers an area of about 58,000 km^2 (Government of the Netherlands, 2016). With its favourable wind conditions, relatively shallow waters, good access to ports and energy intensive industries, which are largely situated or alternatively well connected

to coastal areas, the North Sea is very suitable for offshore wind power. Some of this wind energy could be used to produce hydrogen.

There are various projects underway to start producing hydrogen through electrolysis at or near the North Sea. For example, Shell has recently taken the final investment decision on Holland Hydrogen 1, a 200 MW electrolyser project in Rotterdam on the Second Maasvlakte (Shell, 2022). They intend to produce hydrogen using wind energy from the offshore wind farm Hollandse Kust Noord. Another example is H2opZee, a project in which Germany's RWE and UK-based Neptune Energy join forces to accelerate hydrogen production in the Dutch North Sea. This demonstration project will have an electrolyser capacity of 300 to 500 MW and will use existing pipelines to transport hydrogen produced at sea to land (RWE, n.d.). Another project is NortH2, an international consortium consisting of Equinor, ENECO, Gasunie, Groningen Seaports, RWE and Shell Nederland, endorsed by the Groningen provincial authority, which is currently investigating the feasibility of large-scale production, storage and transmission of hydrogen in Groningen. NortH2 aims to convert offshore wind energy into hydrogen through electrolysis in Eemshaven to supply industry with 2-4 GW of hydrogen by 2030 and upscale to more than 10 GW by 2040 (NortH2, n.d.).

GAS LEGACY ASSETS

With the discovery of the Groningen gas field in 1959, the Netherlands became the number one natural gas producer in Europe. This stimulated the development of an extensive high quality natural gas network connecting the Netherlands and parts of Belgium, France, and Germany. In addition to this, it was the Dutch state that established the institutional arrangements for a European gas market, from which lessons for hydrogen can be drawn. These public-private partnerships made the development of natural gas infrastructures and natural gas markets a great European success (Correljé et al., 2003).

Although the Groningen gas field was long one of the largest onshore gas fields in the world, its supplies are finite. Therefore, in the 2000s, in order to diversify away from a predominant focus on national production, the concept of a gas hub strategy was implemented, partly shifting the focus from national production to imports. This resulted in the construction of necessary infrastructure such as import terminals and storage facilities. The gas hub strategy has proven valuable in this time of geopolitical uncertainty as it enables European countries to replace Russian flows with new liquefied gas supplies from overseas. Furthermore, the repurposing potential of this infrastructure presents a favorable starting position for the future low-carbon hydrogen economy.

On 26 September 2022, well before its anticipated depletion, Hans Vijlbrief, State Secretary for the Extractive Industries, stated that the Groningen gas field would be

put on ‘pilot light’ as of 1 October 2022 due to the seismic risk caused by production activities (Government of the Netherlands, 2022b). This implied that a minimum amount of gas will be extracted from the field so that existing wells and infrastructure can continue to operate, ensuring that the field is still available as spare capacity in case of a severe disruption in low calorific natural gas supplies or an emergency in the Netherlands or neighbouring countries. The Groningen field has closed completely on 1 October 2023, while the decision to break down the production facilities was delayed to 2024. The latter was done to make sure that security of gas supply could be adequately organized in this period of geopolitical uncertainty and tight natural gas markets. Due to the planned closure of the Groningen field and the expected general decline of natural gas demand over the coming years, gas infrastructure will become available for repurposing to transport hydrogen production (Government of the Netherlands, n.d.). The Netherlands has two natural gas pipeline systems, one for high calorific gas and one for low calorific (Groningen quality) gas. With demand for low calorific gas decreasing some spare pipeline capacity is already being converted to carry hydrogen. In 2021 the government decided to refurbish gas pipelines to create the ‘Dutch hydrogen backbone’ connecting the Dutch industrial clusters (European Hydrogen Backbone, n.d.). On 27 October 2023, the first section of the hydrogen backbone, a new pipeline to connect the Maasvlakte in the Port of Rotterdam with the rest of the backbone, was officially launched. The hydrogen backbone will be further discussed later in this chapter.

2 NATIONAL HYDROGEN STRATEGY AND POLICY INITIATIVES

In the Dutch Climate Agreement (2019) the low-carbon hydrogen economy was identified as a key part of the carbon emission reduction strategy (Government of the Netherlands, 2019). Central to the Dutch hydrogen strategy is the National Hydrogen Programme (2022), which originated from the Dutch Climate Agreement. The main task of the National Hydrogen Programme, a public-private partnership, is to investigate and stimulate the contribution of hydrogen to the realization of the energy transition. In 2022 its focus was on creating a Hydrogen Roadmap for the Netherlands together with stakeholders from the hydrogen sector. The Roadmap proposes low-carbon hydrogen targets for 2030 and describes what actions are necessary to achieve them. Figure 1 provides a schematic overview of the Hydrogen Roadmap, for more detailed information please see the Hydrogen Roadmap report (National Hydrogen Programme, 2022). The Dutch government takes an integrated approach to developing hydrogen value chains, focusing on production, import, transportation, storage, as well as the demand side, potential revenue models and on how to deal with safety and regulatory issues (National Hydrogen Programme, 2022; Netherlands Enterprise Agency, 2021a).

CLUSTER-BASED ENERGY STRATEGY

Industry in the Netherlands is highly concentrated in regional clusters, due to economies of scale, location, cooperation opportunities and infrastructure. These clusters are identified as: Rotterdam-Moerdijk, the North Sea Cannel Area (Noordzeekanaalgebied), the Northern Netherlands (Noord Nederland), Chemelot, Zeeland/West-Brabant and 'other industries' (a sixth cluster which contains remaining industries spread across the country) (Programme Sustainability Industry, n.d.). The government has set up Regional and Cluster-based Energy Strategies (RES & CES) to reduce carbon emissions in Dutch industry. The strategies focus on matching future supply and demand of renewable energy and on obtaining a better understanding of the necessary infrastructure. Additionally, the Dutch government created the 'Multi-year Infrastructure Energy and Climate programme' (MIEK) in 2021. MIEK describes the energy and raw material infrastructural projects that the cabinet plans to implement to accelerate the transition in the industry (Netherlands Enterprise Agency, 2021b).

Dutch industry is characterized by strong integration and cooperation between companies within these industrial clusters and a willingness to engage in open

