Interreg
North Sea Region
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European Regional Development Fund

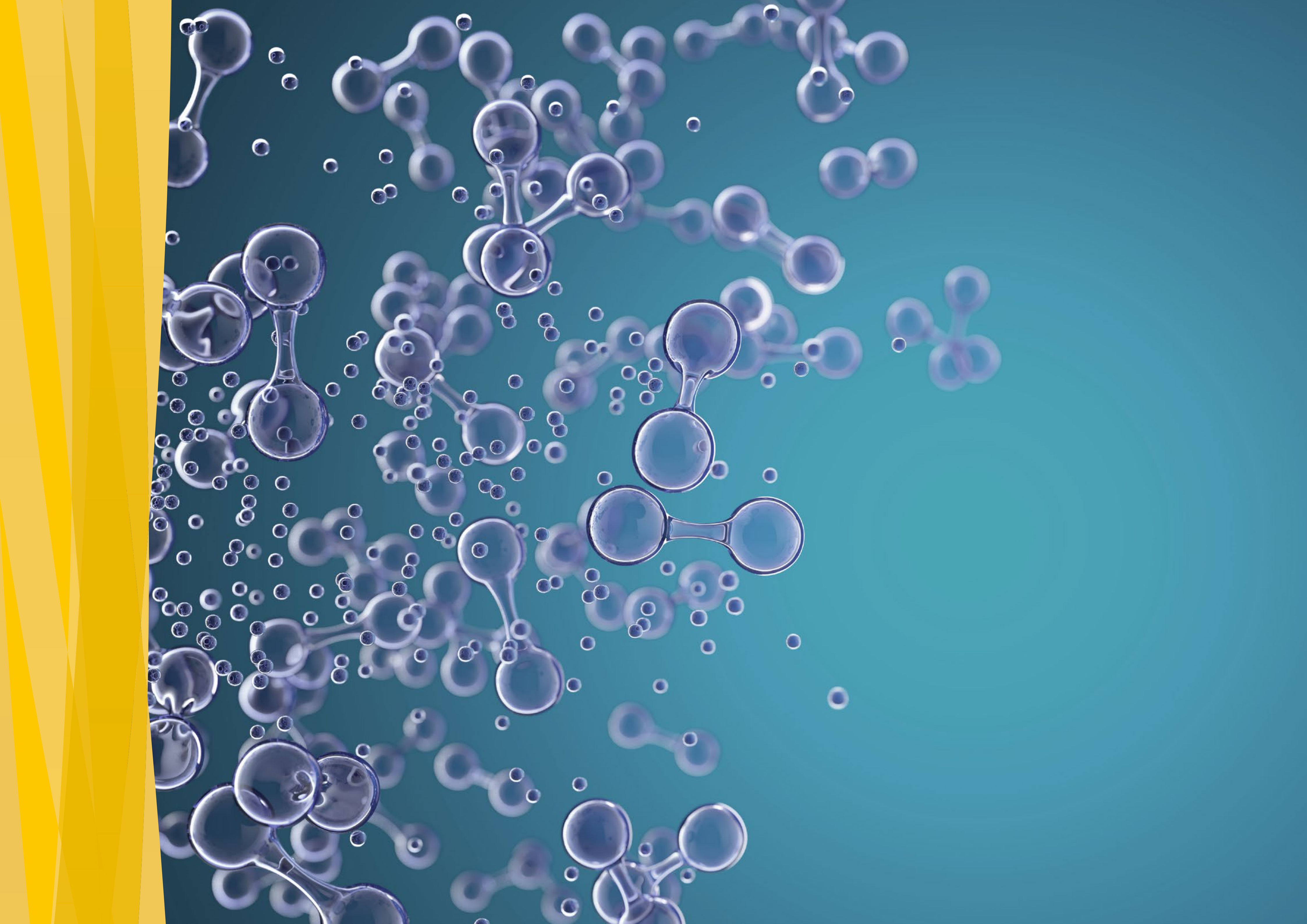
EUROPEAN UNION

# Green Hydrogen
# State of the Nations Summary Report

**ALL NATIONS SUMMARY**

**A report highlighting the Status and Development of the Green Hydrogen Landscape in the North Sea Region, featuring Belgium, the UK, Germany, and the Netherlands.**

**SEPTEMBER 2022**



# 1. Contents

# 1. Introduction

## About Inn2POWER

This report has been produced by the international partnership Inn-2POWER and provides a snapshot of the current green hydrogen landscape in the UK, Belgium, Netherlands, and Germany. Combining the forces of nine partners in four countries of the North Sea region, the aim of Inn2POWER is to expand the capacity for innovation and improve access to the offshore wind industry and green hydrogen for SMEs by connecting offshore wind and green hydrogen businesses in the North Sea region.

The vision is to strengthen the North Sea Regions through supporting SMEs to collaborate and enter new markets through Inn2POWER's company directory, focusing on offshore wind and green hydrogen; grant easy access to test and demonstration facilities; and improve knowledge, skills and availability of qualified staff.

