City of Amsterdam · gasunie · Liander · metropool regioamsterdam · NOBIAN · N7KG noordzeekanaalgebied · Port of Amsterdam · Provincie Noord-Holland · Schiphol Group · TATA STEEL · tennet · VATTENFALL · ZNSTD · ORAM

HYDROGEN HUB AMSTERDAM NORTH SEA CANAL AREA

KICK START

TAKE-OFF

LARGE-SCALE TRANSITION AND IMPORT

N7KG noordzeekanaalgebied

UNIQUE FEATURES OF HYDROGEN HUB AMSTERDAM NORTH SEA CANAL AREA (NSCA)

NSCA INDUSTRIAL CLUSTER
STRONG PORT-RELATED INDUSTRIAL COMPLEX SPECIALISING IN STEEL, FOOD PRODUCTS AND FUELS

€19 BILLION
IN ADDED VALUE

171,000
JOBS *

2.5 MILLION
PEOPLE IN METROPOLITAN REGION AMSTERDAM (MRA)

NSCA CARBON EMISSIONS**
18.3MT

LOCATION CLOSE TO THE NORTH SEA
ACCESS TO GREEN ENERGY FROM OFFSHORE WIND FARMS AND OPPORTUNITIES FOR THE LARGE-SCALE IMPORT OF HYDROGEN

PORT OF AMSTERDAM
FOURTH BUSIEST PORT IN EUROPE, SPECIALISES IN FUEL STORAGE AND TRANSHIPMENT

AMSTERDAM AIRPORT SCHIPHOL
FOURTH BUSIEST AIRPORT IN EUROPE, WITH HIGH SUSTAINABILITY AMBITIONS

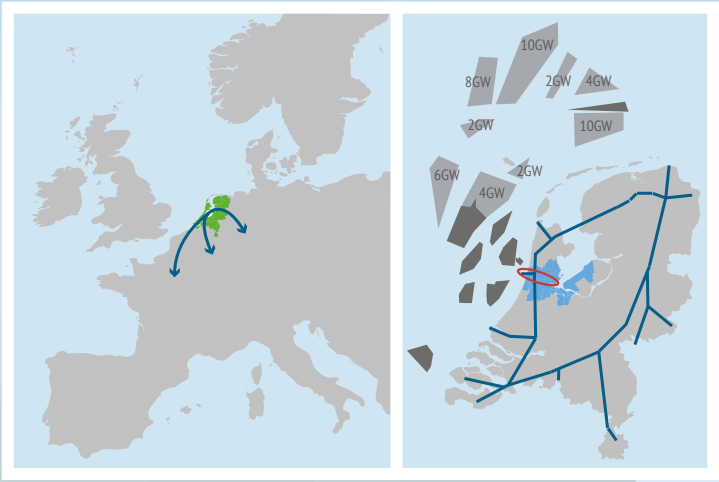
INNOVATIVE CAPACITY OF METROPOLITAN REGION AMSTERDAM (MRA)
PRESENCE OF PROMINENT RESEARCH INSTITUTES AND INNOVATIVE STARTUPS

ATTRACTION OF MRA INFLOW OF TALENT, KNOWLEDGE AND VISITORS

CONNECTION TO HYDROGEN 'BACKBONE'
CONNECTION TO MAIN NATIONAL HYDROGEN GRID ('BACKBONE') OFFERS OPPORTUNITIES FOR FURTHER TRANSPORT OF HYDROGEN

* Combined figures for Schiphol and NSCA. ** Including energy generation.

HYDROGEN HUB AMSTERDAM NSCA



MRA
NSCA
Roadmap to 2030 (11.5GW)
Potential locations

>>> to hydrogen
Electricity is used to split water into oxygen (O_2) and hydrogen gas (H_2)

From electricity >>>
Offshore wind farms generate green electricity

Beverwijk

IJmuiden/Velsen

Zaanstad

>>> via pipelines
hydrogen is transmitted to the Port of Amsterdam and industrial sites

Hydrogen imported by ship

>>> to consumers.
CO_2 is captured and used in the production of clean fuels with H_2

Amsterdam

Residual heat to heat homes and buildings

Hydrogen and clean fuels for industry and transport in the Netherlands and Europe

Clean fuels for aviation

Amsterdam Airport Schiphol

- Clean fuels for aviation and shipping
- Zero-carbon steel
- Natural-gas-free industry
- Transport & mobility
- Grid balancing

1. INTRODUCTION

INTRODUCTION

THE TASK IS ENORMOUS; THE TIME IS NOW

Reducing greenhouse gases is one of the absolute priorities of our time. Europe is aiming to reduce carbon emissions by 55% by 2030 and achieve a carbon-neutral energy supply by 2050 at the latest. The Netherlands also faces a significant sustainability challenge. The North Sea Canal Area (NSCA) plays a crucial role in this. Together with Amsterdam Airport Schiphol and the Port of Amsterdam, the NSCA forms a high-quality logistics and industrial cluster that creates €19 billion in added value and provides around 171,000 jobs. Industry in the NSCA generates significant carbon emissions of approximately 18 megatons (including from energy generation).

HYDROGEN: THE KEY TO A CARBON-NEUTRAL FUTURE

The transition to a carbon-neutral society requires various measures. For many applications, sustainable electrification or heating is a good, cost-effective solution. But hydrogen offers a solution in other situations, for example as feedstock and fuel for the process industry, fuel for aviation and shipping and a source of heating for the built environment. Hydrogen is the key to a carbon-neutral future. It can form the basis for making industry, aviation and shipping, cities, homes and transport & mobility more sustainable. It also opens up opportunities for employment, science and technology.

The Metropolitan Region Amsterdam (MRA) is an economically strong region with ambitious local authorities and a population of over 2.5 million. Parties in the region want to build a circular-economy, emission-free society. The challenge is enormous. The population and economic activities are growing, as are the number of homes and other buildings, the volume of waste, the number of transport movements and the consumption of energy. This growth is also driven by the arrival of new businesses in the metropolitan region. The MRA is going for hydrogen because the region is in an excellent position to build new, sustainable, unique value chains for the Netherlands, such as zero-carbon steel and clean fuels for aviation and shipping.

THE NORTH SEA CANAL AREA AS HYDROGEN BUSINESS ACCELERATOR

The North Sea Canal Area forms part of the MRA. The NSCA is a dynamic environment with an international orientation. The area encompasses the steel industry in the IJmond region and the food industry in the Zaanstreek region and is directly connected with the Port of Amsterdam and Amsterdam Airport Schiphol, respectively the fourth busiest seaport and the fourth busiest airport in Europe. Given the established energy-intensive industry, the high-quality energy and fuel hub at the Port of Amsterdam and the international aviation hub at Schiphol, the area is perfectly positioned to be an accelerator region in bringing about a sustainable future.

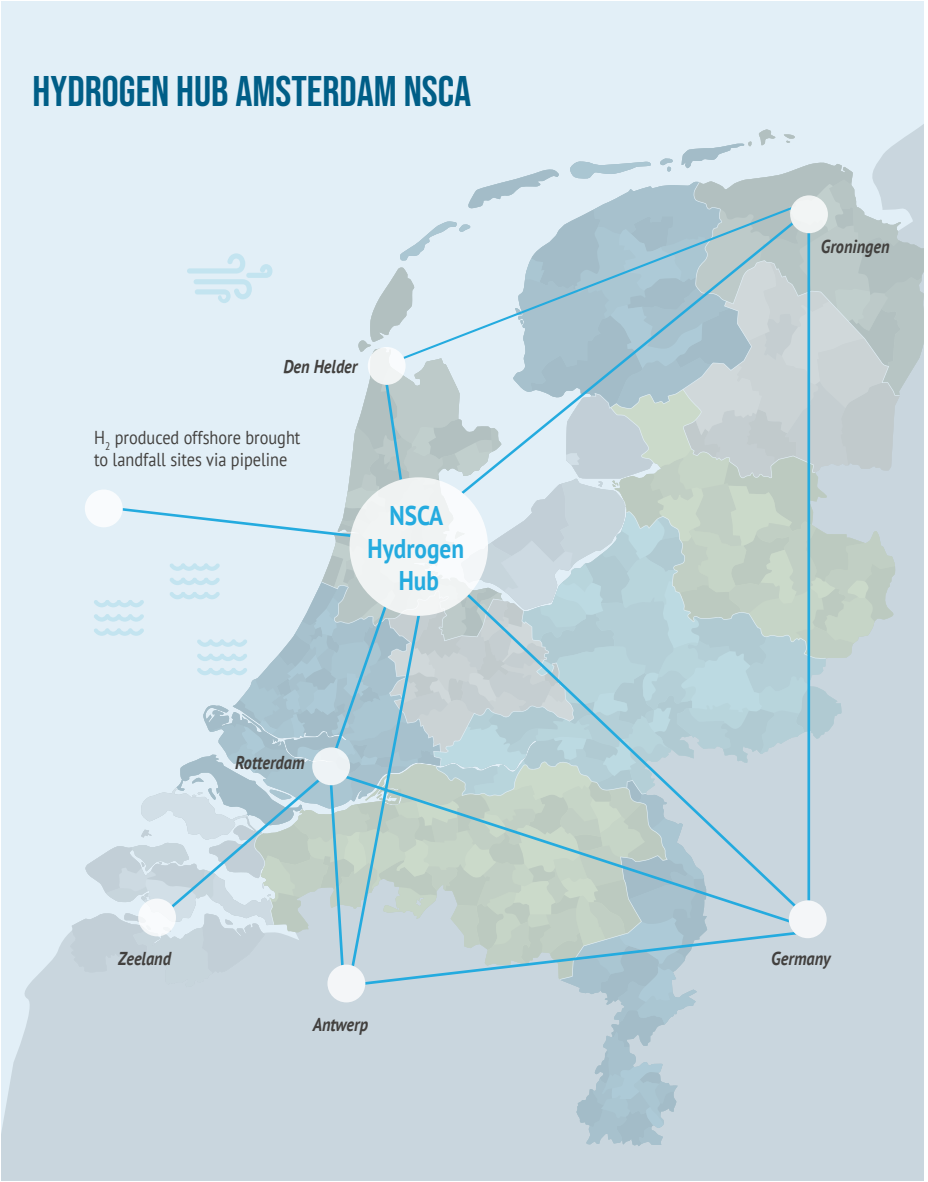
Industry, the port, Schiphol and the cities need each other to complete the transition to carbon neutrality and circularity. The connection with the Port of Den Helder will also increase in importance over time: Den Helder will eventually play an important role in the supply of hydrogen to the NSCA. The connection to the national hydrogen 'backbone' and so to the landing point for offshore wind is also crucial.