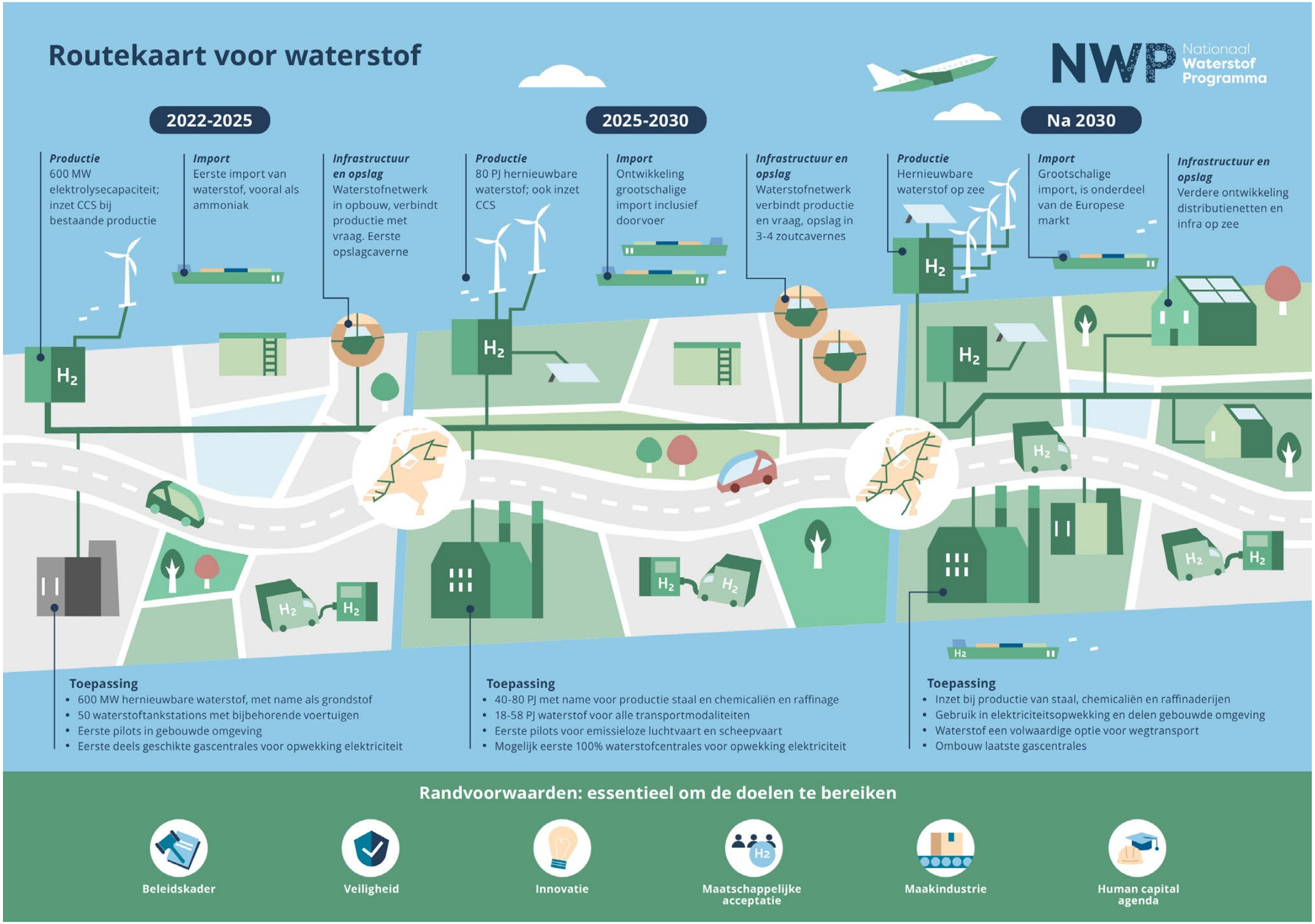

FIGURE 1: SCHEMATIC OVERVIEW OF THE DUTCH HYDROGEN ROADMAP

SOURCE: NATIONAL HYDROGEN PROGRAMME (2022). ROUTEKAART WATERSTOF.

AVAILABLE AT: HTTPS://WWW.NATIONAALWATERSTOFPROGRAMMA.NL/DOCUMENTEN/HANDLERDOWNLOADFILES.ASHX?IDNV=2339011

dialogue and consultation among private sector players. These unique cooperative characteristics create an environment in which innovation can flourish, making the Netherlands a good 'testing ground' for pilot projects. However, it is important to note that the investment climate has recently become less attractive due to changes in the corporate fiscal regime and nitrogen legislation and other permitting issues. National nitrogen policy, introduced to reduce nitrogen emissions and protect biodiversity, make it more difficult and in some cases impossible to get building permits for infrastructural projects in the Netherlands, including projects necessary for the energy transition, like the Porthos project.

PRIORITIZED END-USE SECTORS

The Dutch government believes that clean molecules and in particular low-carbon hydrogen will be necessary for the decarbonization of hard-to-abate industries, seasonal storage, and applications where electrification is not a viable option (Ministry of Economic Affairs and Climate, 2020). In the initial market phase, the supply of hydrogen to heavy industry and for heavy-duty transportation will therefore be prioritized.

Big industrial players are starting to prepare for a hydrogen future. For example, Tata Steel has announced plans to produce steel in the Netherlands using Direct Reduced Iron technology, a process in which iron ores are reduced using natural gas or hydrogen, instead of coal. Tata intends to commence operations before 2030 (Tata Steel, 2021). Shell aims to supply the Shell Energy and Chemicals Park Rotterdam with hydrogen produced via electrolysis in the Holland Hydrogen 1 plant using the HyTransPort gas pipeline in 2025. As the hydrogen heavy-duty truck market grows, Shell also plans to supply hydrogen as a fuel for commercial road transportation (Shell, 2022). Through the Eneco Diamond Hydrogen joint venture, Dutch utility Eneco, jointly with one of its parent companies Mitsubishi, aims to develop, an ultimately, 800 MW electrolyzer plant in the Port of Rotterdam industrial area, implying a future production of 80 kiloton of hydrogen per year (Offshore Energy Magazine, 2023). Although the project still needs to reach FID, construction is envisaged to start in 2026, and first hydrogen could be produced by 2029.

When the low-carbon hydrogen market moves into a later development phase, more sectors could be using hydrogen as an energy carrier. Besides initiatives in the industry and mobility sectors, plans for the first pilot projects in the electricity sector, built environment and agricultural sector are currently being developed; For an extensive list of 165 projects, see the Dutch National Hydrogen Programme (National Hydrogen Programme, n.d.-d; National Hydrogen Programme, n.d.-e).

THE ROLE OF DIFFERENT FORMS OF HYDROGEN PRODUCTION

The Dutch government predominantly focuses on hydrogen produced via electrolysis from renewable electricity and hydrogen made from sustainable biogenic raw materials. Furthermore, there is also room for hydrogen produced from natural gas or residual gases with CCS, as long as this optimally contributes to the development of a broader hydrogen system, without hindering the growth of hydrogen produced via electrolysis from renewable electricity. Hydrogen from natural gas or residual gases with CCS is seen as a cost-effective way to help achieve the 2030 climate targets (National Hydrogen Programme, 2022). However, the current high price of natural gas might hinder the realisation of these plans. In the long-term the focus will be on technologies that reduce emissions to net-zero and replace fossil fuels with biotic and recycled raw material (Government of the Netherlands, 2019).

In the Dutch Climate Agreement of 2019 a target of 4 GW of electrolyser capacity for 2030 was agreed upon (Netherlands Enterprise Agency, 2021a). However, as the Netherlands is determined to reduce its dependence on Russian gas, following the invasion of Ukraine, two former coalition parties (D66 and VVD) proposed to double the already ambitious 2030 electrolyser capacity target to 8 GW (D66 & VVD, 2022). Although hydrogen will not play a role in securing energy supplies soon, it is widely viewed as an important building block for the development of domestic energy carrier production and fuel diversification to increase energy security in the future.

Besides domestic production, the Dutch government set an additional import target of 4 GW[3] of low-carbon hydrogen in 2030. The Netherlands has a rather energy intensive economy combined with a relatively small land area. As hydrogen is expected to fulfil a significant part of the total future energy demand, especially in industry and transportation, it is considered unrealistic to produce all necessary hydrogen domestically (National Hydrogen Programme, n.d.-a). As hydrogen becomes a globally traded commodity, dependence on hydrogen comes with security of supply risks of its own. The Dutch government recognizes the importance of setting up measures to ensure the security of supply of imported hydrogen. Finding the right balance between the development of domestic production and imported flows of low-carbon hydrogen is crucial for a strong and secure hydrogen economy in the Netherlands (Clingendael International Energy Programme, 2022).

3 This is a somewhat unusual unit to quantify hydrogen imports and can be interpreted in various ways. The 4 GW target could represent 1 million tonnes of hydrogen per year ((4 [GW] * 8760 [h]) / 33 [MWh/tonnes]), however, it is not completely clear what the Dutch government means with this target.

POLICIES FOR THE USE OF LOW-CARBON HYDROGEN IN THE INDUSTRIAL SECTOR

The Dutch government has opted for a combination of obligations and subsidies to increase investment security and scale up the low-carbon hydrogen market by 2030 (Ministry of Economic Affairs and Climate, 2020; National Hydrogen Programme, n.d.-c). Currently, with regard to obligation-based policy, the government is exploring possible options to introduce a purchase obligation for low-carbon hydrogen in industry, which would come into effect on 1 January 2026 (National Hydrogen Programme, n.d.-c).