## About the Authors

**Belgium:**

POM West Flanders
Port of Oostende
Blue Cluster
Waterstofnet

**United Kingdom:**

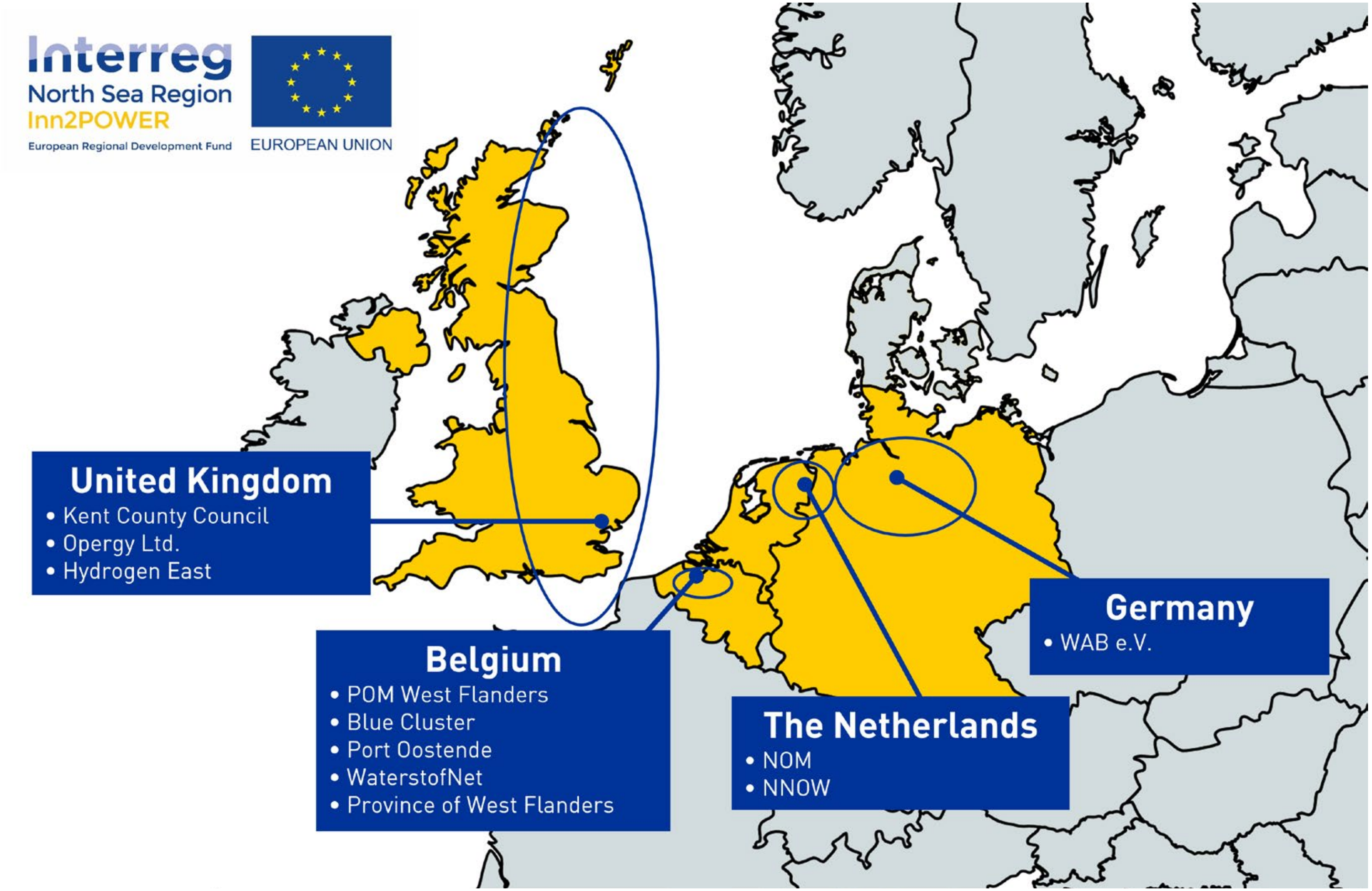
Opergy
Hydrogen East
Kent County Council

**Germany:**

WAB

**Netherlands:**

NOM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• Kent County Council
• Opergy Ltd.
• Hydrogen East
Belgium
• POM West Flanders
• Blue Cluster
• Port Oostende
• WaterstofNet
• Province of West Flanders
The Netherlands
• NOM
• NNOW
Germany
• WAB e.V.

# 2. Defining Green Hydrogen

The source of power used to drive the process of hydrogen production is commonly referred to using a colour-code. "Green hydrogen" refers to hydrogen production powered by low-carbon and renewable sources of power. The below table[1] gives an overview of the different types of hydrogen production.

| Colour | Process | Impact |
|---|---|---|
| **Green Hydrogen** | Electrolysis, using renewable energy to split water into its component parts (H2 + O2) emitting ze-ro-CO2. | No harmful greenhouse has emissions, ability to "store" surplus electricity from renewable sources. |
| **Pink, Purple or Red Hydrogen** | As green hydrogen, using nuclear power instead of renewable energy. | No carbon emissions, ability to "store" surplus electricity. |
| **Yellow Hydrogen** | Yellow hydrogen is a relatively new phrase for hy-drogen made through electrolysis using solar power. | Cleanest (alongside wind) man made gas via electrolysers. Long term sustainability, a favourite in the quest for a circular economy. |
| **Black and Brown Hydrogen** | Gasification, using black coal or lignite (brown coal) to heat water and break it down. Also known as "town gas". | Along with the component parts of water, other harmful elements are produced: carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and ethylene (C2H4). |
| **Grey Hydrogen** | Steam Methane Reforming (SMR), using methane to heat water and break it down and emitting CO2 as by-product. | As above, produces other harmful elements: CH4 and CO2. |
| **Blue Hydrogen** | Steam Methane Reforming (SMR) and passing CO2 through carbon capture, use and storage (CCUS). | Grey hydrogen but with carbon capture so it is seen as a lower carbon option. |
| **Turquoise Hydrogen** | Using Methane Pyrolysis, natural gas is passed through a molten metal that releases hydrogen and solid carbon using renewable energy. | Solid carbon can be used for industrial applications, so it is seen as a lower carbon option. |
| **White hydrogen** | Naturally-occurring geological hydrogen found in underground deposits and created through fracking. | - |