NEW VALUE CHAINS OF NATIONAL AND INTERNATIONAL IMPORTANCE

The airport, seaport and industry in the NSCA jointly have what it takes to build new value chains:

- Clean fuels for aviation and shipping
- Zero-carbon steel
- Natural-gas-free industry
- Transport & mobility
- Reliable energy supply

The first two value chains are unique in the Netherlands, and the other three can benefit from the investments, knowledge development and innovation in these value chains. We can, for example, make the steel industry, seaport and airport more sustainable by connecting them to the hydrogen and offshore wind networks.



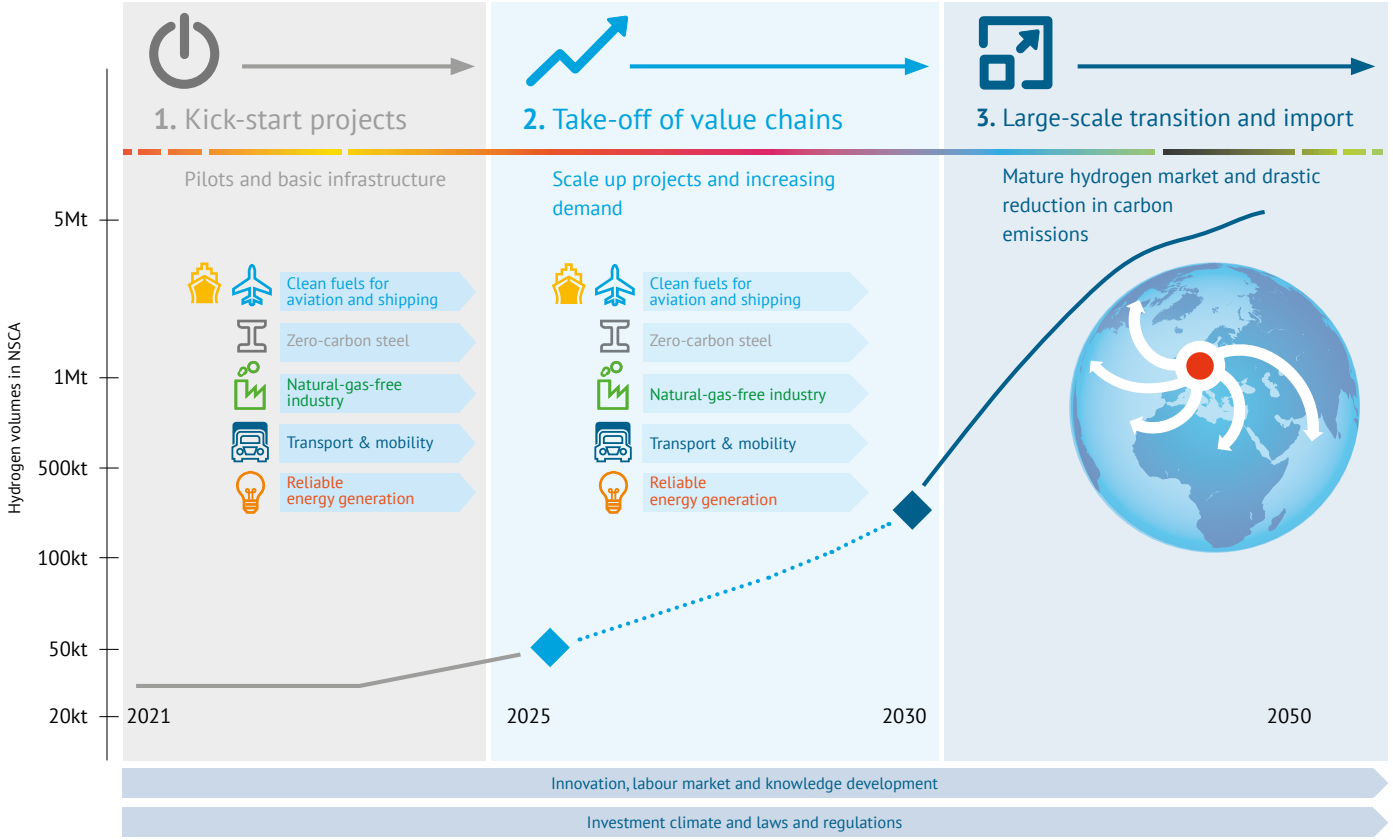
IN THREE STEPS TO A EUROPEAN HYDROGEN HUB

The transition from current fossil-fuel based activities to new carbon-neutral value chains involves three steps:

Kick-start projects: actively cultivate new projects and build the basic infrastructure

Take-off of value chains: scale up projects and incorporate hydrogen extensively in our value chains

Large-scale transition and import: further introduction of hydrogen into the areas of international import and the transition to make fossil-fuel based activities climate neutral



SEIZE THE MOMENTUM

The NSCA can only achieve the climate objectives by fully focusing on hydrogen developments. Hydrogen is essential for the survival of airports, seaports and industry. The Port of Amsterdam, Amsterdam Airport Schiphol, Tata Steel, Gasunie, Nobian, Vattenfall, Alliander, Provincial Authority of North Holland, Municipality of Amsterdam, MRA, Zaanstad Maakstad and Projectbureau NZKG (NSCA project office) have united to accelerate the transition. That's good news, but it is not yet enough; after all, the transition to hydrogen is a system change.

Parties representing the MRA and the NSCA are constantly seeking collaboration with public and private parties in Den Helder, Groningen, Rotterdam and the European hinterland. We work together with established and new players from industry, the ports and international transport, the circular-economy industry, electrochemistry and electrolysis, grid operators for the underground energy infrastructure, and science institutions. Collaboration with all these parties is required to make the transition a success.

2. WHY HYDROGEN?

WHY HYDROGEN?

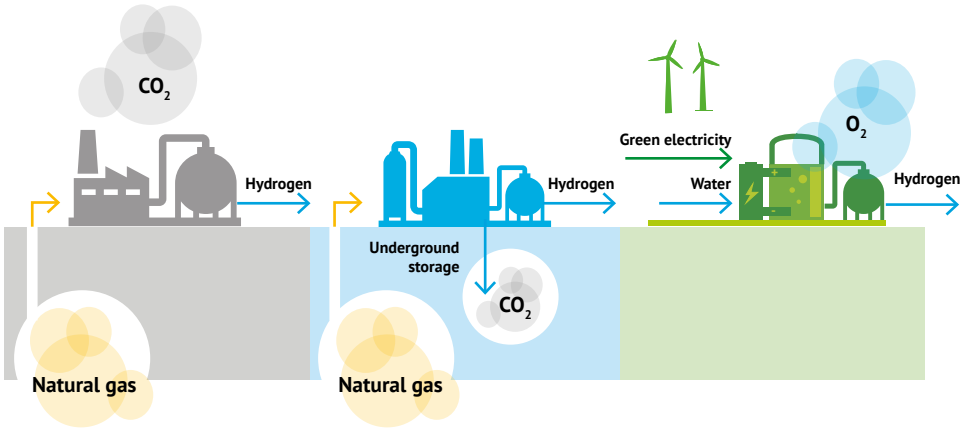
HYDROGEN APPLICATIONS

Hydrogen is one of the ways to realise a carbon-neutral energy system, alongside other sustainable energy solutions. Hydrogen offers a number of advantages:

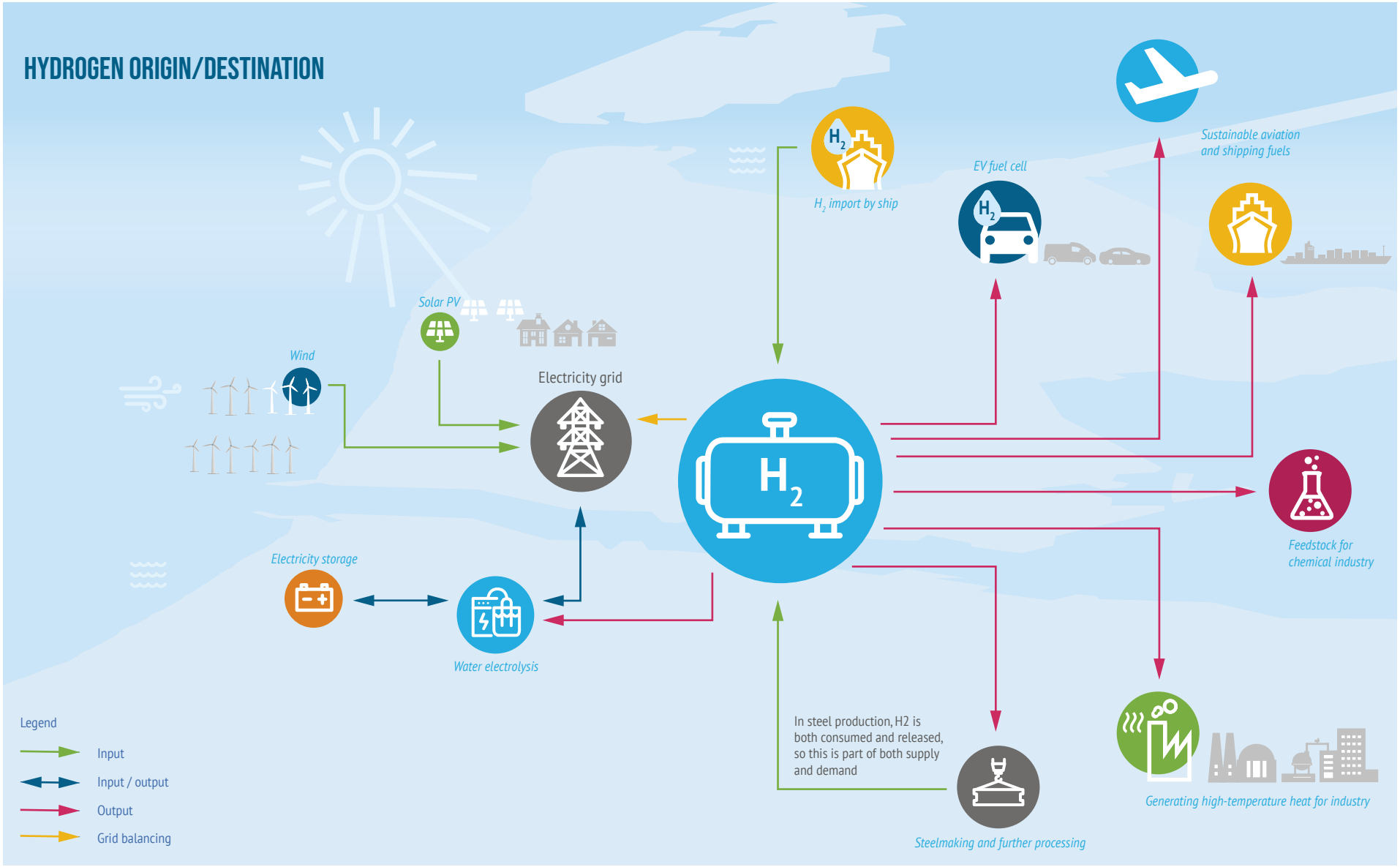
- It can be used as a synthetic fuel for aviation and shipping, and commercial and private transport. In these segments, electricity is not an alternative in the short term due to the very heavy energy demand.
- It is a green alternative to fossil carbon-based feedstock for industry. Currently, oil or natural gas is often used as feedstock or fuel to generate high-temperature heat. Hydrogen offers similar benefits without the carbon emissions.
- Hydrogen can be transported relatively easily over great distances. It can therefore be used to carry sustainable energy, such as solar and wind, from remote areas.
- It can be used in grid balancing. Green energy generation results in a mismatch (imbalance) between supply and demand. Surplus electricity can be converted into hydrogen and stored in this form for the short or long term.