This is intended to ensure that the Netherlands can meet the RED III regulation, which requires that 42 per cent of total hydrogen use for final energy and non-energy purposes in the industry by 2030 is from Renewable Fuels from Non-Biological Origin (European Parliament, 2023). Although, it is unsure whether these kind of volumes will be available in 2030, a purchase obligation would provide hydrogen producers with the necessary demand security to make large scale investments. Furthermore, it would reduce the single dependence on subsidy schemes to achieve the hydrogen target in industry (Ministry of Economic Affairs and Climate, 2020).

Subsidies will provide a targeted means to adjust the market and offset part of the additional costs that come with the transition to low-carbon hydrogen as energy carrier. The financial support schemes are tailored to the various phases of the innovation development process. They are broadly subdivided into the following three categories in the Dutch Government Strategy on Hydrogen: subsidies for applied research and innovative pilot projects, scaling up projects with temporary operating cost support, and roll-out of full-scale projects via the SDE ++ (Ministry of Economic Affairs and Climate, 2020).

As of 2020, the Stimulating Sustainable Energy production and Climate Transition (SDE++) scheme, one of the most important subsidy schemes for realizing large-scale renewable energy or CO_2 reduction projects, includes low-carbon hydrogen projects (Netherlands Enterprise Agency, 2023a). The SDE++ is an operating subsidy scheme. Subsidies are given to technologies that provide the most cost-effective renewable energy or carbon emission reduction. The budget of the SDE++ 2022 has recently been increased to 13 billion euros. The maximum budget for CCS in industry for the SDE++ scheme has been raised for 2022 but will gradually be phased out in the transition to a climate-neutral industry over the years.

Electrolyser projects are currently not the most cost-effective way to reduce carbon emissions, and have so far barely obtained any funding through the SDE++ scheme. Therefore, the Dutch National Growth Fund set up 'greengrowthcapacityNL' (groenvermogenNL) to scale up electrolyser projects and green chemistry ecosystems in the Netherlands. 838 million euros from the National Growth Fund was made available for the first two rounds of projects (Topsector Energy, 2022).

INTERNATIONAL APPROACH

Internationally the Netherlands seeks to position itself as the hydrogen hub of Northwest Europe, connecting Dutch domestic production at the North Sea and international exporters with users in industrial clusters in Northwest Europe. The Port of Rotterdam is currently the most important energy corridor to Northwest Europe and aims to leverage its current position to continue this role in the future hydrogen value chain (Ministry of Economic Affairs and Climate, 2020). Zeeland Port and Eemshaven are also developing hubs based on offshore wind landed in these ports. Nevertheless, Denmark and Belgium have expressed similar ambitions, while also Germany is keen to develop the Wilhelmshafen and Ems delta region for hydrogen hubs. They could be viewed as competitors, although there are also many opportunities for cooperation among these ports and countries. The regional ecosystem of various ports in Europe will help attract global suppliers, for example. Given the scale of the task, the Dutch government views cooperation as essential and is looking for partnerships along the whole value chain on a local, regional and international scale (Netherlands Enterprise Agency, 2021a).

BILATERAL PARTNERSHIPS

Dutch bilateral foreign policy in this field focuses predominantly on cooperation with neighbouring countries and establishing trade relationships with future exporters of low-carbon hydrogen. Together with the German and Belgian governments, the Dutch government is investigating opportunities to collaborate in the production, transportation, and usage of hydrogen. Developments in Germany are especially relevant to the Netherlands, as North Rhine-Westphalia intends to import half of its future hydrogen demand from or via the Netherlands (Eppinga, 2021). An example of current Dutch-German collaboration is the HY3 project, which recently completed a feasibility study (March 2022). They reviewed how Dutch and German offshore wind energy could be used to produce hydrogen, which would then be transported using existing Dutch gas pipelines to Dutch and German industrial clusters (HY3, n.d.). Bilateral cooperation was further underscored in November 2023, when Germany and the Netherlands signed Joint Declarations of Intent to strengthen cooperation in the field of H_2 infrastructure and import. This included a Joint Declaration of Intent to conduct a joint tender under the H2Global instrument (Offshore Energy Magazine, 2023, November 15). Together with the Port of Hamburg and Duisburg, the Port of Rotterdam is seen as a key delivery location for

the international hydrogen flows attracted via the H2Global scheme. Participating in the initiative is important to the Netherlands as it aims to play a role in the development of the first international hydrogen value chains.

As it is of strategic importance to the Netherlands to maintain its current energy hub function in the future low-carbon hydrogen economy, the government and industry are actively pursuing potential import relationships with future prospective exporting countries. It is expected that the first import flows will come from current fossil fuel exporters, such as countries in the Middle East and North America. This is due to the relatively large potential for renewable electricity and the existing networks, infrastructure and expertise that can be utilized in these regions. Shortly thereafter, imports from European countries such as Portugal and Spain are expected to follow. The initial volumes will be small, however, in the future the Netherlands expect to import hydrogen from a growing number of countries within and outside of Europe (National Hydrogen Programme, 2022). The Netherlands was actually the first country to install a dedicated hydrogen envoy and has so far set up exploratory studies and established MoU's with numerous countries for low-carbon hydrogen trade. These countries include Namibia, Chili, South Africa, Canada, Uruguay, Oman, Morocco, Iceland, Spain, Portugal, Brazil, Denmark, Indonesia, Japan, Norway, Saudi Arabia, United Arab Emirates, United States and Australia (see figure 2) (Nationaal Waterstof Programma, n.d.-b).

Two prominent European partnerships should be mentioned here: Cespa and the Port of Rotterdam have recently signed an MoU for a hydrogen corridor connecting Northern and Southern Europe. The corridor is expected to be operational from 2027 and will transport hydrogen derivatives produced in Spain from the Port of Algeciras to the Port of Rotterdam in the Netherlands. The project could contribute to the Port of Rotterdam's target to import 4.6 million tonnes of hydrogen annually into Northwest Europe in 2030 (Raza, 2022). Furthermore, a consortium consisting of ENGIE, Shell, Vopak and Anthony Veder, have agreed to conduct an exploratory study on the production and transportation of liquified hydrogen from Portugal to the Netherlands, with the aim to start delivering liquid hydrogen from the Port of Sines to Rotterdam no later than 2027 (Port of Rotterdam, 2022b).