1 The hydrogen colour spectrum - National Grid

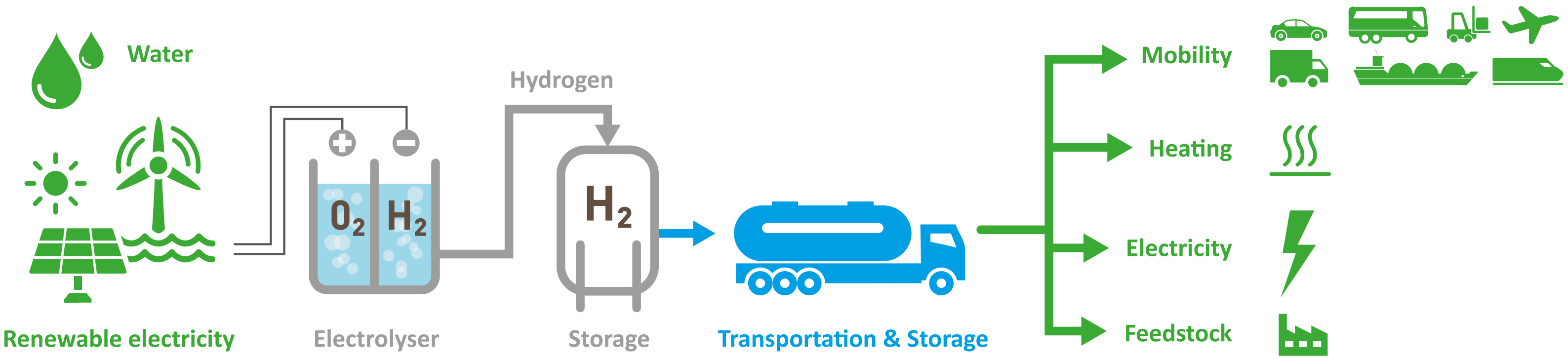
## Defining Green Hydrogen Across the North Sea Region

For the Inn2POWER project and this report, we are focused on the developing green hydrogen sector across the North Sea Region (NSR).

At a European level, in the *EU Hydrogen Strategy; A case for urgent action towards implementation*[2], published in July 2020, green hydrogen is defined as "hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources." It also notes the full life-cycle greenhouse gas emissions of its production are close to zero and that it can be produced through the reforming of biogas or biochemical conversion of biomass too.

Looking closer at the respective countries covered in this report, definitions for green hydrogen are outlined in strategy and policy documents published by each:

Hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources




2 EU Hydrogen Strategy; A case for urgent action towards implementation - Oxford Institute for Energy Studies

**The UK**[3]**:** Hydrogen which is produced through electrolysis, where electricity is used to split water into hydrogen and oxygen - gas from this process is often referred to as green hydrogen or zero carbon hydrogen when the electricity comes from renewable sources. Hydrogen production via nuclear powered electrolysis is also considered within the scope of green hydrogen under the UK's definition.

**Germany**[4]**:** The Federal Government considers only hydrogen that has been produced using renewable energy (green hydrogen) to be sustainable in the long term. It therefore seeks to use green hydrogen, promote its rapid market rollout and establish the necessary value chains.

**The Netherlands & Belgium**[5]: Both countries seemingly use the EU definitions, with hydrogen papers published by the government of the Netherlands covering the existing state of the nation and market for hydrogen (transport, electricity, agriculture, buildings, etc.)

3 UK Hydrogen Strategy - UK government
4 Nationales Reformprogramm 2020 - Die Bundesregierung
5 Government Strategy on Hydrogen - Government of the Netherlands

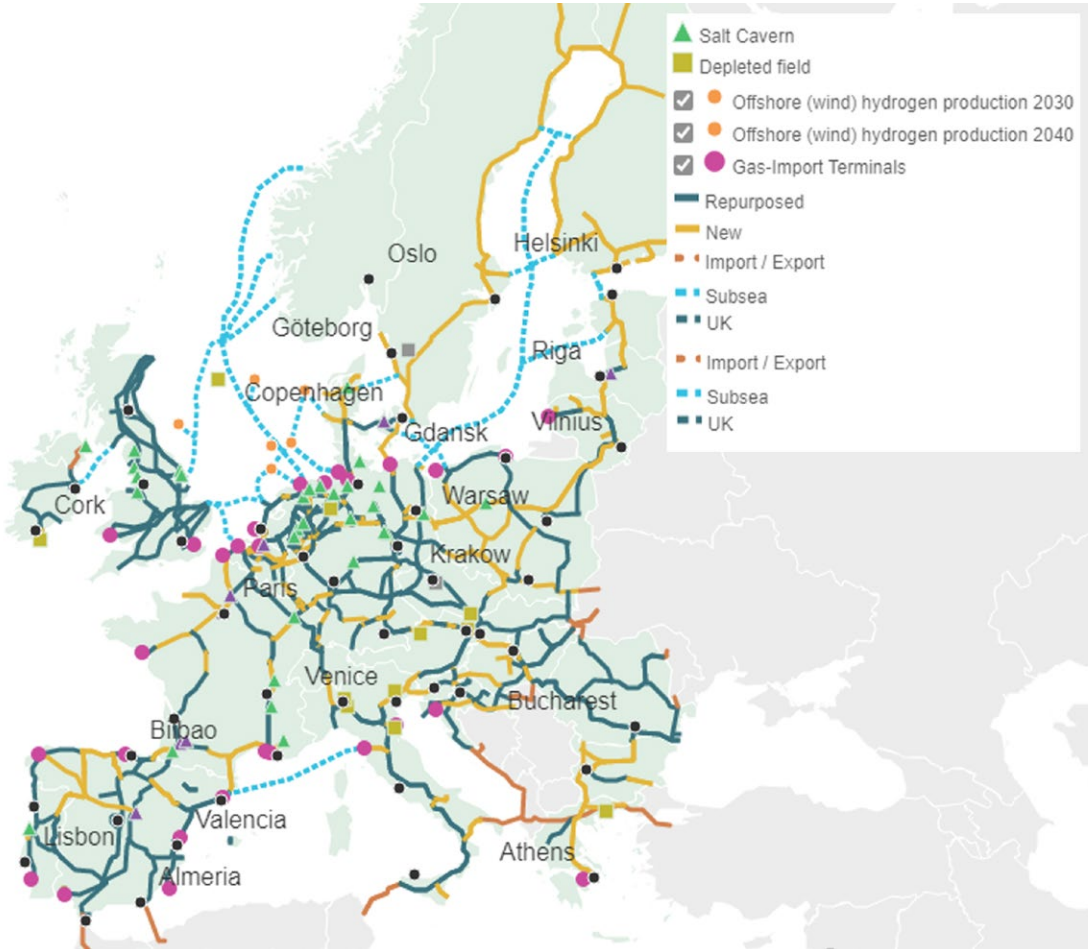
# 3. The Green Hydrogen Policy Landscape