GREY, BLUE OR GREEN?

Though hydrogen itself is colourless, the means of producing it is indicated by a colour: grey, blue or green. Each production method generates a different amount of emissions.



HYDROGEN ORIGIN/DESTINATION

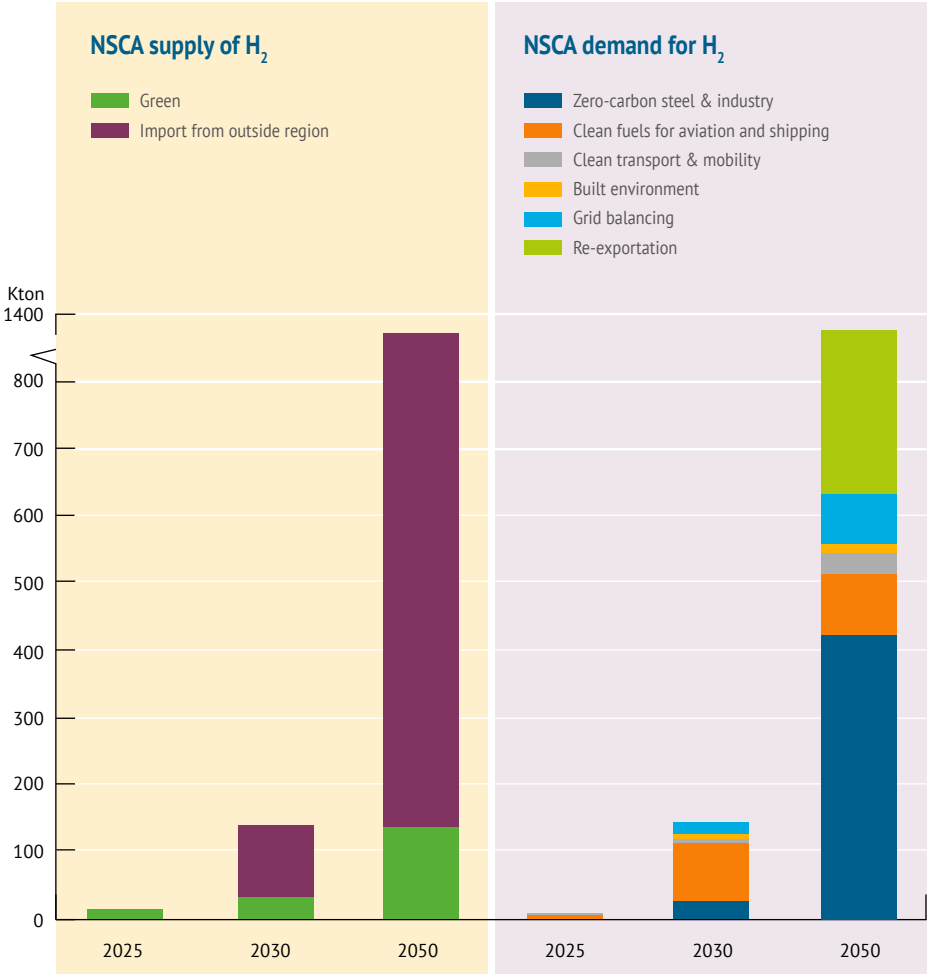


CARBON-NEUTRAL HYDROGEN IN THE NSCA

To meet the climate targets set for 2030 and 2050, the NSCA is focusing on carbon-neutral hydrogen. The ultimate goal is to use only green hydrogen. The main route to a hydrogen cluster in the NSCA therefore lies in building up production capacity for green hydrogen, with sustainable power from offshore wind farms as a source, and connecting up to the national hydrogen 'backbone'. Large-scale hydrogen import will take place after 2030.

Blue hydrogen also has a place on the hydrogen agenda of the NSCA. This is considered a transitional solution to trigger the development of the hydrogen market and to speed up the shift to fully green hydrogen.

The demand for hydrogen is expected to exceed its production. We do not plan to solve this anticipated imbalance by increasing local production, but rather by purchasing hydrogen supplied via the national 'backbone' and by importing hydrogen, for example from sunny regions of the world, via the Port of Amsterdam. This is in line with the Port of Amsterdam's strategy to become a sustainable energy port. With this approach, we can avoid local hydrogen demand in the NSCA from claiming too great a share of the supply of offshore wind energy and the limited space in the area. This way, the Port of Amsterdam can also remain an important international player in the sustainable fuel trade for the MRA and the hinterland.



Source: CES NZKG [NSCA Cluster Energy Strategy]

*Evererest scenario.

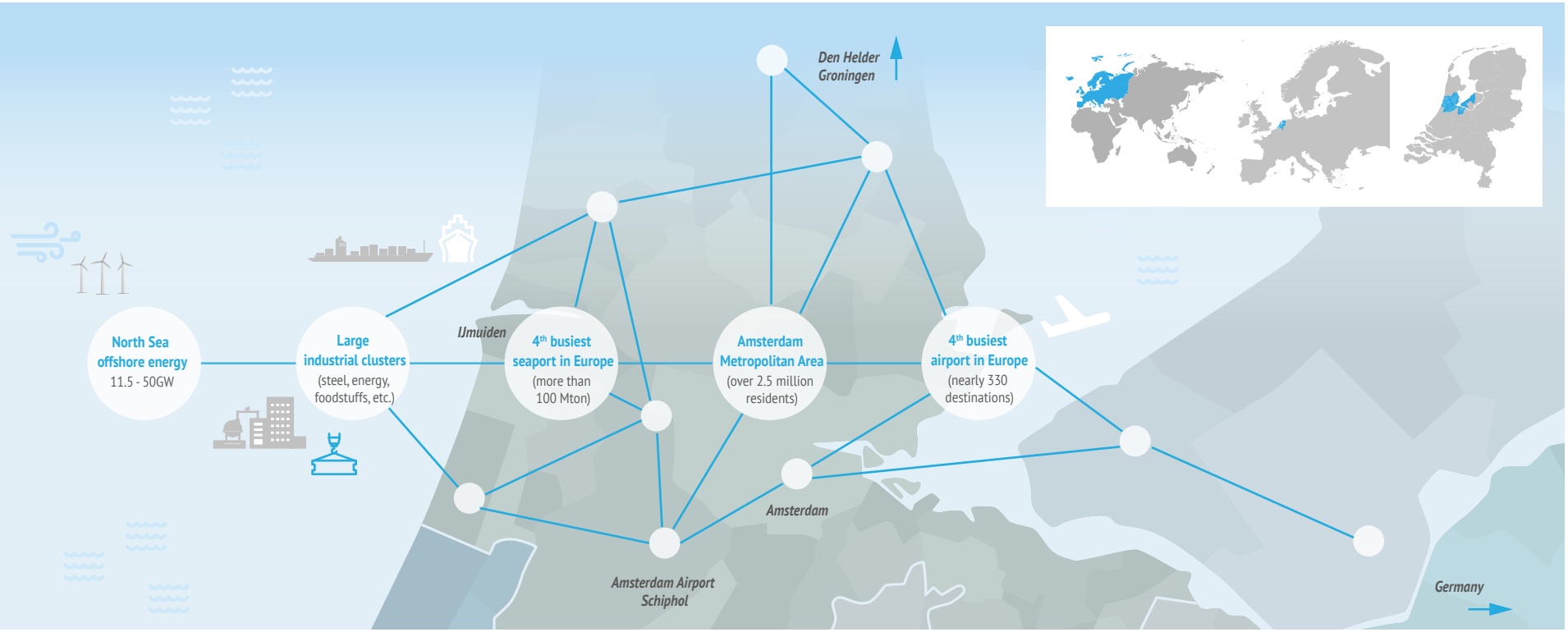
3. THE HYDROGEN HUB AMSTERDAM NSCA AS HYDROGEN ECONOMY AND BUSINESS ACCELERATOR

THE HYDROGEN HUB AMSTERDAM NSCA ECONOMY AND BUSINESS ACCELERATOR

FEATURES OF THE NSCA AND AMSTERDAM AIRPORT SCHIPHOL

The industries and ports located in the North Sea Canal Area have a substantial economic impact. More than 78,000 people work on the industrial estates in the area, 25,000 of them in the manufacturing industry. According to the 'Havenmonitor', an annual overview of the impact of Dutch seaports, port industrial employment has remained stable in recent years, while added value and exports are rising. The added value of the NSCA amounts to almost 9 billion euros (source: *Monitor Ruimte-Intensivering Noordzeekanaalgebied*).

Amsterdam Airport Schiphol is closely linked with the MRA and NSCA. The airport contributes to the economy and employment in the Netherlands through the approximately 93,000 FTE jobs associated directly and indirectly with Schiphol. The total added value of the airport activities amounts to over €10 billion (source: Decision 2019).