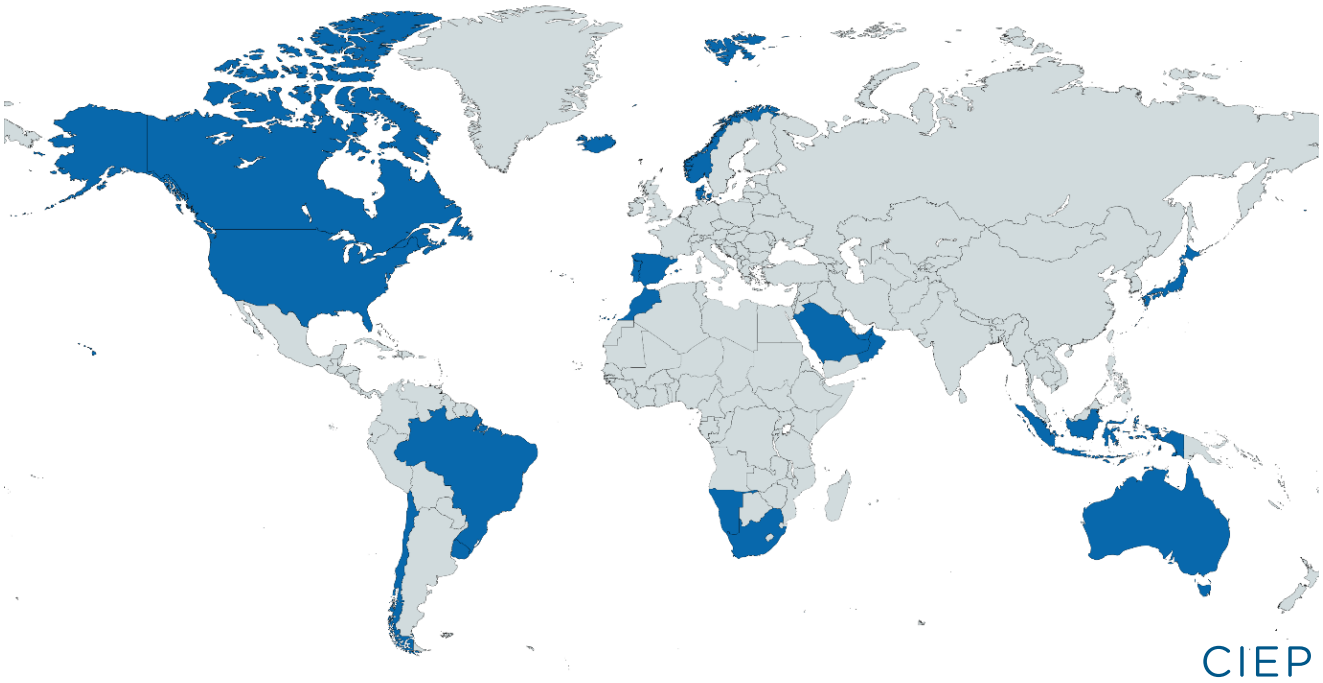

FIGURE 2: DUTCH EXPLORATORY STUDIES FOR COOPERATION AND MOU'S WITH POTENTIAL FUTURE EXPORTING COUNTRIES

MADE BY CIEP, BASED ON DATA FROM NATIONAAL WATERSTOF PROGRAMMA, CREATED WITH MAPCHART.NET

MULTILATERAL PARTNERSHIPS AND POLITICAL DIALOGUE

Besides various bilateral partnerships, the Netherlands is also involved in numerous multilateral partnerships, fora, and initiatives. These include: the Clean Energy Ministerial (CEM), which the Netherlands co-leads together with Canada, the United States, Japan and the European Commission (Clean Energy Ministerial, n.d.); Mission Innovation (MI) and the International Partnership for Hydrogen Fuel Cells in the Economy (IPHE), in which the Netherlands is an active member and participates in R&D related initiatives (Ministry of Economic Affairs and Climate, 2020; Mission Innovation, n.d.); Hydrogen Europe, where the Netherlands is involved in projects such as HyLAW, focused on the removal of legal barriers to the deployment of hydrogen applications, and JIVE2, a joint initiative for hydrogen vehicles in Europe (Hydrogen Europe, n.d.).

Although the Netherlands is an effective participant in the global dialogue and partnership initiatives at various global fora, the main focus of the Dutch international hydrogen strategy is on Europe (Ministry of Economic Affairs and Climate, 2020). European collaboration is seen as crucial to establishing the first international supply chains, as it increases diversification and enables risk sharing of potential

dependencies. The Dutch government therefore supports and will actively participate in the development of the Green Hydrogen Partnerships, Import Corridors and the global European Hydrogen Facility (Ministry of Economic Affairs and Climate, 2022c). According to the Government Strategy on Hydrogen, some of the most important ways of engagement in political dialogue for hydrogen policymaking and cooperation in Europe – besides bilateral contact with neighbouring countries – are assumed to be:

- Continued communication with the *European Commission* about EU hydrogen policy concerning standards for safety, quality, flexible market regulations, sustainability, blending of hydrogen in existing natural gas networks, and innovation support.
- Participation in the *Pentalateral Forum,* consisting of the Benelux, Germany, Austria, Switzerland and France. Here, Austria and the Netherlands have initiated the development of common standards, market regulations, and market incentives prior to the EU discussion, calling on the European Commission to lobby for common global standards on sustainability. Efforts to establish homogenous levels of hydrogen-blending and ensure interoperability between hydrogen networks in Europe are also on the agenda (Pentalateral Energy Forum, 2020).
- Cooperation with *North Sea countries*: The North Sea wind power potential is seen as an essential source of energy for the production of hydrogen in the coming decades. The Netherlands intends to cooperate with North Sea countries through projects like the Sea Wind Power Hub, which aims to harness the North Sea's power potential (Clingendael International Energy Programme, 2021).
- Implementation of *Important Projects for Common European Interest (IPCEI)* focused on hydrogen: On 15 July 2022, the European Commission approved IPCEI Hy2Tech, the first IPCEI to support R&D in the hydrogen technology value chain. The project was initiated and prepared by the Netherlands and fourteen other member states (European Commission, 2022). The Dutch government recently made 1.385 billion euros available for IPCEI hydrogen projects (Government of the Netherlands, 2022a; Ministry of Economic Affairs and Climate, 2020).

One of the most discussed policy topics regarding hydrogen in Europe have been the Delegated acts and specifically the additionality requirements. This has also been a controversial topic in the Netherlands, where it has been met with both praise and opposition. Rob Jetten, Dutch Minister for Climate and Energy Policy, stated on 29 June 2022 that the proposed rules in the delegated acts overall seem to provide the necessary regulatory space for the Dutch hydrogen ambitions (Ministry of Economic

Affairs and Climate, 2022c). He argued that the regulatory proposition provides enough flexibility for short-term projects, while ensuring that over the long-term hydrogen production will not come at the expense of extra renewable electricity on the grid. Although, the Dutch government agreed with the overall idea of the delegated acts, they provided some technical feedback to the Commission on the proposed regulations. See the document "Dutch reaction on European consultation delegated acts renewable hydrogen" for a detailed overview of the feedback (Ministry of Economic Affairs and Climate, 2022a).

Furthermore, there has been considerable pushback recently on the proposed regulations in the Dutch private sector, as companies fear that the regulations are too stringent for the initial phase of market development and are more likely to hinder than enable the low-carbon hydrogen economy from getting off the ground (Clingendael International Energy Programme, 2022). The US Inflation Reduction Act poured fuel on the fire, stirring fears that the combination of strict regulations in the EU and favourable subsidy schemes in the US might cause considerable industry displacement from the EU to the US, creating more demand uncertainty.

SHAPING HYDROGEN INFRASTRUCTURE

In June 2021 Gasunie, the Dutch state-owned natural gas infrastructure and transportation company, received a formal mandate from the Ministry of Economic Affairs and Climate Policy to commence the development of a national hydrogen transport network (The Dutch hydrogen backbone). Gasunie currently operates and owns about 11,700 km of gas pipelines, of which approximately 8,700 km are located in the Netherlands and 3,000 km in Germany (European Hydrogen Backbone, n.d.). The Dutch hydrogen backbone will largely be based on repurposed gas infrastructure and could be complete before 2027. The network will connect the five large industrial hubs in the Netherlands with storage facilities, overseas import, and export to Belgium and Germany (see figure 3). The Dutch hydrogen backbone could have a capacity of approximately 10-15 GW by the end of 2030. The development of the network will take place in multiple phases, a flexible and adaptive approach will be used, based on the needs and development of the hydrogen market (Ministry of Economic Affairs and Climate, 2022b).

Currently HyXchange is being developed, which is a trading platform for hydrogen transported through the Dutch hydrogen backbone, including global import flows and neighbouring countries (HyXchange, n.d.). For this hydrogen exchange to function properly, an open accessible transport infrastructure, a diverse supply of hydrogen and a dependable trading platform are needed. Next to the exchange, long-term contracts are expected to play an important role in the initial phase of market development as the number of suppliers and customers will be limited in the beginning (Clingendael International Energy Programme, 2019).