## The European Hydrogen Backbone

Before summarising the key developments across the UK, Germany, Netherlands and Belgium, a development in which they all feature is that of the European Hydrogen Backbone[6]. Made up of 31 energy infrastructure operators, including **Fluxys** (Belgium), **ONTRAS** and **OGE** (Germany), **National Grid** (UK) and **Gasunie** (Netherlands), the vision of the EHB is for a climate-neutral Europe, enabled by a competitive, liquid, pan-European renewable and low-carbon hydrogen market.

As it stands, the vision for the EHB is that of five pan-European hydrogen supply and import corridors emerging by 2030, connecting industrial clusters, ports and hydrogen valleys to regions of abundant hydrogen supply, helping to support the **European Commission's** ambition for the development of a 20.6Mt renewable and low-carbon hydrogen market in Europe[7]. This infrastructure would then grow to become a pan-European network, spanning almost 53,000km by 2040, primarily based on repurposed existing natural gas infrastructure.

It has an estimated total investment of €80-134bn, with this figure including subsea pipelines and interconnectors linking countries to offshore energy hubs and potential export regions. It also estimates that transporting hydrogen over 1,000km along the proposed onshore back-




*European Hydrogen Backbone*

6 The European Hydrogen Backbone (EHB) initiative - EHB
7 REPowerEU - European Commission

bone would cost €00 of hydrogen, making the EHB "the most cost-effective option for large-scale, long-distance hydrogen transport".

The EHB has identified 12MT of domestic supply - enough to exceed the **European Commission's** REPowerEU target by 20% - as well as 5.4MT of supply from non-EU neighbouring countries, along with 14.7MT of demand. It means five supply corridors will be key to the EHB vision, initially connecting local supply and demand in different parts of Europe, before then expanding and connecting Europe with neighbouring regions with export potential. These corridors are North Africa & Southern Europe; Southwest Europe & North Africa; North Sea; Nordic and Baltic regions; and East and South-East Europe. It is Corridor C (North Sea) perhaps

most relevant to this report. This includes hydrogen supply from ongoing and planned offshore wind, blue hydrogen and large-scale integrated hydrogen projects in the North Sea and would meet demand from industrial clusters and ports in the **UK**, **Netherlands**, **Belgium**, and **Germany**.

This corridor is likely to see imports of hydrogen derivatives such as ammonia, methanol and liquid hydrogen shipped to meet demand around the industrial clusters and **Ports of Rotterdam**, **Zeebrugge**, **Antwerp**, **Wilhemshaven**, **Brunsbüttel** and **le Havre**. The **Netherlands**' national backbone was noted as being set to be ready by 2027, connecting all industrial clusters, storage facilities and neighbouring network operators - **Germany** and **Belgium** - before then functioning as a ring network from 2030, while in **Germany**, hydrogen clusters in the **North-West**, **Ruhr area** and in the **East**, the **Central German Chemical Triangle**, are all expected to develop and be interconnected and linked to hydrogen networks in other North-West European countries.

A **Belgian national hydrogen backbone** is expected to emerge through developments in and around the industrial clusters of **Antwerp** and **Ghent**, as well as the industrial valley in **Wallonia**. Port-to-port interconnections with the Netherlands are likely, given the proximity between **Antwerp** and **Rotterdam**, while imports and exports with all neighbouring countries by 2040 could be possible with hydrogen demand expected to exceed production capacity. Imports through the **Zeebrugge terminal** could be crucial to shaping the North-Western European Hydrogen infrastructure development.

In terms of how the **UK** features here, four of the five industrial clusters could be connected and form the basis of a **GB hydrogen transmission backbone** by 2030. There could also be connections to **St Fergus** in north Scotland and **Bacton** on the east coast. A converted pipeline to **Bacton** could then enable future hydrogen flows across interconnectors between GB and Belgium and GB and the Netherlands, once ready.

## National Policy Landscapes

The **UK** has committed to taking a twin-track approach[8] to developing hydrogen, meaning both green and blue hydrogen will be pursued, but there is growing emphasis on the former, as evidenced by its new 10GW low carbon hydrogen production capacity target 2030, with "at least" half coming from green hydrogen, as per the *Energy Security Strategy*[9] published in April 2022.

**Germany** has a *National Hydrogen Strategy* (NWS)[10] which aims to

8 UK Hydrogen Strategy - UK Government
9 British Energy Security Strategy - UK Government
10 The National Hydrogen Strategy - Federal Ministry for Economic Affairs and Climate Action

establish green hydrogen and its derived products, with elements including a Hydrogen Research Network and National Hydrogen Council, along with targets for 5GW of production capacity by 2030 and a further 5GW by 2035, or 2040 at the latest. A Network Development Plan 2022-2032 is expected to be published later this year[11] with updated hydrogen networks.