STRONG STARTING POSITION FOR HYDROGEN

Hydrogen has enormous potential in the NSCA and Noord-Holland. There are many possibilities for the production, import, trade and international distribution of hydrogen and for the application of this energy carrier in the value chains. Below we describe the key strengths of the area.

WORLD PLAYERS IN STRONG SECTORS: NUMBER OF JOBS PER CLUSTER*

* excluding wholesale

(source: *Onderzoek MRA Maakindustrie 2017* [Study of MRA manufacturing industry 2017])

PRESENCE OF HIGH-VALUE INDUSTRY

Industry in the NSCA can be roughly divided into three clusters, economically and spatially: steel in the IJmond region; fuels and chemicals in Amsterdam; and manufacturing industry in the IJmond region, along the Zaan river and in Amsterdam. Many of the companies in the NSCA are active internationally, use advanced technologies and are largely dependent on fossil energy sources, such as coal and natural gas. Hydrogen can serve as an alternative feedstock and fuel. This industrial complex offers the critical mass to successfully make the switch to hydrogen and to develop new value chains.

LARGE SEAPORT AND AIRPORT

The MRA has the fourth busiest seaport and fourth busiest airport in Europe. This ensures an extensive network of companies operating in international logistics. To make the seaport and airport more sustainable, it is both necessary and attractive to invest in hydrogen. There are many options for producing and using green hydrogen and related synthetic fuels. Aviation can be made more sustainable with e-kerosene and shipping with e-methanol, for example.

HIGH-QUALITY KNOWLEDGE AND INFRASTRUCTURE

The Port of Amsterdam is one of the largest fuel ports in the world. The port has the knowledge and experience to transport fuels safely with its many terminals and extensive network of pipelines. This knowledge and infrastructure are superbly suited for use in the transition to hydrogen. The Port of Amsterdam is also connected to Amsterdam Airport Schiphol via underground pipelines for the supply of aviation fuels. A part of the existing infrastructure can be repurposed for hydrogen applications.

LOCATION CLOSE TO LARGE OFFSHORE WIND FARMS

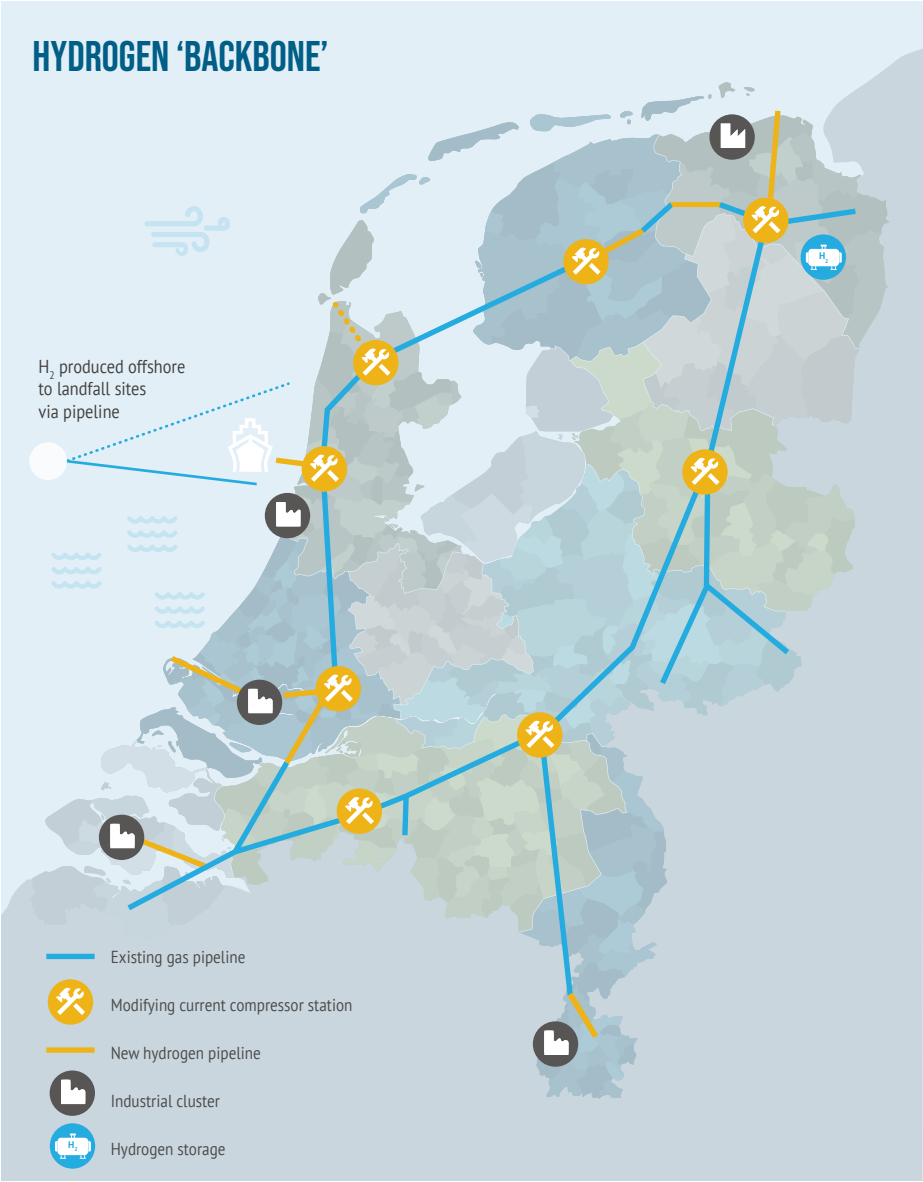
The NSCA is located on the North Sea coast and close to the large wind farms being built in the North Sea. By 2030, 2.1GW of electricity from offshore wind will be transmitted onshore in the IJmond region. This power can meet the energy demands of industry. The energy produced in the North Sea after 2030 may eventually be transported in the form of hydrogen. Thanks to the proximity of these wind farms, the power-to-hydrogen process can take place close to the generation source. In addition, the NSCA is well equipped to bring ashore hydrogen produced offshore. The possibility of bringing additional offshore wind power ashore in the NSCA is currently being investigated.

OFFSHORE PRODUCTION OF HYDROGEN

In the future, some of the hydrogen may be produced in offshore facilities. The Port of Den Helder is just next door to the NSCA. This seaport is a perfect landing point for offshore hydrogen and a perfect base for its production and transmission/transport. The NAM gas treatment facility is a strategic asset in the central role that Den Helder can play. Hydrogen can be fed into the proposed national hydrogen 'backbone' via Den Helder and other landing points. In addition, the existing natural gas infrastructure can be repurposed for the storage of CO_2 under the sea (in depleted gas fields belonging to NAM among others, which are already connected to the mainland via pipelines).

IMPORT POSSIBILITIES AND CONNECTIONS TO NATIONAL HYDROGEN 'BACKBONE'

Its location by the sea, the deep-water navigation channel with mooring locations, and the fuel storage and gas transmission facilities of the hydrogen backbone make the NSCA suitable as a port for importing hydrogen. In a European context, the large-scale import of green hydrogen is already being considered; the NSCA can play a major role here. The Port of Amsterdam is already one of the largest energy import ports in the world. Large-scale imports of green hydrogen can help fulfil the agreements of the European Green Deal and achieve the Dutch climate objectives.



LARGEST METROPOLITAN REGION IN THE NETHERLANDS

With a population of around 2.5 million people, the MRA is the largest metropolitan region in the Netherlands, with an international orientation and great diversity in its residents and businesses. The excellent business climate is evident from the many international companies that have chosen the MRA. This business climate is also an important asset for innovative companies operating in the field of hydrogen technology. In addition, hydrogen has a clear place in the bold sustainability ambitions of the MRA. Hydrogen is not only the envisioned solution for municipal sanitation, urban distribution and public transport, for example, but also for weaning parts of the MRA off natural gas.

KNOWLEDGE DEVELOPMENT

The MRA has a leading position in the area of knowledge development and innovation. The applied research centre TNO is very active and operates its 'Faraday lab' in Petten, the largest hydrogen research facility in Europe. In this facility, TNO works on technological, hydrogen-related innovations together with a large number of industrial and academic partners, including the EU Joint Research Centre.

The Science Park in Amsterdam is responding to the energy transition with initiatives such as the ICLA and Green Campus and the recently launched AMCEL consortium. At this centre, established on the initiative of University of Amsterdam's van 't Hoff Institute for Molecular Science (HIMS), in collaboration with Amsterdam University of Applied Sciences, AMOLF and industrial partners, researchers are studying sustainable chemistry and electrochemical challenges.

Through the AMS Institute, located on the Marineterrein site in Amsterdam, the region has short lines of communication with prominent research groups at Delft University of Technology and Wageningen University & Research in the Netherlands and MIT in the United States. Several organisations in the region are closely involved in ISPT's Hydrohub Innovation Programme. These programmes focus on sector-wide research into hydrogen electrolysis, fuel cells, infrastructure, storage and transport, electrochemistry and the upscaling of the technology.

In addition, there are excellent pilot and test facilities for technology upscaling at Prodock at the Port of Amsterdam and at InVesta in Alkmaar. The island of Texel is serving as a living lab for hydrogen applications. This innovation in the area of knowledge development is reinforced by the internationally recognised start-up culture in the MRA and the talent emerging from science institutions where teaching and research programmes are closely aligned with the current developments.

Lastly, MRA is home to many industrial giants: Nobian, Vattenfall and Tata Steel all have expertise in the production and use of hydrogen. Network operators Gasunie and Alliander are experts in energy storage and transmission. The Shell Technology Centre is also a leader in hydrogen innovation. Avantium, a specialist in the field of electrochemistry, is further developing this technology at the Amsterdam Science Park. In addition, various industrial parties are investigating whether they can integrate hydrogen into their production processes. Hydrogen knowledge development is therefore progressing rapidly in the region and is also linked to the various value chains.

4. POWER OF THE NSCA: ACTIVATING CARBON-NEUTRAL VALUE CHAINS

POWER OF THE NSCA: ACTIVATING CARBON-NEUTRAL VALUE CHAINS

The strength of the hydrogen ambitions in the NSCA lies in the fact that they are strongly intertwined. There is synergy between the various sectors, and the MRA, industry, seaport and airport are all working together on a unified hydrogen system.