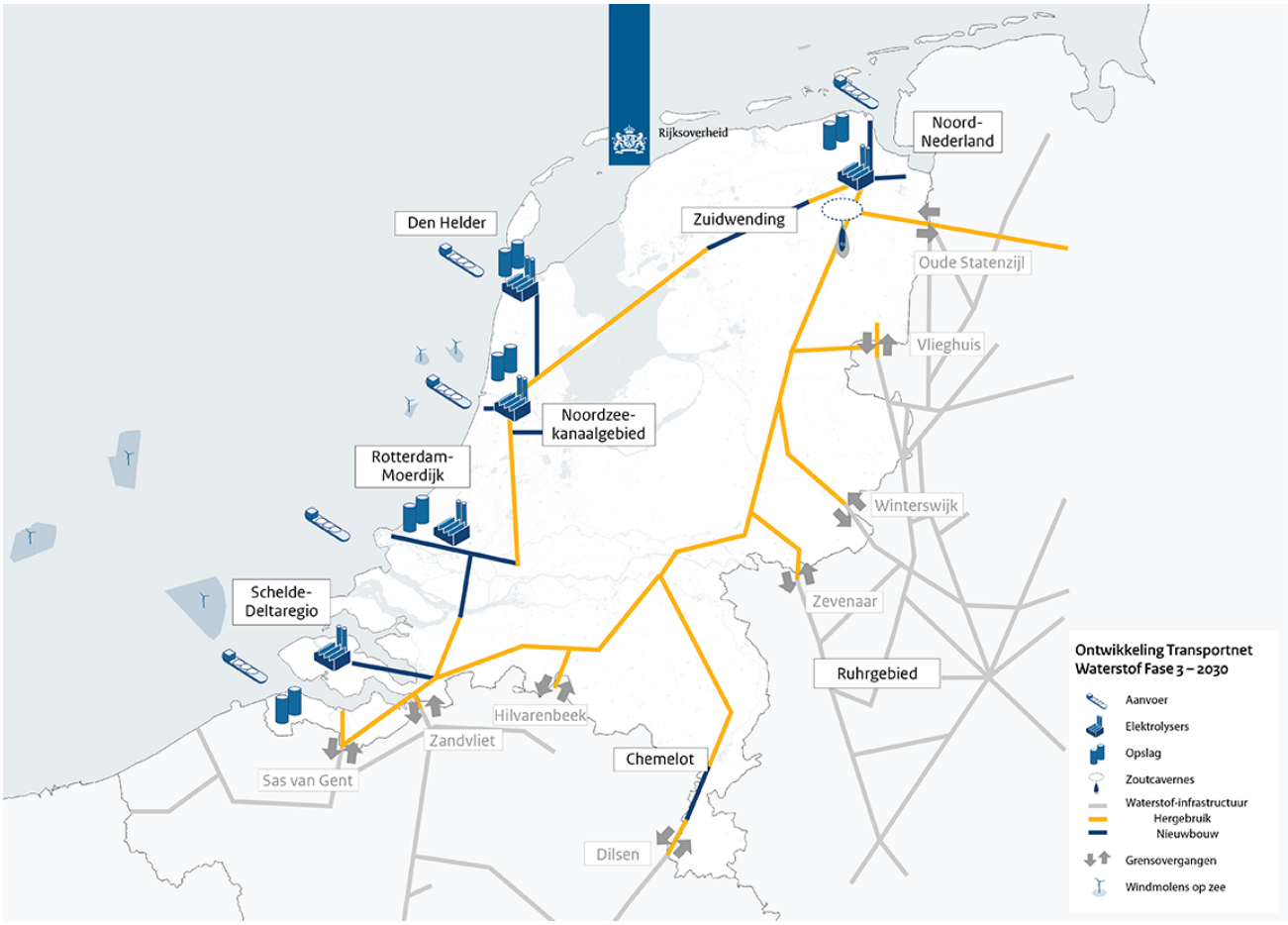

FIGURE 3: THE DUTCH HYDROGEN BACKBONE

SOURCE: MINISTRY OF ECONOMIC AFFAIRS AND CLIMATE (2022). LETTER TO PARLIAMENT ON THE TRANSPORTATION NETWORK FOR HYDROGEN. AVAILABLE AT: HTTPS://OPEN.OVERHEID.NL/REPOSITORY/RONL-5C57A9BA35FA907DCC805CA0DA463DC33B036BB8/1/PDF/ONTWIKKELING-TRANSPORTNET-VOOR-WATERSTOF.PDF.

Besides the Dutch hydrogen backbone, the Delta Corridor, a key infrastructural project for the Netherlands to secure its future position as a European energy hub, is currently being developed. After the completion of an initial feasibility study the project is now entering a second phase, to do a more detailed feasibility study, for which the necessary funding has been obtained. In this initiative the private sector has the lead but is working closely with the EU and the Dutch and German governments. The Delta Rhine Corridor Partners currently consist of Gasunie, OGE, Shell and BASF (Netherlands Enterprise Agency, 2023b). The intended project consists of a bundle of pipelines between the Port of Rotterdam, Chemelot, and the German Rhineland Region.

The Final Investment Decision is expected to be taken before 2026 and the pipeline network is scheduled to enter operation by 2028 (Ministry of Economic Affairs and Climate, 2023b). It will connect large inland industrial clusters in the Netherlands

and Germany with branches along the entire network, providing access to low-carbon hydrogen and CCS capacity (see figure 4). It will supply hydrogen to industrial hubs across, Moerdijk, Geertruidenberg, Chemelot and North Rhine-Westphalia (Gelsenkirchen, Cologne and wider areas). Additionally, in the future the Delta Corridor could also connect industrial hubs in Belgium and further into Germany. The capacity will be based on and grow with demand in Northwest Europe.

FIGURE 4: THE DELTA CORRIDOR

SOURCE: MIEK (2021). MIEK OVERVIEW 2021 MULTIYEAR PROGRAMME INFRASTRUCTURE ENERGY AND CLIMATE. AVAILABLE AT: HTTPS://WWW.RIJKSOVERHEID.NL/DOCUMENTEN/RAPPORTEN/2021/11/26/MEERJARENPROGRAMMA-INFRASTRUCTUUR-ENERGIE-EN-KLIMAAT---OVERZICHT-2021. LAST ACCESSED ON 08.12.2022

Lastly, Gasunie is actively participating in the European Hydrogen Backbone initiative, working together with other European network operators on connecting EU member states with an intercontinental hydrogen network. The Netherlands maintains close contact with Germany and Belgium regarding the potential interconnections, development of the hydrogen network and other possibilities for cooperation.

ANTICIPATING ON THE STAGES OF DEVELOPMENT IN ORGANISING THE LOW-CARBON HYDROGEN ECONOMY

The Dutch government supports the proposals made by the European Commission regarding harmonized rules for the development of a single European market for hydrogen (Ministry of Economic Affairs and Climate, 2022b). However, the regulatory framework may be a mismatch for the initial stages of hydrogen market development (Clingendael International Energy Programme, 2022). The European Union intends to regulate hydrogen in the same way as the natural gas market is regulated today, with legal separation between networks, production and distribution. This model has shown to work relatively well in mature gas markets with various suppliers and buyers operating in the market. However, legal separation might frustrate the hydrogen economy in the first phases of market development as it could hinder supply as well as demand security in a market with only few participants (Clingendael International Energy Programme, 2022).

During the development of the oil and gas industry, supply chains (production, transportation, and distribution) were built by vertically integrated oil companies in consortiums and public-private partnerships. To reduce investment risks for large infrastructural projects like oil and gas exploration and extraction, security of demand is essential. Vertical integration provides the necessary demand security to significantly decrease the risk of oil and gas production investments as well as supply security for buyers. Similar investment securities are necessary for companies that intend to participate in the future low-carbon hydrogen economy (Clingendael International Energy Programme, 2022). The Dutch government is aware that it might be wise to draw lessons from the development of the world oil and gas markets and provide the regulatory space necessary for companies that are willing and able to set up the supply chains to kickstart the hydrogen economy.

