AMSTERDAM-NSCA HYDROGEN HUB: HYDROGEN ECONOMY ACCELERATOR

N7KC noordzeekanaalgebied

HYDROGEN HUB AMSTERDAM NSCA

From electricity >>>
Offshore wind farms generate green electricity

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

Residual heat to heat homes and buildings

Hydrogen supply from the rest of the Netherlands through the hydrogen backbone

Beverwijk

IJmuiden/Velsen

>>> via pipelines
hydrogen is transported via H2BB pipelines in the North Sea Canal Area to the port of Amsterdam and industry in Zaanstad

Zaanstad

Hydrogen imported by ship

>>> to users
in the value chains

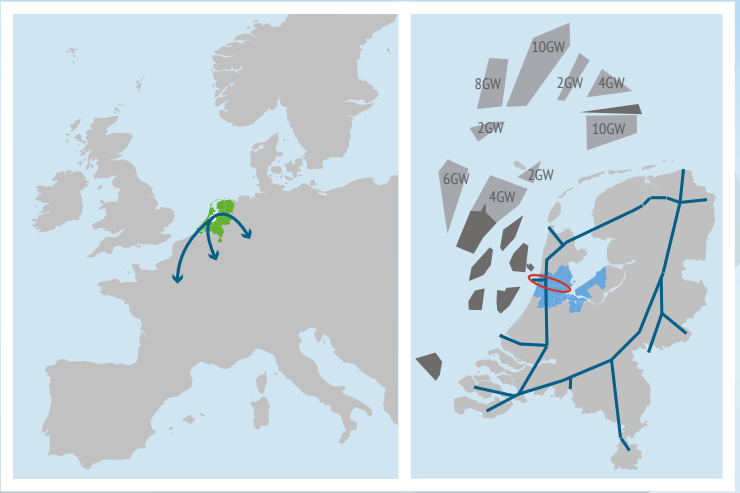
Amsterdam

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. Industry in the NSCA generates significant carbon emissions of approximately 18 megatons (including from energy generation). With the help of green hydrogen, carbon emissions in the NSCA can be cut by about half by 2030 and can be reduced to zero by 2050.

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. 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 energy, 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.

THE AMSTERDAM METROPOLITAN AREA AND THE NORTH SEA CANAL AREA AS HYDROGEN ACCELERATOR

The Metropolitan Region Amsterdam (MRA) is an economically strong region with ambitious local authorities and a population of over 2.5 million. 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. The focus on hydrogen offers opportunities for employment, technology and science.

The NSCA is part of the MRA. 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. The NSCA 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.

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*).

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: Decisio, 2019).