CLEAN FUELS FOR AVIATION AND SHIPPING

Current fuels are mostly based on fossil hydrocarbons. To make fuels more sustainable, we need to go back to basics. We need to stop using crude oil or natural gas as a feedstock and switch to green hydrogen and green carbon. By combining these, we lay the foundation for carbon-neutral synthetic fuels.

Schiphol: global leader in sustainable aviation

Amsterdam Airport Schiphol is the fourth busiest airport in Europe. The high passenger and cargo volumes make the airport a major consumer of fossil fuels. In view of its hub function in the transport system, Schiphol presents opportunities for aviation to take major steps forward in the area of hydrogen utilisation. The airport wants the Netherlands to emerge from the coronavirus crisis as a stronger and more sustainable society and aims to become the global leader in sustainable aviation. Key elements of this ambition are the planned use of e-kerosene and the aim of becoming a zero-emissions airport in terms of its own operations.

Schiphol is aiming for 14% of all aviation fuels to be sustainable by 2030 and for the entire energy supply at the airport to be emission free. Fossil kerosene must be completely replaced by sustainable alternatives by 2050. To meet this target, the production and use of Sustainable Aviation Fuel (SAF), including the green hydrogen required for this, must be accelerated. This approach should contribute to a rapid reduction in carbon-emissions in aviation and help Schiphol achieve a leading position internationally in the market for SAF.

Parties in the region, including Schiphol and the Port of Amsterdam, will explore a regional roadmap for direct and indirect use of hydrogen in aviation by 2030. The required safety framework will also be studied.

Port of Amsterdam

The Port of Amsterdam is the largest petroleum port in the world. The Amsterdam port area and the NSCA serve internationally as an important link in the supply of energy and feedstock. Large flows of feedstock for energy production enter the area by way of the sea. Here they are processed, stored and transhipped and transported to locations in the Netherlands and Northwest Europe.

For the Port of Amsterdam, hydrogen is a building block for sustainable fuels and circular-economy chemicals. The Port of Amsterdam has set itself the goal of being a pioneer in the energy transition. Like the businesses located in its vicinity, the Port of Amsterdam is experienced in the import, storage and transhipment of fossil fuels, experience that can be applied in the hydrogen trade. This also applies to products derived from hydrogen, such as synthetic fuels. The Port of Amsterdam also has the crucial infrastructure, such as storage tanks, pipelines and ships, to transport and transmit hydrogen.

Work is underway in the Port of Amsterdam on production capacity for e-kerosene. The ambition is to realise between 50,000 and 80,000 Ktons of production capacity in the port area for SAF by 2027.

Hydrogen also opens up opportunities for the shipping industry to become more sustainable. The port is currently working on equipping one of its vessels with hydrogen fuel cells. In IJmuiden, Windcat Workboat vessels will also be hydrogen powered. Furthermore, the Port of Amsterdam and tank storage company Evos, together with three specialised hydrogen companies, are drawing up a blueprint for hydrogen import in the region and a roadmap for the period from 2030.

ZERO-CARBON STEEL

Steel producer Tata Steel in IJmuiden is the largest company in the NSCA. With its 6.3Mt in annual carbon emissions, it is responsible for most of the carbon emissions in the NSCA (91%). It accounts for 3.8% of all emissions generated by Dutch industry. Tata Steel is working towards ultimately producing green steel with zero carbon emissions. This will enable the company to take a huge step in the reduction of carbon emissions in the NSCA, the Netherlands and Europe. Hydrogen is essential in the production of zero-carbon steel.

Tata Steel has several projects underway to make the transition to green steel and reduce its carbon emissions, for example H_2ermes (where the company is working together with Nobian on the production of 15,000 tons of green hydrogen).

The H_2ermes project enables Tata Steel to gain practical experience with hydrogen in the short term, both for reduction applications and for heating the material in the furnaces (up to 1,200°C).

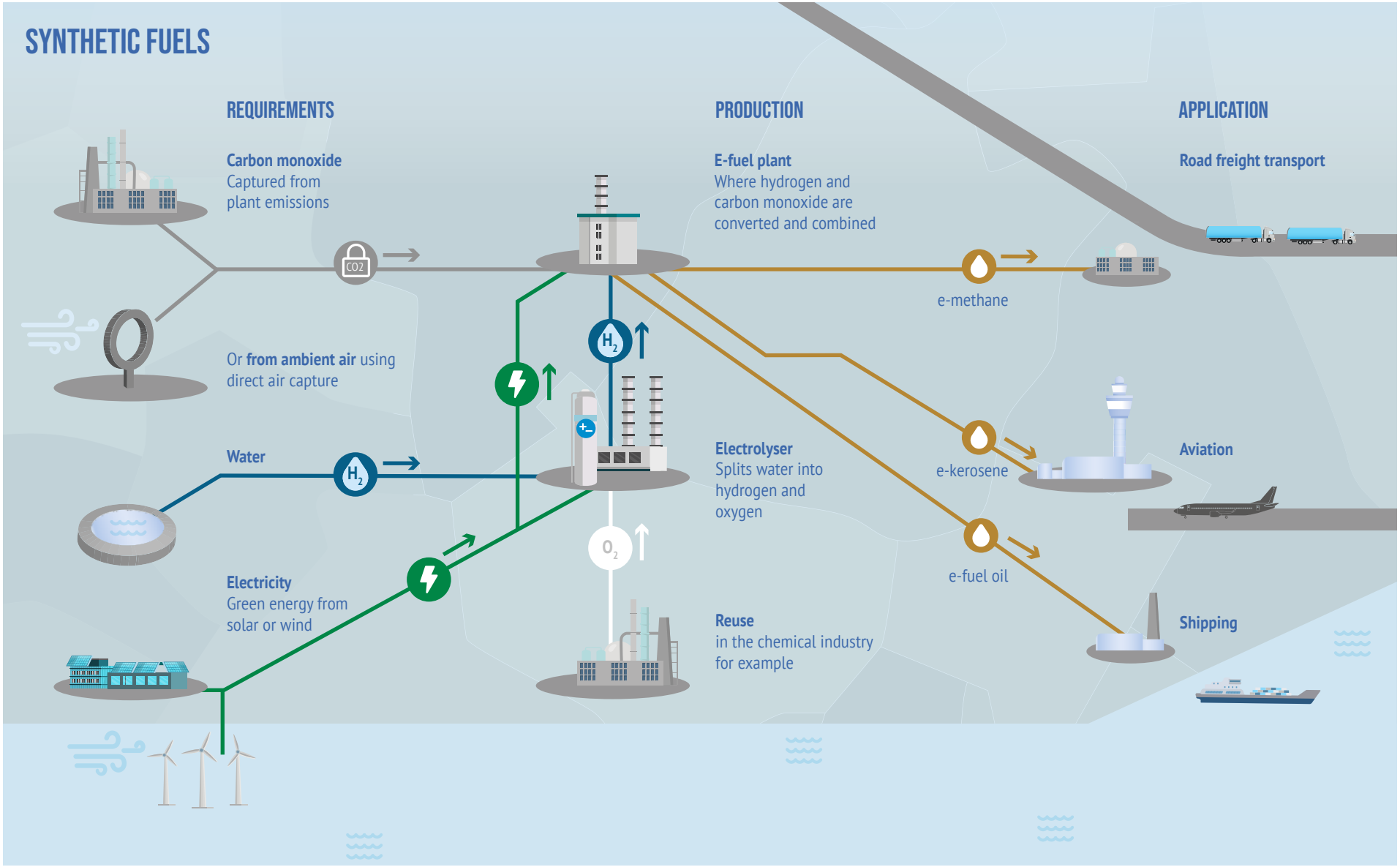
This hydrogen will eventually be used in the direct iron process (DRI) thereby enabling the production of green steel. This will enable Tata Steel to make the leap from 40% to 65% reduction in emissions by around 2030. Until then, the hydrogen will be available to external parties who want to start their transition quickly and need hydrogen to do so.

NATURAL-GAS-FREE INDUSTRY

Industry with hydrogen as a feedstock

While the use of grey hydrogen as a feedstock in industry is already widespread, the use of green hydrogen for this purpose is still in its infancy. Hydrogen is currently used as a feedstock for the production of ammonia, methanol and methane, in the refining of crude oil and in the food industry, among other applications. In such production processes, green hydrogen can help significantly in enabling individual companies and the region in general achieve emission-reduction targets. A number of initiatives are currently taking place in the region whereby green hydrogen will be used as a feedstock in the future. Avantium, for example, is looking into the use of green hydrogen for the production of chemical building blocks and plastics. Synkero and Vattenfall are investigating whether they can use green hydrogen for the production of synthetic fuels.

Several industries are already actively involved in technological innovations, for example, for the production of chemicals, plastics and synthetic fuels. There are also opportunities for biorefinery in the region. Green hydrogen can be used for the production of biodiesel. An important consideration here is how prices will develop and how readily available green hydrogen will be. This rapid pace of knowledge development in the field of hydrogen and electrochemistry puts the MRA in a promising position.


SYNTHETIC FUELS
REQUIREMENTS
Carbon monoxide
Captured from plant emissions
Or from ambient air using direct air capture
Water
Electricity
Green energy from solar or wind
PRODUCTION
E-fuel plant
Where hydrogen and carbon monoxide are converted and combined
Electrolyser
Splits water into hydrogen and oxygen
Reuse
in the chemical industry for example
APPLICATION
Road freight transport
e-methane
Aviation
e-kerosene
e-fuel oil
Shipping

Industry with hydrogen as a fuel

There are even more companies in the NSCA that are actively looking into ways to make their own operations more sustainable, such as the manufacturing and food industries in the Zaanstreek region, the asphalt industry and the circular-economy industry at the Port of Amsterdam. Here, hydrogen offers an alternative in particular for companies that require high-temperature heat in their production processes and are looking for an alternative to natural gas. Although the industrial companies in the NSCA have not yet made any final investment decisions, many companies are already assessing what adjustments would be needed for the switch to hydrogen.

CLEAN TRANSPORT & MOBILITY

In the NSCA a lot of heavy transport takes place – by road, water, rail and air. It is therefore important to make the transport sector more sustainable, and hydrogen is an interesting solution for many different parties. The first hydrogen filling station in the Port of Amsterdam was opened in 2020 and several more stations will be built in the MRA between 2021 and 2023. The use of hydrogen is also important for Schiphol airport's ground traffic. The Municipality of Amsterdam is in the process of equipping waste collection vehicles with a hydrogen drive system. The first trials are also taking place in the area of logistics operations.