MORE DEVELOPMENTS IN 2023

On 3 July 2023, the Minister of Climate and Energy Policy, Rob Jetten, submitted a letter to parliament, which accompanied the draft National Plan Energy System (NPE) (Ministry of Economic Affairs and Climate, 2023a). The NPE consists of a main document and is supported by multiple other documents dealing with various aspects of the future energy system of the Netherlands. According to the draft NPE, electricity should serve as the backbone of the energy system, promoting direct electrification where possible in combination with domestic produced and imported low-carbon hydrogen (carriers). Low-carbon hydrogen will play a crucial role in industry and international mobility, according to the plan.

The plan is focussed on meeting the 2030 and 2050 climate targets but misses to include the phases of development of new value chains. The phases of development involve an introduction, expansion, maturity, and stagnation or decline phase, stretched out over many years. The market organisation in these various phases is very different and each phase requires a different approach to stimulation and regulation (Clingendael International Energy Programme, 2022). Affordability and security of supply will also differ in these phases of development. The EU proposed draft 'gas market and hydrogen regulation' suffers from the same blindness for dynamic market developments. In the case of the EU, they try to hammer an infant low-carbon hydrogen sector into the mould of the mature gas market model, creating a mismatch in risks and benefits along the value chain in the early stages of development. In the case of the draft NPE, it would have helped if they also focused on the logic of the value chain development instead of 2030 and 2050.

In the Netherlands, they are confronted with challenges related to the pace at which offshore wind expansion can occur to realise both the direct electrification of low-temperature heating in the built environment and the powering of passenger cars, as well as fostering domestic production of hydrogen via electrolysis. In the draft NPE, direct electrification is preferred, and scarcity of solar and wind supply will come at the detriment of hydrogen production via electrolysis, increasing the investment risk due to potential low utilization rates. The increased cost of capital and materials, in addition to the risk of low utilization leaves many projects in a pre-FID phase. Towards 2030, the draft NPE foresees some government supported electrolysis hydrogen come on stream, but this is far from enough to meet the RED III requirement to replace 42% of grey hydrogen in industry with domestic supply. Dutch industry, part of the ARRRA-cluster, is relatively energy-intense, Northwest

Europe is home to about 60% of EU hydrogen supply and demand (IEA & CIEP, 2021). Much will depend then on the organisation of imported flows, although also there, the increased capital and material costs may play a role in coming to FID and despite the many MoU's concluded in the past year. Relief can come from the first $7 billion tranche of the American IRA to develop H2Hubs, building on the existing hydrogen infrastructure in Texas (Petroleum Intelligence Weekly, 2023). In addition to increased oil, oil products and LNG imports from the US, imported US low-carbon hydrogen would add to a low level of diversity of supply in the years until more diverse supplies would become available on international markets.

On 17 October 2023, the report Integrale Infrastructuur-Verkenning 2030-2050 (Integral investigation into (Energy) Infrastructure 2030-2050) was published (Netbeheer Nederland, 2023). This study is a stark reminder of the huge infrastructure task to facilitate the Dutch energy transition. Already, electrification of industry and perhaps low temperature heating may be delayed for lack of electricity network capacity in the coming ten years. This applies to both the transportation and the distribution networks. The hydrogen network may offer some relief in these years, but the draft NPE does not take this sufficiently into account, perhaps creating some investment hesitation among companies on the production/import and demand side. Companies wanting to electrify will have to wait maybe a decade to receive larger volumes of power, while companies looking at hydrogen are uncertain about utilization rates and industrial demand uncertainties. The foreseen new energy system also has very large flexibility needs, which in part must come from hydrogen. In the Netherlands energy infrastructure (apart from liquids infrastructure) is run by government-owned companies, forcing the government to invest heavily, while also supporting private companies in the hydrogen value chain in the start-up phase of the value chain. Without infrastructure many of the transition routes cannot materialise. The recent report on energy infrastructure presents the situation in four scenarios, ranging from a very large challenge to an enormous undertaking for the infrastructure companies.

Moreover, in a high-over assessment, the claim on mineral commodities for electrification solutions is substantial. Competition from other countries following the same path may require re-routing, developing substitutes, and prioritizing the energy transition in a more logic step-by-step approach in line with infrastructure developments, rather than pushing everything at the same time and with government managing scarcity. In the present economic climate, with higher cost of capital and materials, there is a risk that planned project timelines are unattainable, forcing the government to re-adjust its policy support when fiscal stress increases. Instead, the government may have to reduce its interventionist stance in appointing preferred sectors of demand for electricity and hydrogen, as outlined in the draft

NPE, and instead allow market forces to do this heavy lifting itself. If this scenario unfolds, markets will determine the preferred consumer of renewable power and low-carbon hydrogen, potentially altering the order of sectorial progress in CO2 reduction. Neighbouring countries may suffer from the same fiscal stress and allow industry to take the lead, while the built environment and perhaps electrification of mobility must take an initial slower route and rely on intermediate solutions such as biofuels and insulation, until network capacities and flexibility solutions have been developed.

At the same time, the Netherlands and Germany signed a letter of intent on 14 November 2023 to launch a joint tender with Germany for renewable hydrogen through the H2Global instrument. The Netherlands reserved 300 million euros for this tender. The Netherlands sees this initiative as an important addition to its import policy. Also, discussions on connecting the Dutch hydrogen back bone to North Rhine Westphalia are ongoing and are meant to facilitate hydrogen transportation from the Netherlands to Germany (Government of the Netherlands, 2023).

CONCLUSIONS

The Netherlands is prepared to be among the driving forces shaping the European low-carbon hydrogen economy. This is shown by the government's hydrogen strategy and established subsidy schemes, but more so by the many hydrogen projects that have been announced and first final investment decisions that have been taken recently. Nevertheless, the recent change in the economic environment may require some adjustment to policy instruments to lure more pre-FID projects into FID in order to build out both a domestic hydrogen sector and import platforms.
An international low-carbon hydrogen economy presents an opportunity for the Netherlands to continue its role as energy corridor to Northwest Europe in a future sustainable European energy system. The Netherlands can contribute to the decarbonization of the continent by connecting industrial clusters in neighbouring countries with hydrogen from international markets. However, nitrogen legislation, lack of available space, and labour market constraints are among the various issues that could yet delay or hinder the development of the low-carbon hydrogen industry in the Netherlands.
Internationally, the Netherlands focuses on cooperation, especially with neighbouring countries. Cooperation with Germany plays a particularly prominent role, especially if a significant share of German demand will have to be met via imports that enter Europe through the Netherlands. However, coordinating timing and coherence along the emerging value chain presents significant challenges. The ability to scale up production and imports will depend, among other things, on whether the necessary infrastructure, regulations, and modifications in the manufacturing industry in the wider hinterland, are in place. Intensive cooperation between all players in the chain, both nationally and internationally is required to implement a policy framework that will lead to investments in the short-term.
The Dutch government fully supports setting up harmonized rules for the development of the EU hydrogen market. However, the natural gas market model currently proposed for the low-carbon hydrogen market – legally separating production, networks and distribution – might not match with the requirements for companies in the initial stages of market development. Instead, the EU should be more open to a variety of market structure models befitting the introduction and early expansion phase of low-carbon hydrogen. The recent highly ambitious RED III targets for the industry should stimulate rather than frustrate the low-carbon hydrogen market development. It should allow for a wider variation of CO2 emission

reduction technologies in the hydrogen sector, to pave the way for no-carbon hydrogen markets in the Netherlands and its neighbours without losing sight of the CO2-emission reduction targets.

BIBLIOGRAPHY

Aramis (2023, June 22). *Arami Welcomes Dutch-Belgian Agreement.* Retrieved November 6, 2023, from https://www.aramis-ccs.com/news/aramis-verwelkomt-nederlands-belgisch-akkoord-over-grensoverschrijdend-transport-van-co2

BP (2022, June 28). *bp Statistical Review of World Energy 2022* | *71st edition.* Retrieved November 23, 2022, from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Clean Energy Ministerial. *Hydrogen.* Retrieved November 23, 2022, from https://www.cleanenergyministerial.org/initiatives-campaigns/hydrogen-initiative/

Clingendael International Energy Programme (2019, October). *From an invisible to a more visible hand? Hydrogen and electricity: towards a new energy system backbone.* Retrieved November 23, 2022, from https://www.clingendaelenergy.com/inc/upload/files/CIEP_Paper_2019_2B_web.pdf

Clingendael International Energy Programme (2021, April). *Hydrogen in North-Western Europe, a vision towards 2030*. Retrieved November 23, 2022, from https://www.clingendaelenergy.com/inc/upload/files/NW-Europe-Hydrogen-Final.pdf.