NEW VALUE CHAINS OF NATIONAL AND INTERNATIONAL IMPORTANCE

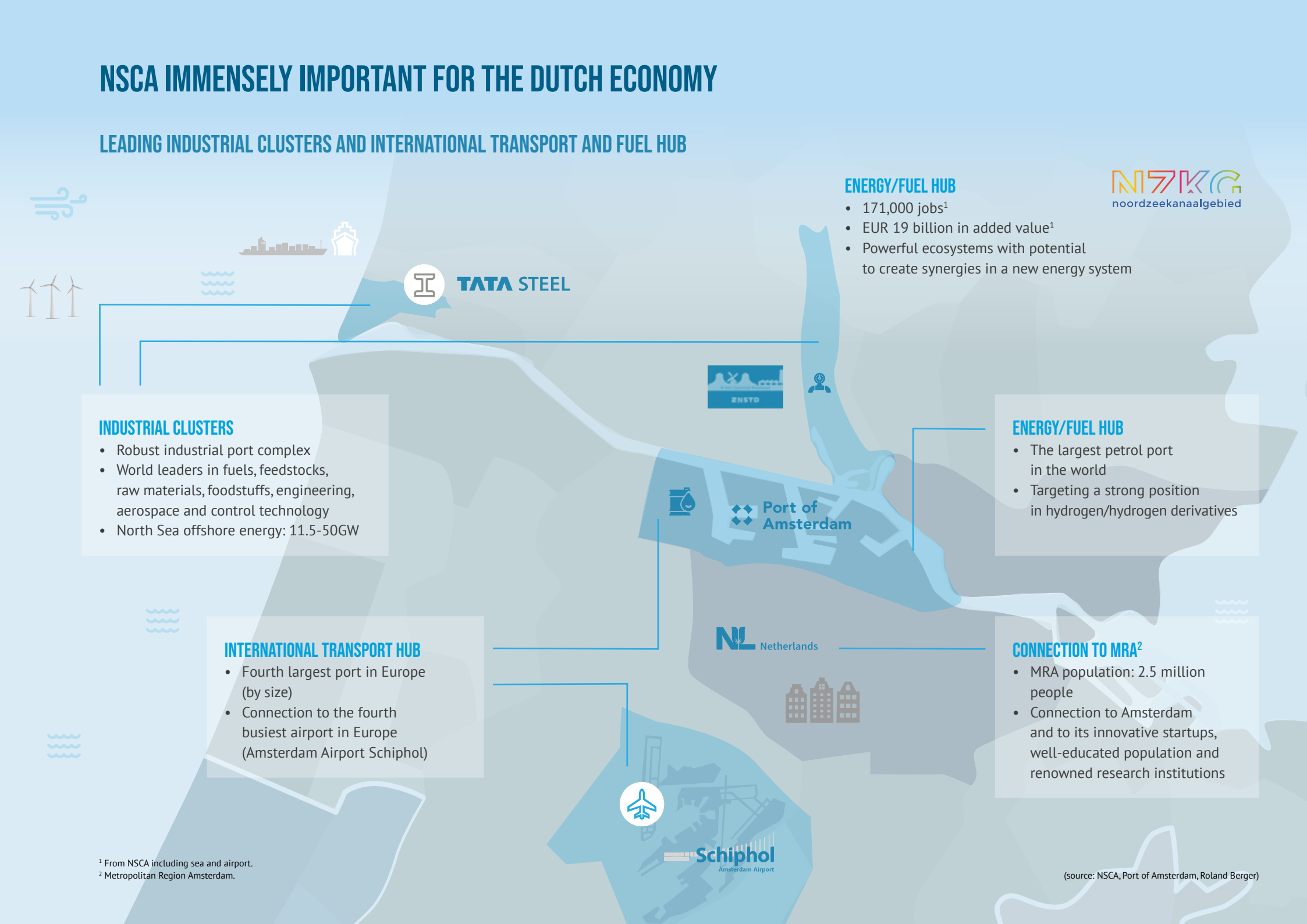
The airport, seaport and industry in the NSCA jointly have what it takes to build new value chains:

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

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.

NSCA IMMENSELY IMPORTANT FOR THE DUTCH ECONOMY

LEADING INDUSTRIAL CLUSTERS AND INTERNATIONAL TRANSPORT AND FUEL HUB



ENERGY/FUEL HUB

- 171,000 jobs[1]
- EUR 19 billion in added value[1]
- Powerful ecosystems with potential to create synergies in a new energy system

N7KG noordzeekanaalgebied

INDUSTRIAL CLUSTERS

- Robust industrial port complex
- World leaders in fuels, feedstocks, raw materials, foodstuffs, engineering, aerospace and control technology
- North Sea offshore energy: 11.5-50GW

ENERGY/FUEL HUB

- The largest petrol port in the world
- Targeting a strong position in hydrogen/hydrogen derivatives

INTERNATIONAL TRANSPORT HUB

- Fourth largest port in Europe (by size)
- Connection to the fourth busiest airport in Europe (Amsterdam Airport Schiphol)

CONNECTION TO MRA[2]

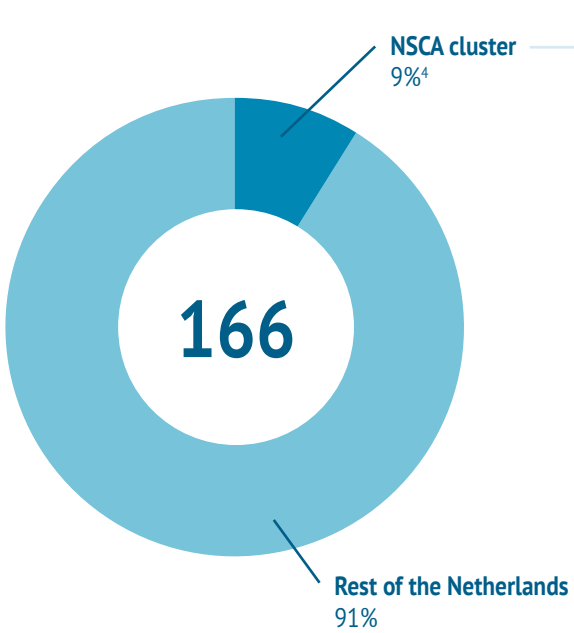
- MRA population: 2.5 million people
- Connection to Amsterdam and to its innovative startups, well-educated population and renowned research institutions

[1] From NSCA including sea and airport.
[2] Metropolitan Region Amsterdam.