There are still a number of obstacles though. Given that investment and operating costs are currently much higher than for fossil-fuelled vehicles, there is currently no business case to support investment in hydrogen vehicles. Furthermore, there is the uncertainty about future policy and regulations, for example with regard to taxes and distance-based road charging. The expected return, the supply of hydrogen vehicles and the hydrogen infrastructure are therefore still uncertain. As a result, the demand for hydrogen in particular is lagging in the transport & mobility sector.

A region-wide approach is needed to remove barriers and uncertainties and accelerate the potential demand for hydrogen in transport & mobility. The Provincial Authority of North Holland is currently working together with Versnellingstafel Waterstof NZKG [NSCA hydrogen acceleration committee] on ways to aggregate demand in order to bring the costs down. In the coming period, the parties involved will map out what is needed to accelerate the demand for hydrogen in transport & mobility, fully in line with the European hydrogen programmes for 2021.

RELIABLE ENERGY SUPPLY

Availability of infrastructure

Having the right infrastructure available is essential for the further development of the hydrogen economy and, accordingly, for making the Netherlands more sustainable. It is with this in mind that national grid operator Gasunie is developing an open-access high-pressure hydrogen pipeline. Gasunie is also working with the Port of Amsterdam on regional hydrogen infrastructure, the 'Regional Integrated Backbone' (NSCA RIB), which will connect the IJmond region to the Port of Amsterdam and to the national hydrogen 'backbone'. The idea is to also connect the NSCA RIB to local low-pressure hydrogen networks in the Amsterdam port area and possibly also to those in the municipality of Zaanstad. Alliander is aiming to make the existing low-pressure natural gas network suitable for the transmission of hydrogen gas or to build new low-pressure hydrogen gas grids to distribute hydrogen gas to industry and, possibly later, for use in transport & mobility and the built environment.

Grid balancing

Vattenfall is looking into blending green hydrogen into the fuel for the Hemweg and Diemen gas-fired power plants, thereby supplying fossil-free flexible capacity for the power grid. The first power plant will blend in up to 30% hydrogen before 2030 at times when solar and wind sources do not produce enough sustainable electricity. The power plants will be retrofitted for hydrogen-only use between 2030 and 2040. The plants in Diemen are connected to the district heating network, so an additional effect of this development is the decarbonisation of the heat supply. Vattenfall is currently discussing this matter with Gasunie, Tennet, the Port of Amsterdam and gas-fired power plant supplier Siemens.

Grid congestion

In the short term, hydrogen will play a role locally in resolving local grid congestion. This also applies to the industrial cluster in the NSCA, where large generators of sustainable energy cannot feed energy into the grid, a situation that is slowing down the energy transition. Using the surplus electricity generated to produce hydrogen and then storing this can offer a solution.

5. DEVELOPMENT AGENDA FOR THE NSCA HYDROGEN HUB

DEVELOPMENT AGENDA FOR THE NORTH SEA CANAL AREA HYDROGEN HUB

Developments are moving fast and many companies and other organisations are already involved in hydrogen initiatives. The outlook is positive and demand is substantial. To meet the demand for carbon-neutral hydrogen, we have defined three horizons.

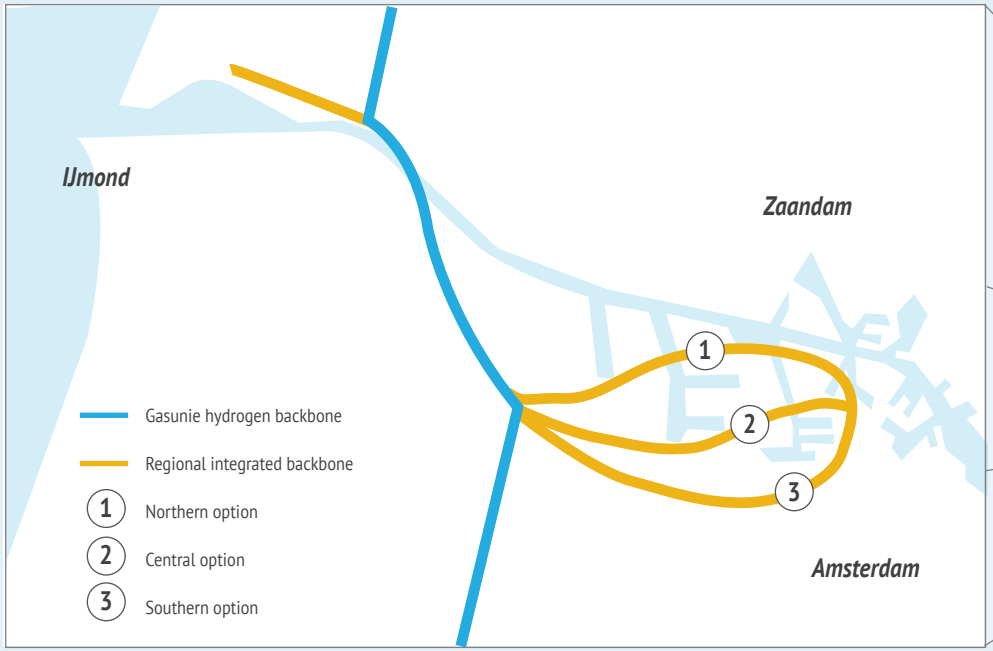
FLAGSHIP PROJECT: REGIONAL HYDROGEN 'BACKBONE'

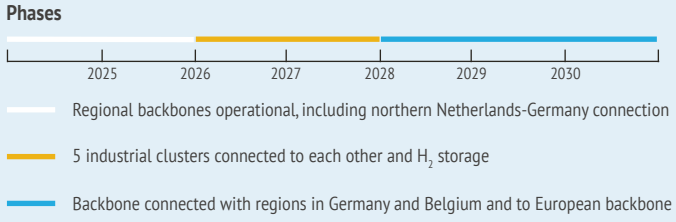
The Port of Amsterdam is working together with Gasunie on the development of a hydrogen pipeline connecting IJmuiden and Amsterdam. This pipeline will be directly connected to the national hydrogen 'backbone'. The development of the basic infrastructure is a precondition for setting up and scaling up hydrogen projects in the coming period.

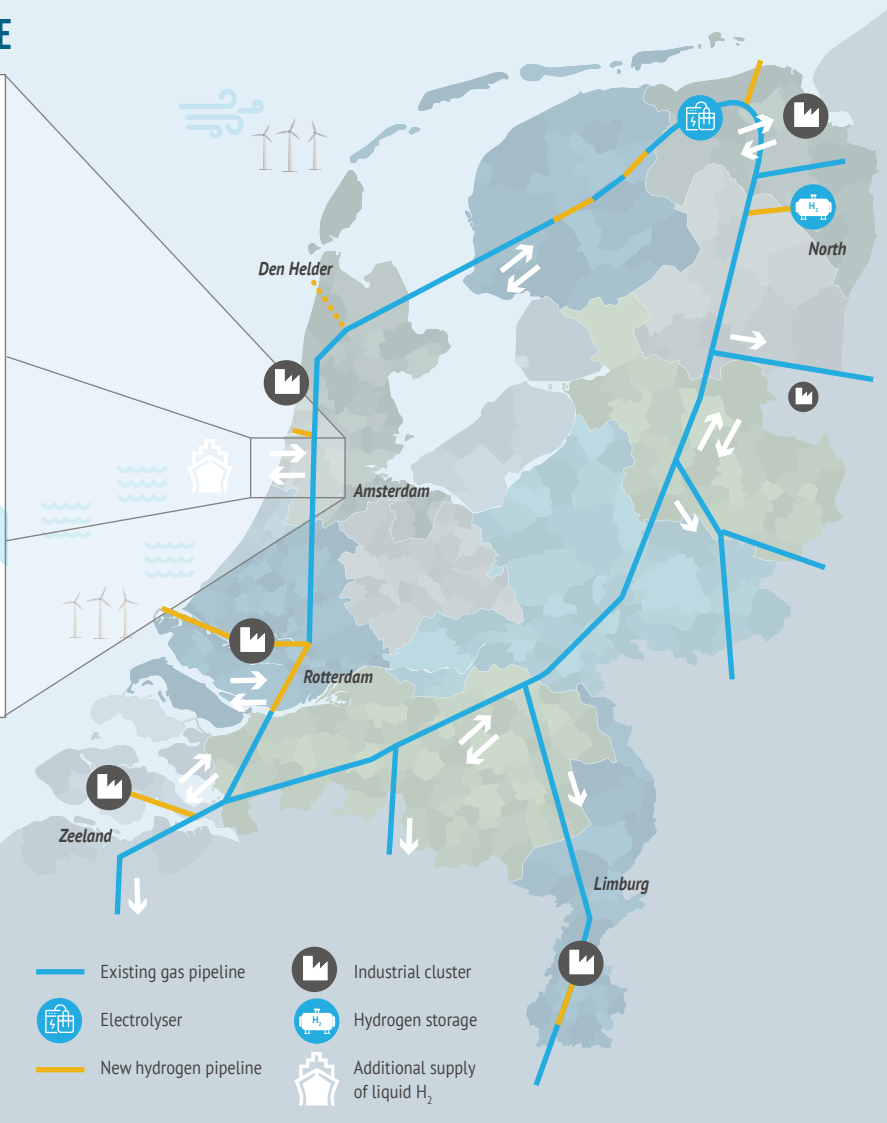
HORIZON 1: KICK-START PROJECTS (2021-2025)

This is a period characterised by local hydrogen-related developments. The use of small-scale, locally produced green hydrogen is mainly directed towards heavy transport by road and water. During this period, hydrogen is used to address local grid congestion problems. Other activities in this phase are pilots and explorations of the electrolysis capacity for the production of green hydrogen, pilots for the production of e-kerosene, and the exploration of the use of hydrogen in the built environment and as a feedstock and fuel for industry. Studies into the pipeline route for the hydrogen 'backbone' and opportunities for offshore hydrogen production will also be carried out. The import of green hydrogen will also be explored. This pioneering phase is the time for learning and experimentation.