Clingendael International Energy Programme (2022, July). *Managing future security of low-carbon hydrogen supply.* Retrieved November 23, 2022, from https://www.clingendaelenergy.com/inc/upload/files/CIEP-Paper-202201-web-2.pdf

Correljé, A., Van der Linde, C., & Westerwoudt, T. (2003). *Natural gas in the Netherlands. From cooperation to competition?*. Retrieved from https://www.clingendaelenergy.com/inc/upload/files/Book_Natural_Gas_in_the_Netherlands.pdf

D66 & VVD (2022, April). *Nederland als waterstofkoploper - actieplan VVD-D66.* Retrieved November 23, 2022, from https://d66.nl/wp-content/uploads/2022/04/Nederland-als-waterstofkoploper-actieplan-VVD-D66.pdf

Eppinga, A. (2021, August 28). *Germany is fully committed to hydrogen, and the Netherlands should follow suit.* Retrieved November 22, 2022, from https://innovationorigins.com/en/germany-is-fully-committed-to-hydrogen-and-the-netherlands-should-follow-suit/

European Commission (2022, July 15). *State Aid: Commission approves up to 5.4 billion euro of public support by fifteen Member States for an Important Project of Common European Interest in the hydrogen technology value chain.* Retrieved November 23, 2022, from https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4544

European Hydrogen Backbone. *Country Narratives.* Retrieved November 22, 2022, from https://ehb.eu/page/country-specific-developments

European Parliament (2023, April). *EU Rules for Renewable Hydrogen*. Retrieved November 6, 2023, from https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/747085/EPRS_BRI(2023)747085_EN.pdf

Government of the Netherlands. *Afbouw gaswinning Groningen*. Retrieved November 22, 2022, from https://www.rijksoverheid.nl/onderwerpen/gaswinning-in-groningen/afbouw-gaswinning-groningen#:~:text=Afbouw%20gaswinning%20naar%20nul&text=Vanaf%20oktober%202022%20staat%20het,winter%20of%20bij%20grote%20leveringsproblemen

Government of the Netherlands (2015, December 15). *Policy Document on the North Sea 2016-2021.* Retrieved November 22, 2022, from https://www.government.nl/binaries/government/documenten/policy-notes/2015/12/15/policy-document-on-the-north-sea-2016-2021/nz-eng-beeldscherm.pdf

Government of the Netherlands (2019, June 28). *Klimaatakkoord.* Retrieved November 22, 2022, from https://www.klimaatakkoord.nl/binaries/klimaatakkoord/documenten/publicaties/2019/06/28/klimaatakkoord/klimaatakkoord.pdf

Government of the Netherlands (2022a, July 15). *Kabinet trekt extra 1,3 miljard uit voor waterstofprojecten*. Retrieved November 22, 2022, from https://www.rijksoverheid.nl/actueel/nieuws/2022/07/15/kabinet-trekt-extra-13-miljard-uit-voor-waterstofprojecten

Government of the Netherlands (2022b, September 26). *Gaskraan Groningen op waakvlam.* Retrieved November 22, 2022, from https://www.rijksoverheid.nl/actueel/nieuws/2022/09/26/gaskraan-groningen-op-waakvlam

Government of the Netherlands (2023, November 14). *Duitsland en Nederland versterken samenwerking op gebied waterstof. Retrieved November 16, 2023 from* https://www.rijksoverheid.nl/actueel/nieuws/2023/11/14/duitsland-en-nederland-versterken-samenwerking-op-gebied-waterstof#:~:text=Nederland%20en%20Duitsland%20leggen%20elk,van%20hernieuwbare%20waterstof%20vanaf%202027

Hydrogen Europe. *EU projects - Hydrogen Europe*. Retrieved November 22, 2022, from https://hydrogeneurope.eu/eu-projects/

HyXchange. *About us.* Retrieved November 22, 2022, from https://hyxchange.nl/about/.

HY3. *Decarbonizing the Dutch & German Industry through hydrogen.* Retrieved November 22, 2022, from https://hy3.eu/.

H-vision. *Using hydrogen to make large and fast cuts in carbon emissions*. Retrieved November 22, 2022, from https://www.h-vision.nl/en

IEA & CIEP (2021, April). *Hydrogen in North-Western Europe, A vision towards 2030.* Retrieved November 14, 2023, from https://www.clingendaelenergy.com/inc/upload/files/NW-Europe-Hydrogen-Final.pdf

IRENA (2022, January 15). *Geopolitics of the Energy Transformation: The Hydrogen Factor*. Retrieved November 22, 2022, from https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen.

Meijer, B. (2022, November 2). Dutch court carbon capture project ruling alarms building sector. *Reuter*. https://www.reuters.com/world/europe/dutch-court-says-permits-major-carbon-storage-project-are-uncertain-2022-11-02/

MIEK (2021, November 22). *MIEK overview 2021 Multiyear programme Infrastructure Energy and Climate*. Retrieved December 8, 2022, from https://www.rijksoverheid.nl/documenten/rapporten/2021/11/26/meerjarenprogramma-infrastructuur-energie-en-klimaat---overzicht-2021

Ministry of Economic Affairs and Climate (2020, April 6). *Government Strategy on Hydrogen.* Retrieved November 22, 2022, from https://www.government.nl/documents/publications/2020/04/06/government-strategy-on-hydrogen.

Ministry of Economic Affairs and Climate (2022a, June 28). *Nederlandse reactie op de publieke internetconsulatie door de Europese Commissie.* Retrieved November 22, 2022, from https://open.overheid.nl/repository/ronl-1c27dc1e0ab3ace66554a763d09eadb2c70d0362/1/pdf/22229490bijlage-3-nederlandse-reactie-op-europese-consultatie-gedelegeerde-handelingen-hernieuwbare-waterstof.pdf

Ministry of Economic Affairs and Climate (2022b, June 29). *Kamerbrief over ontwikkeling transportnet voor waterstof.* Retrieved November 22, 2022, from https://open.overheid.nl/repository/ronl-5c57a9ba35fa907dcc805ca0da463dc33b036bb8/1/pdf/ontwikkeling-transportnet-voor-waterstof.pdf.

Ministry of Economic Affairs and Climate (2022c, June 29). *Kamerbrief voortgang ordening en ontwikkeling waterstofmarkt*. Retrieved November 22, 2022, from https://open.overheid.nl/repository/ronl-c369632dae73cb4ed9dd9e8e4af10e64e74ae1f9/1/pdf/voortgang-ordening-en-ontwikkeling-waterstofmarkt.pdf

Ministry of Economic Affairs and Climate (2022d, December 9). *Kamerbrief over garantieregeling Porthos.* Retrieved November 22, 2022, from https://www.rijksoverheid.nl/onderwerpen/klimaatverandering/documenten/kamerstukken/2022/12/09/garantieregeling-porthos.

Ministry of Economic Affairs and Climate (2023a, July 3). *Concept-Nationaal Plan Energiesysteem: Hoofddocument.* Retrieved November 22, 2022, from https://www.rijksoverheid.nl/documenten/rapporten/2023/07/03/bijlage-1-hoofddocument-concept-npe

Ministry of Economic Affairs and Climate (2023b, October 5). *Voortgang Delta Rhine Corridor.* Retrieved November 22, 2022, from https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2023Z16805&did=2023D40820

Mission Innovation. *Catalysing clean energy solutions for all.* Retrieved November 22, 2022, from http://mission-innovation.net/.