## In the case of each country, hydrogen is seen as an important part of their respective decarbonisation journeys.

Earthquakes caused by extraction of the Groningen gas field have left the **Netherlands** wanting to shift away from being a leading European natural gas provider, with hydrogen seen as a viable alternative pathway to ensuring 20,000 jobs in that industry do not go to waste.

The *Kabinetsvisie Waterstof*[12] sets out how hydrogen can help to decarbonise sectors struggling to move away from fossil fuels. Both green and blue hydrogen are tipped to play a key role, while the *Nationaal Waterstof Programma*[13] describes the implementation of hydrogen plans for 2022-25, connecting national and local developments, ensuring all lines related to hydrogen development align.

In **Belgium**, meanwhile, there is a *Federal Hydrogen Strategy*[14] based around four main pillars, including positioning Belgium as an import and transit hub of renewable molecules for Europe; consolidating Belgium leadership in hydrogen technologies; organising a robust hydrogen market, with 100-160km of open-access hydrogen transport pipelines targeted for 2026 to add to an existing 613km network; and sufficient and effective collaboration at all levels to ensure success.

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11 European Hydrogen Backbone - EHB
12 Kabinetsvisie waterstof - Rijksoverheid
13 Nationaal Waterstof Programma - NWP
14 Belgian federal Hydrogen Strategy - economie

## Regional / Cluster Policy Landscapes

A *North German Hydrogen Strategy*[15] in **Germany** tasks the Ministers of Economics of five northern states with overseeing a transformation process and supporting the federal government in creating a level playing field for climate-neutral energy carriers. This should see at least 500MW of electrolysis capacity installed in northern Germany by 2025, before rising to 5GW by 2030 - **WAB** is part of the moderating leadership of one field of action here, while working as a supporter in all four fields of action of the North German Hydrogen Strategy.

Moving to the **Netherlands**, the north of the country is aiming to be a leading hydrogen valley in Europe[16], encompassing the entire hydrogen value chain. **Rotterdam** is being eyed as a European Hydrogen Hub[17], while the **Smart Delta Region**[18] - a Dutch-Belgian cross-border industrial cluster - is focused on the implementation of large-scale green and blue hydrogen as feedstock material in the chemical, refinery and steelmaking industries.

In **Belgium**, there is a *Flemish Hydrogen Vision*[19]**,** aiming to realise the necessary technological breakthroughs in hydrogen technologies and propagate this ambition across the Flemish policy domains of energy. There is also a bottom-up strategy[20] from Flemish industry within the framework of the **Waterstof Industrie Cluster (WIC)**. The Walloon government is still working on a regional hydrogen strategy, but Cluster TWEED has developed a vision[21] of its own, aiming to pave the way for high quality and industrial-sized projects in sustainable energy, including hydrogen.

Finally, the **East Coast Cluster** and **HyNet North West** have been selected through the government's track 1 carbon capture, usage and storage (CCUS) cluster sequencing process[22] in the **UK**, with the **Scottish Cluster** selected as a reserve. Four hydrogen projects have been shortlisted[23] through the second phase of the process, meaning they can be considered for government funding to join up with them. Across the country, however, other potential clusters and hydrogen ecosystems are being targeted such as in **South West England** and **South Wales**, **East Kent** and the **East of England**.

15 On the way to a green hydrogen economy in 2035 - Bremeninvest
16 Dutch pin hopes on 'hydrogen valley' to revive declining gas region - Euractiv
17 Hydrogen in Rotterdam - Port of Rotterdam
18 Together for a future proof industry - SDR
19 Beslissingen van de Vlaamse Regering - Vlaanderen
20 A Flemish Hydrogen Strategy - WIC
21 Roadmap hydrogène pour la Wallonie - Cluster TWEED
22 Track-1 clusters confirmed - UK government
23 Cluster sequencing Phase-2: shortlisted projects (power CCUS, hydrogen and ICC) - UK government

# 4. The Green Hydrogen Development Pipeline

***The projects discussed below offer a snapshot of what's included in the development pipelines discussed in depth in each of the individual State of the Nation reports.***

## National Development Pipeline

**Germany** has seen a transitional amendment[24] to the *German Energy Act* to convert existing natural gas pipelines to pure hydrogen pipelines, as well as introductory regulations for the regulatory treatment of pure hydrogen networks. There are also 62 large-scale projects selected under the **Important Projects of Common European Interest[25]**, receiving €8bn in funding, as well as an amendment to Germany's *Wind Energy at Sea Act[26]*, including a plan to tender 500MW of offshore wind annually over six years from 2023 for the **production of green hydrogen at sea**.

In **Belgium**, the conversion of existing natural gas pipelines at sea is being explored, with the federal government also easing the rules for planning pipelines that can bring hydrogen produced at sea onshore. **Fluxys** has developed a roll-out scenario[27] for hydrogen and CO2 infrastructure made up of an initial first phase - short-term options towards first minimum decarbonisation infrastructure, ahead of a second phase - long-term development towards a fully carbon-neutral grid.

Nationally significant projects in the **UK** include trials such as **HyDeploy[28]**, exploring how a blend of hydrogen can be used to heat homes; National Grid's investigation into **green hydrogen injection into the NTS**; and detailed design studies for **Hydrogen Villages[29]**. There are also others looking into how green hydrogen can combine with desalination[30][31], particularly relevant given the UK having issues with water stressed regions, as well as others looking to use wind power to make green hydrogen[32].