(source: NSCA, Port of Amsterdam, Roland Berger)

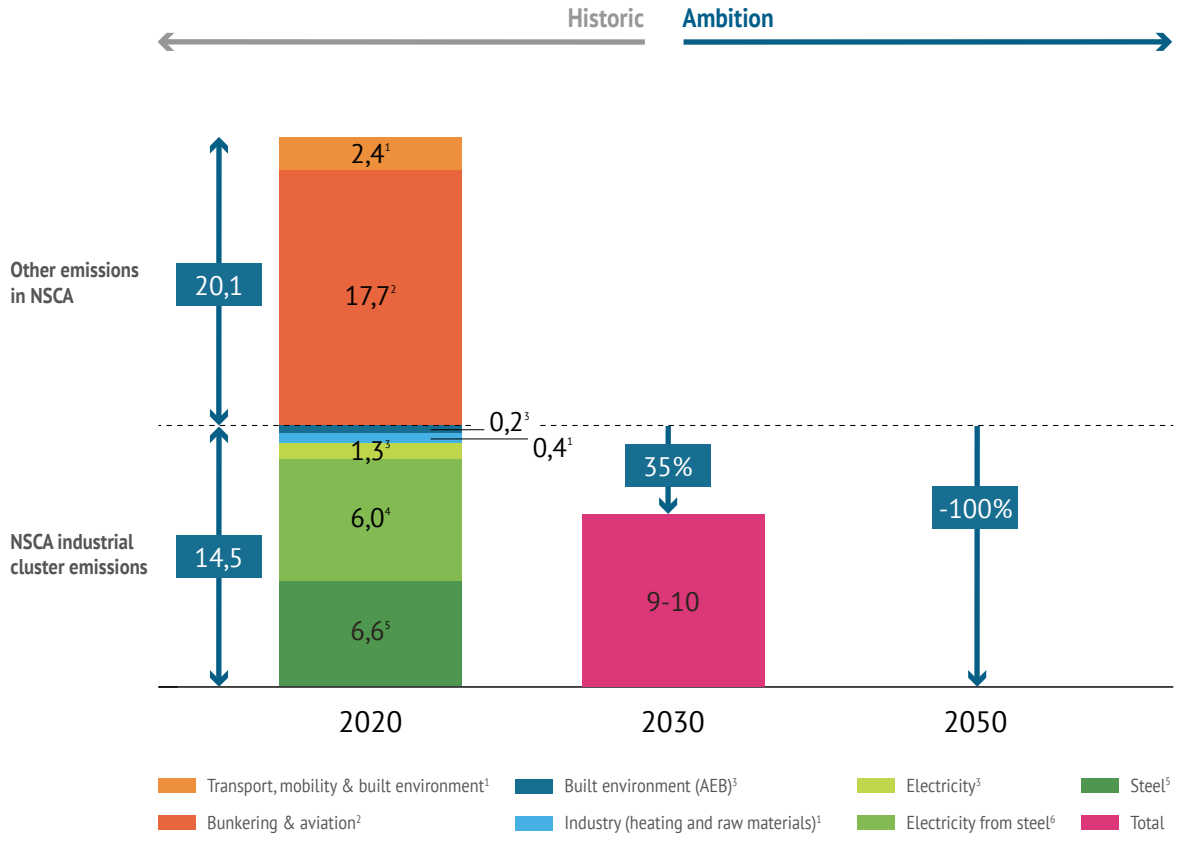
NSCA CARBON EMISSION REDUCTION TARGET

Dutch emissions in 2020 (Mt CO_2e)



GREENING THE NSCA FURTHER CAN LEAD TO A REDUCTION OF 4-6MT CO_2 IN 2030 AND 14-15MT CO_2 BY 2050, AS WELL AS AROUND ANOTHER 20MT CO_2 FROM AVIATION, BUNKERING, TRANSPORT & MOBILITY

(source: Statistics Netherlands, Klimaatmonitor, NSCA, Port of Amsterdam, Roland Berger)



[1] Based on 2019 industry-specific carbon emissions from the municipalities of Amsterdam, Beverwijk, Haarlemmermeer, Heemskerk, Velsen and Zaanstad.
[2] Bunkering and aviation emissions are not allocated to a specific country/region and are therefore presented separately.
[3] AEB (waste incineration) emissions count as 1/3 fossil and 2/3 biogenic; only the fossil emissions are shown.
[4] Since power plants use exhaust gases from steel, these emissions must be partially attributed to steel.
[5] Based on a standardised volume of production.