National Hydrogen Programme (2022, November). *Routekaart.* Retrieved November 22, 2022, from https://nationaalwaterstofprogramma.nl/documenten/handlerdownloadfiles.ashx?idnv=2339011.

National Hydrogen Programme (a*). Import en export.* Retrieved November 22, 2022, from https://nationaalwaterstofprogramma.nl/themas/thema+import+en+export/default.aspx.

National Hydrogen Programme (b). *Internationale Samenwerking.* Retrieved November 22, 2022, from https://www.nationaalwaterstofprogramma.nl/kennisbank/2543118.aspx?t=Internationale-samenwerking

National Hydrogen Programme (c). *Subsidiemogelijkheden waterstof.* Retrieved November 22, 2022, from https://nationaalwaterstofprogramma.nl/kennisbank/2244223.aspx?t=Subsidiemogelijkheden-waterstof

National Hydrogen Programme (d). *Thema's.* Retrieved November 22, 2022, from https://nationaalwaterstofprogramma.nl/themas/default.aspx

National Hydrogen Programme (e). *Waterstofprojecten.* Retrieved November 22, 2022, from https://nationaalwaterstofprogramma.nl/kennisbank/2215926.aspx?t=Waterstofprojecten.

Netbeheer Nederland (2023). *Integrale Infrastructuur-Verkenning 2030-2050.* Retrieved November 22, 2022, from https://www.netbeheernederland.nl/_upload/RadFiles/New/Documents/A%20II3050%20Eindrapport%203.pdf

Netherlands Enterprise Agency (2021a, March). *Excelling in Hydrogen.* Retrieved November 22, 2022, from https://www.rvo.nl/sites/default/files/2021/03/Dutch solutions for a hydrogen economy.pdf.

Netherlands Enterprise Agency (2021b, April 26). *Programma Energyhoofdstructuur*. Retrieved November 22, 2022, from https://www.rvo.nl/sites/default/files/2021/04/Concept-Notitie-Reikwijdte-en-Detailniveau-Programma-Energiehoofdstructuur.pdf.

Netherlands Enterprise Agency (2021c, November 18). *Aramis.* Retrieved November 6, 2023, from https://www.rvo.nl/onderwerpen/bureau-energieprojecten/lopende-projecten/aramis#projectfase.

Netherlands Enterprise Agency (2023a, January 27). *Stimulering Duurzame Energieproductie en Klimaattransitie (SDE++).* Retrieved November 13, 2023, from https://www.rvo.nl/subsidies-financiering/sde?gclid=Cj0KCQjwxveXBhDDARIsAI0Q0x2yDvlyPafxqRxTifQs8-BsbzICfJ3zU-cydvQk8IGC5Yxu00Pr45MaAsEAEALw_wcB

Netherlands Enterprise Agency (2023b, February 3). *Delta Rhine Corridor.* Retrieved November 22, 2023, from https://www.rvo.nl/onderwerpen/bureau-energieprojecten/lopende-projecten/drc

NortH2. *Kickstarting the green hydrogen economy*. Retrieved November 22, 2022, from https://www.north2.eu/en/

Offshore Energy Magazine (2023, November 20). *Eneco plans to build 800 MW green hydrogen plant in Europoort.* Retrieved November 20, 2023, from https://www.offshore-energy.biz/eneco-plans-to-build-800-mw-green-hydrogen-plant-in-europoort/

Offshore Energy magazine (2023, November 15). *The Netherlands and Germany bolster hydrogen ties.* Retrieved November 20, 2023, from https://www.offshore-energy.biz/the-netherlands-and-germany-bolster-hydrogen-ties/#:~:text=The%20aim%20is%20to%20secure,of%20green%20hydrogen%20from%202027.

Pentalateral Energy Forum (2020, May 11). *Joint political declaration of the pentalateral energy forum on the role of hydrogen to decarbonise the energy system in Europe*. Retrieved November 22, 2022, from https://zoek.officielebekendmakingen.nl/blg-939618.pdf.

Petroleum Intelligence Weekly (19 October 2023).

Port of Rotterdam (2022a, April 6). *Broad industry support for Delta Corridor project.* Retrieved November 22, 2022, from https://www.portofrotterdam.com/en/news-and-press-releases/broad-industry-support-for-delta-corridor-project

Port of Rotterdam (2022b, July 18). *Renewable liquid hydrogen supply chain between Portugal and Netherlands on the horizon.* Retrieved December 13, 2022 from https://www.portofrotterdam.com/en/news-and-press-releases/renewable-liquid-hydrogen-supply-chain-between-portugal-and-netherlands-on

Port of Rotterdam (a). *Import of hydrogen.* Retrieved November 22, 2022 from https://www.portofrotterdam.com/en/port-future/energy-transition/ongoing-projects/hydrogen-rotterdam/import-of-hydrogen.

Port of Rotterdam (b). *Refining and Chemicals*. Retrieved November 22, 2022 from https://www.portofrotterdam.com/en/setting/industry-port/refining-and-chemicals.

Programme sustainability industry. *Industrieclusters.* Retrieved November 22, 2022 from https://www.verduurzamingindustrie.nl/industrieclustersre/industrieclusters/default.aspx.

Raad van State (2022, November 2). *Bouw vrijstelling stikstof van tafel, maar geen algehele bouw stop.* Retrieved November 22, 2022 from https://www.raadvanstate.nl/actueel/nieuws/@133608/bouwvrijstelling-stikstof-van-tafel/ - highlight=porthos

Raad van State (2023, Augustus 16). *Porthos-project Mag Doorgaan.* Retrieved November 6, 2022 from https://www.raadvanstate.nl/actueel/nieuws/augustus/porthos-project-uitspraak/

Raza, R. (2022, October 13). Port of Rotterdam and Cespa Sign MoU for a Green Hydrogen Corridor. *Fleetmon.* https://www.fleetmon.com/maritime-news/2022/39829/port-rotterdam-and-cespa-sign-mou-green-hydrogen-c/

RWE. *H2opZee.* Retrieved November 23, 2022 from https://www.rwe.com/en/research-and-development/hydrogen-projects/h2opzee

Shell (2022, July 6). *Shell start bouw van Europa's grootste groene waterstoffabriek in Rotterdam*. Retrieved October 16, 2022 from https://www.shell.nl/media/nieuwsberichten/2022/holland-hydrogen-1.html

Tata Steel (2021, October 30). *Klimaatambities.* Retrieved October 20, 2022 from https://www.tatasteeljobs.nl/nieuwsberichten/2021/klimaatambities.html

TNO (2020, June). *The Dutch hydrogen balance, and the current and future representation of hydrogen in the energy statistics.* Retrieved October 20, 2022 from https://repository.tno.nl/islandora/object/uuid%3A77b361fb-0598-40aa-8be2-97e1f6e73ce5.

Topsector Energy (2020, May 1). *Overview of Hydrogen Projects in the Netherlands*. Retrieved October 20, 2022 from https://www.topsectorenergie.nl/sites/default/files/uploads/TKI Gas/publicaties/Overview Hydrogen projects in the Netherlands versie 1mei2020.pdf.

Topsector Energy (2022). G*eld uit het Nationaal Groeifonds voor innovatie waterstof en duurzame materialen.* Retrieved October 23, 2022 from https://www.topsectorenergie.nl/nieuws/geld-uit-het-nationaal-groeifonds-voor-innovatie-waterstof-en-duurzame-materialen

van der Linde, C., Stapersma, P. (2018). *The Dutch energy economy: the energy gateway to Northwest Europe.* Retrieved October 20, 2022 from https://spectator.clingendael.org/pub/2018/2/the-dutch-energy-economy/

CLINGENDAEL INTERNATIONAL ENERGY PROGRAMME | CIEP

ADDRESS

Breitnerlaan 299
2596 HA The Hague,
The Netherlands

+31 70 374 67 00
www.clingendaelenergy.com
ciep@clingendaelenergy.com