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24 Current state of hydrogen projects in Germany - CMS
25 Germany shortlists 62 hydrogen projects with 2 GW capacity for IPCEI state aid - SPGlobal
26 Germany prepares for green hydrogen production at sea - Pinsent Masons
27 Shaping the hydrogen and $CO_2$ infrastructure for Belgium - Fluxys
28 Project Phases - HyDeploy
29 Hydrogen Village Trial Detailed Design Studies Decision - Ofgem
30 ERM Dolphyn and Source Energie announce plans to develop Gigawatt scale "green hydrogen" floating wind sites in the Celtic Sea - ERM
31 Hydrogen Turbine 1 - Vattenfall
32 Vision - Gigastack Project

In the **Netherlands**, similarly, there are projects looking to use offshore wind with hydrogen, such as **PosHYdon**[33], which is aiming to validate the integration of offshore wind, offshore gas and offshore hydrogen in the Dutch North Sea. There is also the work of **Gasunie**, which is building a **national network**[34] to connect future carbon-free hydrogen supply and demand, with five industrial clusters to be linked to one another, foreign countries and hydrogen storage facilities.


## Regional / Cluster Development Pipeline

Notable projects in **Belgium** include **Hyport**[35], which aims to have a green hydrogen plant operational at the Port of Oostende by 2025; the **HyTrucks consortium**[36] which is aiming to have 1,000 hydrogen-powered trucks on the road by 2025 and build appropriate infrastructure to link Belgium, the Netherlands and West Germany; and the **HaYrport Project**[37], which is striving to equip Liege airport with installations for production, distribution and use of green hydrogen for clean mobility.

33 PosHYdon
34 Hydrogen network Netherlands - Gasunie
35 Hyport Oostende Hydrogen project - GlobalData
36 HyTrucks consortium aims to have 300 hydrogen-powered trucks on the road in Belgium by 2025 - Port of Antwerp
37 Green light for HaYrport, the hydrogen ecomobility project of John Cockerill and Liege Airport - John Cockerill

**Project Union**[38] in the **UK** would link industrial clusters around Britain, creating a 2,000km network by 2030 and also seek to link up with the **European Hydrogen Backbone**. Elsewhere, there is the **East Coast Hydrogen** project[39], set to repurpose and build new hydrogen pipelines across the North East, before then spreading further around the country. There are also plans for a **Southampton Hydrogen Hub**[40], **Bacton Energy Hub**[41] and the **Capital Hydrogen Project**[42], among many others.

In **Germany**, the Northern states have pledged to install at least 500MW electrolysis capacity until 2025 as part of their Hydrogen Strategy. Hydrogen hubs are seen as starting points for the development of a green hydrogen economy in this area by 2035.

In the **Netherlands**, **HEAVENN**[43] is a six-year European program, dedicated to the creation of a hydrogen valley in Northern Netherlands; **NorthH2**[44] is looking to use large-scale green hydrogen production using offshore wind power to produce 4GW by 2030 and 10GW by 2040; the **Hydrogen Delta Program**[45] will aim to link up with the country's national hydrogen backbone long-term; and then there is **HyStock**[46], which is an electrolyser converting solar energy into hydrogen and storing it in salt caverns to function as a "lung" in the hydrogen network, supporting the energy system in both the Netherlands and Europe to achieve sustainability targets.

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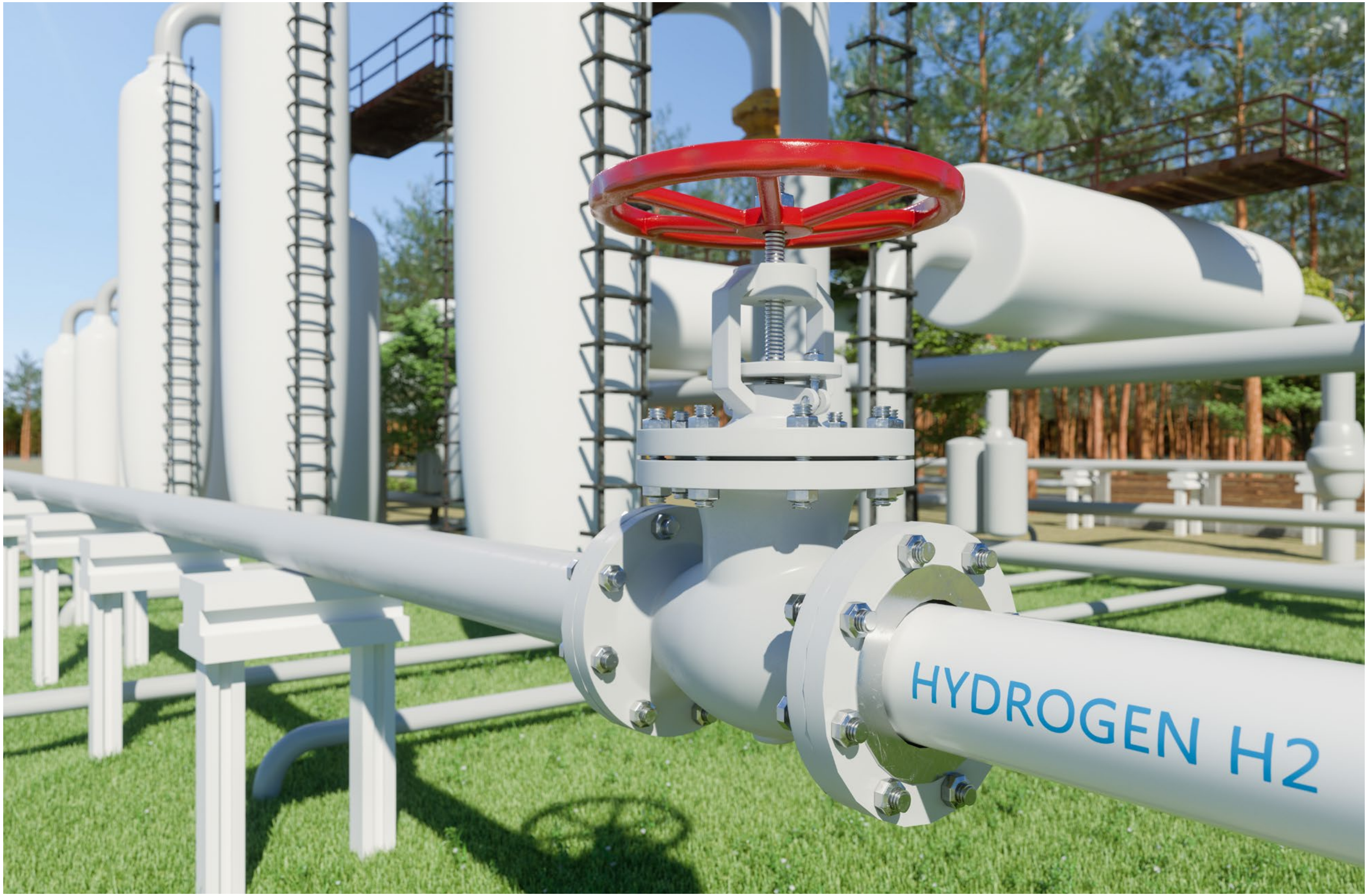
38 Making plans for a hydrogen 'backbone' across Britain - National Grid
39 East Coast Hydrogen - Cadent
40 MoU signed to explore potential for Southampton hydrogen hub - GIG
41 Bacton Energy Hub - NSTA
42 London study to kick-start hydrogen vision for capital - SGN
43 HEAVENN
44 Kickstarting the Green Hydrogen Economy - NorthH
45 Hydrogen Delta Program - SDR
46 HyStock hydrogen storage - Gasunie