CONNECTING THE REGIONAL BACKBONE TO THE GASUNIE HYDROGEN BACKBONE







HORIZON 2: VALUE CHAINS TAKE OFF (2025-2030)

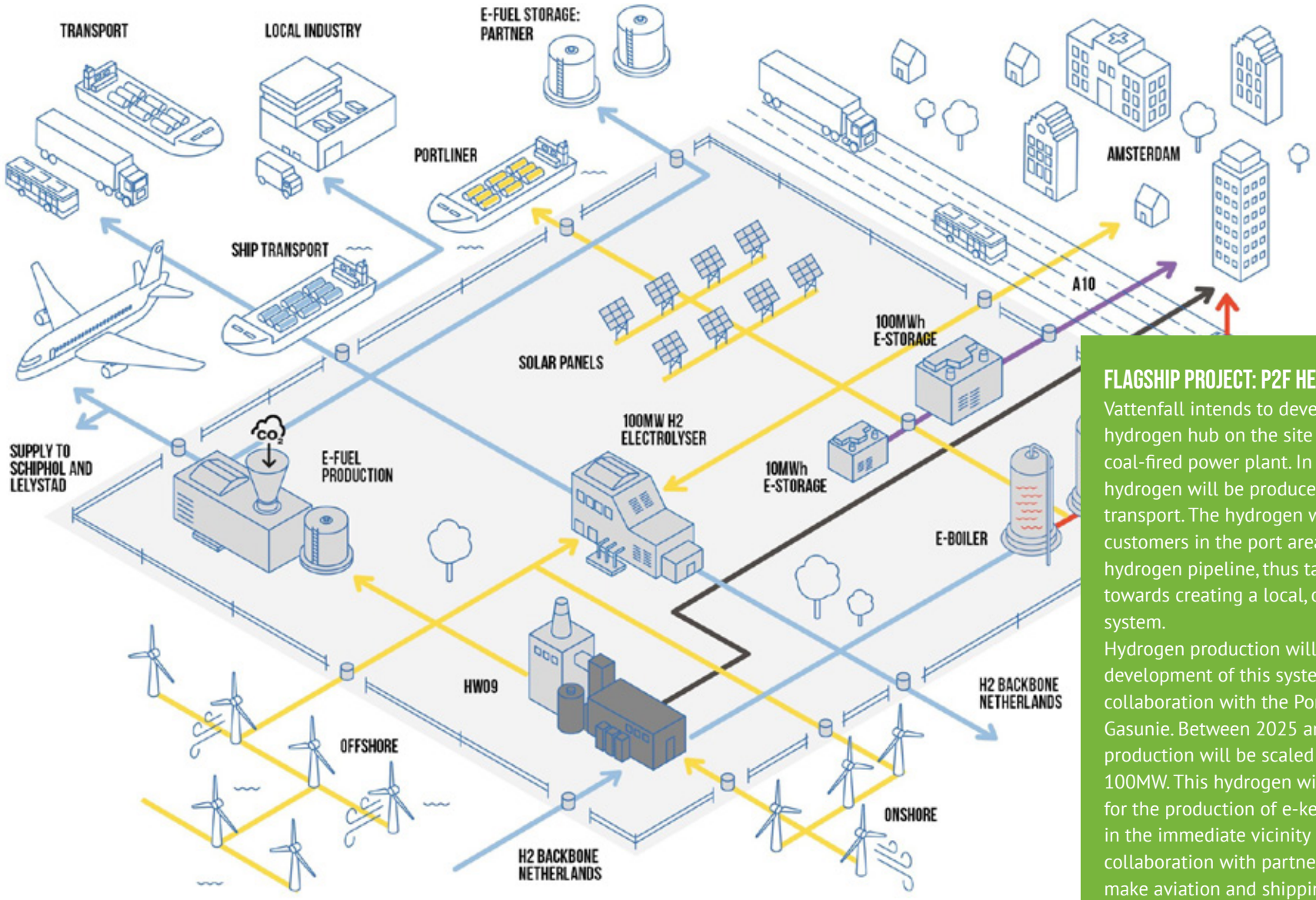
The medium term is characterised by an upscaling of hydrogen use across the Netherlands. The production of blue hydrogen will be scaled up, leading to a decrease in the industrial demand for grey hydrogen. The national hydrogen 'backbone' will also be completed by the end of this period. In addition, the production of green hydrogen will be scaled up. Green hydrogen will increasingly be used as a fuel for heavy transport. Lastly, it will be used to a greater extent to take pressure off the electricity infrastructure and so provide flexibility for the new energy system.

FLAGSHIP PROJECT: H_2ERMES

With the H_2ermes project, Nobian, Tata Steel and the Port of Amsterdam are looking into setting up a 100MW hydrogen plant on the Tata Steel site in IJmuiden (with possible upscaling to 500MW). This plant will be able to produce up to 15,000 tons of green hydrogen per year using sustainable electricity. Green oxygen and zero-carbon heat are also produced in this process. The expertise for the plant comes from Nobian, which has over 100 years of experience in electrolysis. With the oxygen and hydrogen, Tata Steel can produce steel in a more sustainable way and thus significantly reduce carbon emissions. Furthermore, this hydrogen can be used to make the region more sustainable, for example in heating buildings, for new forms of green fuels and chemicals in the port area, and as a zero-emission fuel for public and commercial transport. This way H_2ermes can generate momentum for the further greening of the MRA.

FLAGSHIP PROJECT: OPPORTUNITIES FOR E-KEROSENE

The Port of Amsterdam wants to import, store, tranship and export hydrogen and synthetic fuels. The port operator wants to do this in part to make aviation more sustainable via Schiphol international airport. Hydrogen can be used to produce e-kerosene as a synthetic aviation fuel (SAF) The existing technologies are currently being applied on a small scale. The Port of Amsterdam is directly connected to Schiphol via an underground pipeline through which e-kerosene can be transmitted. Together with SkyNRG, Tata Steel, Royal Schiphol Group and KLM, the Port of Amsterdam is investigating the possibilities of setting up a pilot production facility for e-kerosene. This could produce around 50,000 tons of e-kerosene per year by 2030. As a Hydrogen Hub, the NSCA can make a significant contribution to the improved sustainability of international air traffic.



FLAGSHIP PROJECT: P2F HEMWEG VATTENFALL

Vattenfall intends to develop a fossil-free hydrogen hub on the site of the former Hemweg coal-fired power plant. In the first phase, green hydrogen will be produced for local industry and transport. The hydrogen will be distributed to customers in the port area via a low-pressure hydrogen pipeline, thus taking the first step towards creating a local, open-access hydrogen system.

Hydrogen production will start in 2025 and the development of this system will take place in collaboration with the Port of Amsterdam and Gasunie. Between 2025 and 2030, hydrogen production will be scaled up from 10MW to 100MW. This hydrogen will serve as a feedstock for the production of e-kerosene and e-methanol in the immediate vicinity of the Hemweg plant. In collaboration with partners, this value chain will make aviation and shipping more sustainable.

HORIZON 3: LARGE-SCALE TRANSITION AND IMPORT (2030-2050)

The long term is characterised by the internationalisation of the hydrogen economy. Because more offshore wind energy is being produced, the production of green hydrogen can be scaled up further. This is the period in which energy suppliers, like Vattenfall in Amsterdam, will use hydrogen on a larger scale to help balance electricity supply and demand. From 2030, it should be possible to bring the hydrogen produced offshore to landing points in the Netherlands, like Den Helder and the NSCA, for example. Heavy industry will make the switch to green hydrogen. This also applies to parts of the built environment that cannot be heated any other way. The national hydrogen backbone will acquire interconnections with the national hydrogen infrastructure in other European countries. In the NSCA, there will be ever-increasing import, storage and transport/transmission of hydrogen and hydrogen-derived energy carriers. Aviation will make the switch to green hydrogen.

FLAGSHIP PROJECT: H2GATE

The demand for hydrogen is expected to exceed what we in the Netherlands can or would want to produce. Importing hydrogen from sunny regions of the world is the obvious choice to address this issue. The Port of Amsterdam and terminal operator Evos are focussing on the development of a hydrogen import hub with capacity for 1 million tons of hydrogen per year by 2030. Hydrogen transport has its challenges. To transport large quantities, hydrogen must be highly compressed and cooled. In the H2Gate project, the parties are exploring the possibilities of various hydrogen carriers. This may later lead to studies and pilot projects for the design and realisation. H2Gate is an important step in the realisation of an international value chain for hydrogen on a commercial scale. This supply chain is expected to scale up by the end of this decade, depending on the availability of green hydrogen around the world and the growth of demand in Europe.

FOCUS ON INNOVATION, KNOWLEDGE DEVELOPMENT AND EMPLOYMENT

The impact of this hydrogen agenda on employment is substantial. Research by CE Delft shows that green hydrogen will contribute to national employment levels. According to the study, the new jobs, in FTEs, will be between 6,000 and 17,300 in 2030 and between 16,400 and 92,400 in 2050.

Year	Total one-off demand for labour (average, in FTEs/ year)	Permanent demand for labour (in FTEs/year)
2030	1,800 – 4,700	4,200 – 12,500
2040	2,000 – 13,000	9,200 – 43,000
2050	2,200 – 20,000	14,200 – 72,600

It is difficult to predict where these jobs will be created, though the prerequisites are that electrolysis facilities must be available and energy-intensive industry, offshore wind facilities and a world-class metropolis must all be close by. The North Sea Canal Area and the Amsterdam Metropolitan Area are therefore ideally positioned.

To establish a hydrogen economy, it is essential that knowledge and talent be developed. The MRA is home to prestigious knowledge institutions, research centres and industries that work closely with government bodies to develop knowledge and expertise clusters aligned to hydrogen innovation, application and utilisation. Various groups and alliances have been examining the specific knowledge needs in the value chains.

Work is also being done on establishing a broad yet targeted range of educational and training programmes at all educational and professional levels, including learning pathways (Techport, Techlands, NOVA College, universities of applied science training programmes, etc.). These programmes are key to job retention in the energy sector, transport sector and technical sectors, and will enable the region to maintain a leading position in the area of knowledge and talent development with the commitment to emerge as a hotbed for knowledge and innovation for the energy transition.

In time, the region will occupy a leading position internationally and be *the* place where knowledge and talent is developed at the knowledge institutions and where sustainable industries are welcomed.