HYDROGEN H2

# 5. Developing a Hydrogen Network

In the **UK**, the **Gas Goes Green** programme[47] is focused on changes needed to convert gas infrastructure to hydrogen and biomethane and involves all **five** of Britain's gas network companies. It also has a growing number of companies involved in electrolytic production, as well as distribution and trade bodies proving vocal and active for the industry.

**Belgium's Waterstof Industrie Cluster[48]** is made up of over 120 companies from Belgium and the Netherlands, while **Cluster TWEED[49]** includes hundreds of actors from the renewable energy sector and is organised across six ecosystems, one of which is **H2Hub Wallonia**, dedicated to hydrogen. The **Blauwe Cluster[50]** is a network of companies active in the sustainable blue economy and, with 140 out of 200 members active in offshore renewable energy, it is considered ideally placed to link offshore wind with green hydrogen production.

Moving onto the **Netherlands** and **HyNorth** is focused on establishing the Northern Netherlands as a frontrunner of the hydrogen economy, while **Gasunie** is focused on making the transition to a national hydrogen backbone affordable. Gasunie is working with the **Port of Rotterdam** on the **HyTransPort pipeline[51]** to integrate local production and import large volumes of hydrogen from other parts of the world - this will connect to the national backbone - while **Smart Delta Resources** is contributing to various studies, subsidy programs and projects within the **Hydrogen Delta Program[52]**.

**WAB e.V.** is supporting the emerging market of green hydrogen in **Germany** and other regions, including through active participation in the *North German Hydrogen Strategy*. Many of its 250 or so members are very interested in green hydrogen, with some involved in its **Wind Power Hydrogen Working Group[53]**, while it has also held a number of **cross-cluster workshops** with the likes of France and Scotland, formulated a **first joint political advocacy for green hydrogen** with seven other regional hydrogen initiatives and signed a **declaration of cooperation** with four other networks from the five northern German states. **WAB** has further commissioned a study on the value creation and employment potential for hydrogen in five Northern German federal states from the experienced market research institute, *wind:research*, affiliated with *trend:research*. As it stands, some 100 market participants have been evaluated, with the aim to extend the study to the whole of Germany.

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47 Gas Goes Green - Energy Networks Association
48 Waterstoft Industrie Cluster - WaterstofNet
49 TWEED - Les Clusters Walloons - TWEED
50 Blauwe Cluster
51 HyTransPort - HyTransPort.RTM
52 Hydrogen Delta - SDR
53 Hydrogen Working Group formed to focus on green hydrogen from wind power - H2View

# 6. Challenges & Opportunities for green hydrogen sector

Challenges in **Germany** include political and legal ones, social ones and economically, given how green hydrogen is not yet competitive with hydrogen produced from fossil fuels, mainly due to the significantly higher production costs of electrolysis.

Here, it was highlighted how a competitive market design for offshore wind hydrogen is a necessary step to balancing cost differences.

In its coalition agreement, the German federal government has announced it will consider the introduction of “Carbon Contracts for Difference” to compensate for the additional costs of using hydrogen. Opportunities include “enormous growth potential” for the German mechanical engineering sector and other branches of industry, as well as how green hydrogen can transport and store large amounts of energy over long distances at a low cost. The emergence of a Green Hydrogen Union, with cross-border cooperation with neighbouring European countries, will create opportunities for domestic production and the establishment of green hydrogen production plants with northern European partner states. Another opportunity could be to use the tested remuneration model for the purchase of green hydrogen abroad, as requested by **WAB e.V.** and partnering associations, also for a sprinter program domestically. This could support the rapid deployment of 2GW of green hydrogen generation offshore, with the first tenders in 2023.

The hydrogen-based knowledge and expertise in **Flanders** is regard as an opportunity in **Belgium**, as is the logistical assets it has at its disposal, including the world’s largest hydrogen pipeline network that stretches around its country to its seaports and can transport hydrogen to its industrial clusters. In terms of challenges, as a small, densely populated country, local production capacity of green energy will always remain limited, while its complex state structure is also considered potentially challenging as well.

The **Northern Netherlands** is faced with challenges such as the need to establish supportive regulatory frameworks for production and demand and the need to compensate for the initial investment gap there will be for essential infrastructure. A particular obstacle is that of offshore wind capacity in close proximity not being sufficient to meet a planned 75PJ of green hydrogen by 2030, while the need to invest and build up a hydrogen ecosystem to transfer intangible assets from other industries, including talent, knowledge and innovation, was also cited as being important.

The green hydrogen sector has been identified as a significant economy opportunity for the **UK**, with the **Offshore Wind Industry Council** and **Offshore Renewable Energy Catapult** claiming production and overseas export of electrolysers could produce £320bn of GVA and 120,000 jobs by 2050[54]. It also can be used across a range of transport modes and ensure jobs in conventional oil and gas and other high carbon industries do not get to waste, with skills transferred over. Potential challenges identified include the cost of hydrogen relative to existing high carbon fuels; policy and regulatory uncertainty, given how hydrogen is a nascent area of energy policy; the need for supply and demand coordination; and the need for first-of-a-kind and next-of-a-kind investment and deployment to scale up projects and the low carbon hydrogen economy.

54 Offshore Wind and Hydrogen: Solving the Integration Challenge - OWIC & ORE Catapult

# 7. Barriers & Opportunities for Innovation

Opportunities for innovation in the **UK** include the repositioning of major oil and gas companies across the North Sea, offering a chance to take innovative approaches to developing green hydrogen production, while there are also projects across industrial clusters involving hydrogen to decarbonise the likes of chemicals, iron, steel, glass, ceramics and paper manufacturing, work on fuel cells and aviation, and the chance to export hydrogen technology and know-how, such as through ITM Power. Barriers identified include planning and permitting needing to be simpler and faster, relatively low existing gas storage capacity and a view uncovered among producers and industrial clusters[55] that green hydrogen at scale will not happen before the 2030s, with concerns over the UK's ability to manufacture and install enough electrolyser capacity.

**Belgium's** size was noted as a barrier, meaning it will be largely dependent on imports of green hydrogen, with the scale up from a MW electrolyser to GW electrolyser also noted as a challenge - albeit a global one, rather than one specific to Belgium. Linked to Belgium's smaller size is a limited budget for research, development and innovation, with budgets available mostly general calls rather than hydrogen specific. An academic network for hydrogen has been set up - the **BE-HyFE project**[56] - to achieve a Belgian hydrogen foundation of academic knowledge and expertise.

For **Germany**, a lack of skilled workers is something becoming more acute in offshore wind energy and all other areas of the energy transition, while green hydrogen not yet being competitive with hydrogen from fossil fuels means a competitive market design for offshore wind hydrogen is a necessary step to balance cost differences. Desalination was also noted as a "basic prerequisite" for producing green hydrogen at sea. Companies from the offshore wind industry, as well as maritime industry, are expected to provide a large part of value creation with offshore wind research institutes already active in the field of green hydrogen. The requirements of the Renewable Energy Directive (RED II) that exclude the use of electricity from subsidised existing installations for electrolysis is seen as a barrier to the rapid expansion of this technology.

In the **Netherlands**, markets for green hydrogen are not yet, or insufficiently, developed, with an open access and connecting infrastructure between potential markets, import and storage not available yet and connections to important demand markets not ready either. It also, like Germany, drew on the issue of the workforce, noting it is not sufficiently available yet. This is a problem across the entirety of the hydrogen value chain, with collaborations with technical universities and retraining people from former natural gas plants put forward as solutions.

55 Britain's Hydrogen Network Plan - ENA

56 BE-HyFE

# 8. Conclusions

The **Netherlands**’ has a National Hydrogen Program, aiming to drive large-scale development of hydrogen in industrial clusters and ports, including the Northern Netherlands, Port of Rotterdam and Hydrogen Delta Valley in the South West. This approach is being prioritised as new production and demand developments lead to volume, meaning infrastructure and storage can be rolled out, growing import and export functions. Following this, decentralised regions will link to the existing hydrogen backbone and develop regional hydrogen projects. Before, however, the Netherlands’ potential can be realised, barriers must be turned into opportunities, including a strengthening of public-private and regional cooperation to optimally coordinated the production and landing of sustainable electricity and interregional production and demand for hydrogen. This will call for ministries, provinces, municipalities and regional players to further enter into partnerships.

For **Germany**, there is a need to provide a basis for economic production of green hydrogen at sea, something that can only be solved through appropriate regulatory framework - both domestically and at an EU level. This will then allow for SMEs to become a part of the supply chain. With the development of the offshore wind industry and that of the hydrogen economy show strong parallels, it is assumed that market ramp-up will require close interaction between players from industry, innovative SMEs, financiers and insurers, political players both regionally and nationally, and research.

In the **UK**, momentum for hydrogen appears to be growing, with what was a 5GW low carbon hydrogen production target becoming a 10GW goal for 2030, with at least half coming from green hydrogen, in the space of 17 months. A growing number of clusters are in development, with different regions signalling their hydrogen ambitions and plans for a UK hydrogen backbone that would link up with the EU one. While the UK has a number of strengths it can exploit, not least its offshore wind capacity and a strong industrial base, challenges remain, including a lack of gas storage capacity and need for policy and regulatory certainty for the sector to grow and realise its full potential.

While **Belgium** has a limited surface area and small budget, it has many assets that will allow it to play a pioneering role in the green hydrogen revolution. While unlikely to ever become a major producer, its strategic location - three major ports - and existing hydrogen and natural gas pipeline network mean it can become a gateway into Europe for green hydrogen produced in countries with lots of sun and wind. It also has technological leadership in the production of electrolysers, something it can maintain and even expand, though its “enormously complex state structure and corresponding division of competences” was highlighted as a potential danger.

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Haven Oostende
BLUE CLUSTER
WaterstofNet
NOM
opergy
$H_2$ East
Kent County Council kent.gov.uk
wab windenergie agentur
west-vlaanderen de gedreven provincie
NORTHERN NETHERLANDS OFFSHORE WIND NNOW
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