FLAGSHIP PROJECT: DIRECT REDUCED IRON

Tata Steel has started preparations for its largest carbon emission reduction project in years; the production of green steel using the Direct Reduced Iron (DRI) technique, also referred to as the 'hydrogen-route'. In addition to reducing CO_2 emissions, this alternative way of steel production also improves the quality of the living environment around Tata Steel grounds. The DRI technique enables iron production with gas and/or hydrogen, using electric arc furnaces. At the moment, the availability of green hydrogen is limited, but in time it will replace natural gas in the production process.

WHAT IS REQUIRED TO REALISE THE NSCA HYDROGEN HUB?

The NSCA Hydrogen Hub will help reduce emissions and at the same time build a sustainable, new revenue model for the region and for the Netherlands. It is therefore important that the above initiatives be included in the Dutch National Hydrogen Programme, the Dutch National Growth Fund, IPCEI, Hydrogen for Climate Action and the European Clean Hydrogen Alliance, for example.

Additionally, it is important that the following preconditions be realised.

INVESTING IN INFRASTRUCTURE

- Having the required infrastructure in place is a precondition for the hydrogen economy and the NSCA Hydrogen Hub. This starts with: (1) constructing the hydrogen 'backbone', the main network; (2) connecting up the north-western part of the 'backbone' between Groningen, Den Helder and Amsterdam; and (3) establishing the regional hydrogen 'backbone' (RIB) between IJmuiden and Amsterdam.
- Another precondition is bringing energy generated at new offshore wind farms to landing points in the NSCA and Den Helder in order to guarantee sufficient sustainable electricity and, with this, the electrolysis capacity and upscaling possibilities to support, for example, the H_2ermes project. Investments are also needed to strengthen grid capacity in the NSCA and to guarantee robust connections.
- Clarity on the timeline for the construction of the national and regional hydrogen 'backbones', the landing points for offshore wind farms, and the robustness of the underlying network are important preconditions for offering companies investment security.
- In view of the expected high demand for hydrogen and the limited space available in the NSCA, the import, storage and transhipment of hydrogen will play a major role in the long term. Developing the international supply chain needs to be facilitated right now, for example through projects like H_2Gate.

STIMULATING DEMAND

- Creating the NSCA Hydrogen Hub requires upscaling and cost reduction, and this in turn depends on boosting both the demand for and the supply of sustainable hydrogen.
- CAPEX and OPEX support and instruments for upscaling are needed to cover the unprofitable gap (unrecoverable investment costs) and provide companies with solid financial incentives to invest in hydrogen production.
- Subsidy schemes are also needed to incentivise companies to use hydrogen, starting with those in promising sectors such as the steel industry, chemicals, manufacturing and transport. Support for projects such as P2F Hemweg Synkero is therefore very important to the NSCA given the presence of the steel industry (Tata Steel), chemical industry (Nobian), manufacturing industry (Zaanstad, IJmond) and transport sector (Schiphol, seaport) in the area and the gains in sustainability to be made.
- The revision of the European Renewable Energy Directive (RED 2) will also play a major role in boosting the demand for sustainable hydrogen and ensuring a level playing field in Europe. Having an active and committed central government – a government that closely monitors developments in the industrial port clusters in the Netherlands when drawing up relevant regulations – is of great importance in this regard.

A CLEAR FRAMEWORK

- Making hydrogen projects a reality requires an unambiguous framework for the spatial and environmental integration of hydrogen production and infrastructure and the associated licensing.
- The nitrogen issue is having a major impact on the development opportunities of the hydrogen economy. In particular, a legally robust framework for the long term is needed to provide investment security to businesses and guarantee that there will be leeway in terms of nitrogen depositions arising from hydrogen projects. Given the key role of hydrogen and other transition projects in the implementation of the Dutch Climate Agreement, it is precisely these projects that should be given priority in the future allocation of 'nitrogen permits' (leeway for nitrogen depositions).
- There must be commitment to knowledge development and knowledge sharing at research institutes and companies and to having sufficient technically trained personnel.

6. APPENDIX: PROJECTS

PROJECTS RELATING TO LARGE-SCALE HYDROGEN PRODUCTION

#	Description of project	Location	Parties involved	Size	Duration/status
1	H_2ermes: hydrogen production via electrolysis with the aim of making the steel industry more sustainable	IJmuiden / NSCA	Tata Steel, Nobian and Port of Amsterdam	100MW (with possible upscaling to 1GW)	In study phase Operational in 2024
2	P2F Hemweg	Amsterdam	Vattenfall, Port of Amsterdam, VTTI	Production of 10MW of green hydrogen with upscaling to 100MW of green hydrogen for the production of e-fuels	Technical and economic feasibility study completed First phase: 10MW operational in 2025 Second phase: 100MW operational in 2025-2030

PROJECTS CONCERNING BUILDING THE INFRASTRUCTURE (HYDROGEN 'BACKBONE' AND STORAGE)

#	Description of project	Location	Parties involved	Size	Duration/status
3	Regional hydrogen infrastructure H_2ermes Regional integrated 'backbone' (RIB)	NSCA	Gasunie, Port of Amsterdam		Potential pipeline routes being studied Completion in 2025
4	Rietlanden: a transhipment terminal at the Port of Amsterdam where the transition from coal to hydrogen-related activities or a logistical role in the transition of the port is being investigated.	Port of Amsterdam	Rietlanden		Exploratory phase between 2020 and 2025

PROJECTS FOR LOCAL HYDROGEN PRODUCTION TO TAKE PRESSURE OFF THE POWER GRID OR FOR GRID BALANCING

#	Description of project	Location	Parties involved	Size	Duration/status
5	Hydrogen in gas-fired power station: operation of controllable, flexible hydrogen-fired power stations in 2030	Amsterdam	Vattenfall, Gasunie, TenneT, Port of Amsterdam, Siemens	Blending with 30% hydrogen at existing Hemweg gas-fired plant In the period 2030-2040, further upscaling to 100% hydrogen at the Hemweg and Diemen power plants	Research phase. Start blending 30% hydrogen in power plant in 2030, moving up to 100% hydrogen in the period between 2030 and 2040 at Hemweg and Diemen

PROJECTS AIMED AT HYDROGEN APPLICATIONS FOR TRANSPORT & MOBILITY

#	Description of project	Location	Parties involved	Size	Duration/status
6	Tata Steel hydrogen vehicles pilot: using hydrogen to power its own vehicles	IJmuiden	Tata Steel		
7	Decarbonise waste collection and sweeper fleet using hydrogen	Municipality of Amsterdam	Municipality of Amsterdam	6 waste collection vehicles	Realisation in 2020
8	Hydrogen filling stations: plans to open a hydrogen filling station for road traffic	Municipality of Amsterdam, Amsterdam Airport Schiphol	Various parties Holthausen and Shell		2021/2022

#	Description of project	Location	Parties involved	Size	Duration/status
9	H_2Ships: European project focussed on identifying the conditions for successful market introduction of hydrogen as a fuel for shipping. As part of the pilot, the Port of Amsterdam's new management vessel will be powered by hydrogen stored in sodium borohydride	Port of Amsterdam	European Institute for Energy Research (Germany), Port of Amsterdam		Operational in 2022 Ship and shore facilities
10	Hydrogen bunkering in the Port of Amsterdam (as part of H_2ships)	Municipality of Amsterdam	Port of Amsterdam, Vattenfall		Feasibility study 2020/2021 Implementation after 2025
11	Crew transfer and Windcat	IJmuiden	CMB (Belgium), Vattenfall, Windcat workboats		2022
12	Several company vehicles of Port of Amsterdam on hydrogen	Port of Amsterdam	Port of Amsterdam		2020
13	ZOOF: retrofit of an urban pusher tug for hydrogen propulsion		ZOOF		2022
14	Hydrogen demos for GSE and logistics at and around Schiphol (TULIPS)	Amsterdam Airport Schiphol	SNBV, Port of Amsterdam, KLM, NOBIAN, NLR, EU partners (SINTEF, Fraunhofer, Polito, Ballard, ZEPP)	Study into hydrogen logistics at Schiphol/MRA and demos of GPUs and towing vehicles powered by hydrogen fuel cells	Start in 2022; running up to 2025

RESEARCH FACILITIES

#	Description of project	Location	Parties involved	Size	Duration/status
15	InVesta Experience Centre H_2HUB: hydrogen hub in the InVesta expertise centre with hydrogen production facility, including electrolyser, fuel cell (grid balancing) and local hydrogen grid for storage and transmission Several parties will supply or purchase hydrogen via the H_2HUB	Alkmaar	InVesta, BE+, TAQA Various other initiatives.	0.1MW electrolyser	FID 2021, start 2022
16	AMCEL	Amsterdam	University of Amsterdam (HIMS), Amsterdam University of Applied Sciences Industry sector (Avantium and others) AMOLF		Operational
17	Voltachem	Petten Delft	TNO and industrial and academic partners		Operational
18	AMS Institute	Amsterdam	Delft University of Technology, Wageningen University & Research, MIT		Operational
19	Green Campus	Amsterdam	Clusius College, Wellantcollege, AERES University of Applied Sciences, Inholland, the IBED, HIMS and SILS research institutes of the University of Amsterdam and its IXA innovation centre		Operational

#	Description of project	Location	Parties involved	Size	Duration/status
20	ILCA, Matrix Innovation Centre	Amsterdam	University of Amsterdam, VU University Amsterdam, Municipality of Amsterdam, Amsterdam Science Park, Dutch Research Council, Rabobank		Operational
21	Prodock, the innovation centre in the Port of Amsterdam for startups and labs focussing on hydrogen	Amsterdam	Amsterdam		Operational
22	Joint Research Centre in Petten: the hydrogen safety research centre for the EU	Petten			Operational

OTHER PROJECTS

#	Description of project	Location	Parties involved	Size	Duration/status
23	Synkero: a startup researching the development of a pilot production facility to produce e-kerosene to make aviation more sustainable	Port of Amsterdam	SkyNRG, Port of Amsterdam, Amsterdam Airport Schiphol, KLM	The facility could produce between 10,000 and 25,000 tons of e-kerosene	Operational in 2030
24	Bio Energy Netherlands: produces green hydrogen from biogas	Amsterdam	Bio Energy Netherlands	360 tons of hydrogen per year	Operational

NSCA project office
Plein 1945 – No. 96 (6th floor)
1971 GC IJmuiden
T +31 (0)255 56 05 00
Email: info@noordzeekanaalgebied.nl
Website: www.noordzeekanaalgebied.nl
Twitter: @PBNZKG

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