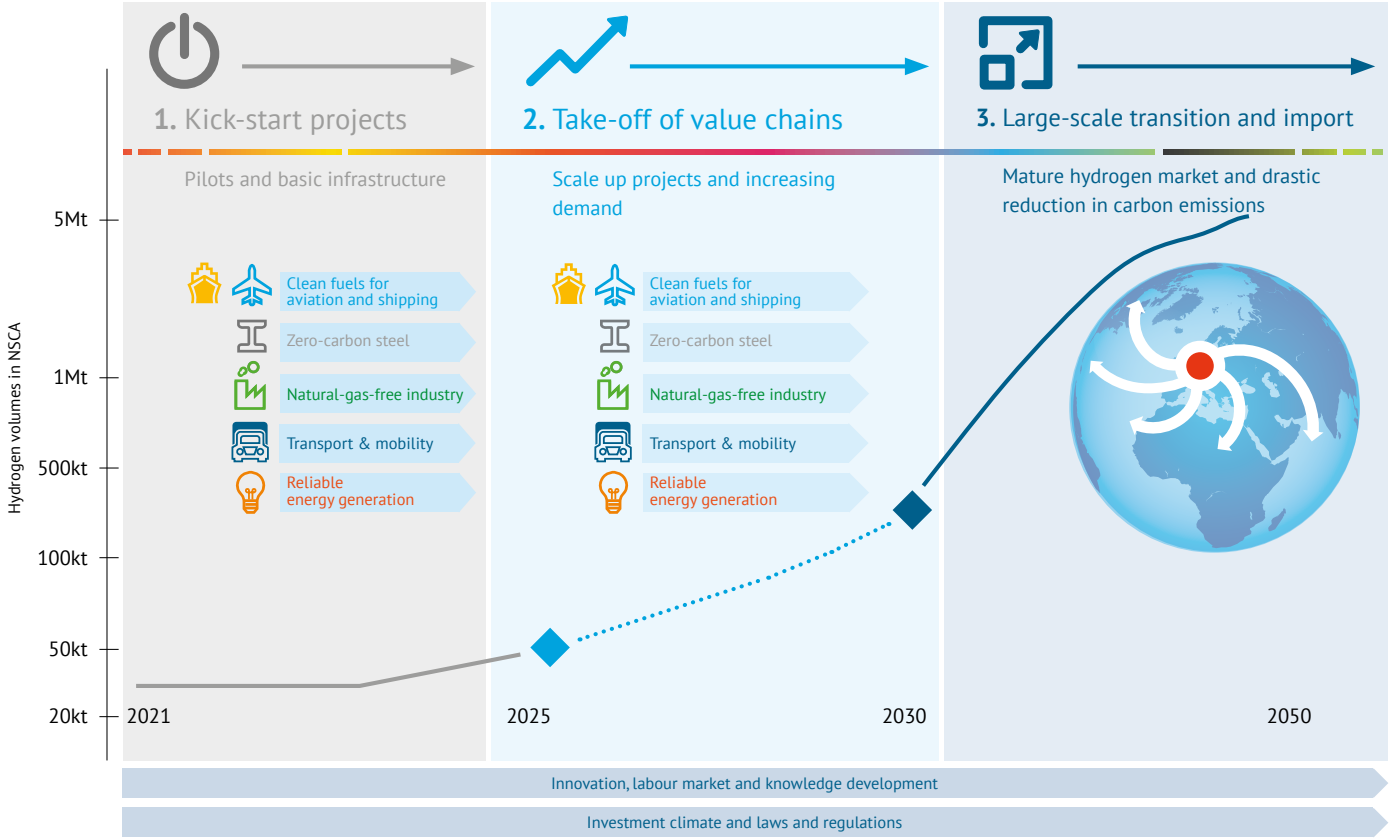
IN THREE STEPS TO A EUROPEAN HYDROGEN HUB

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.

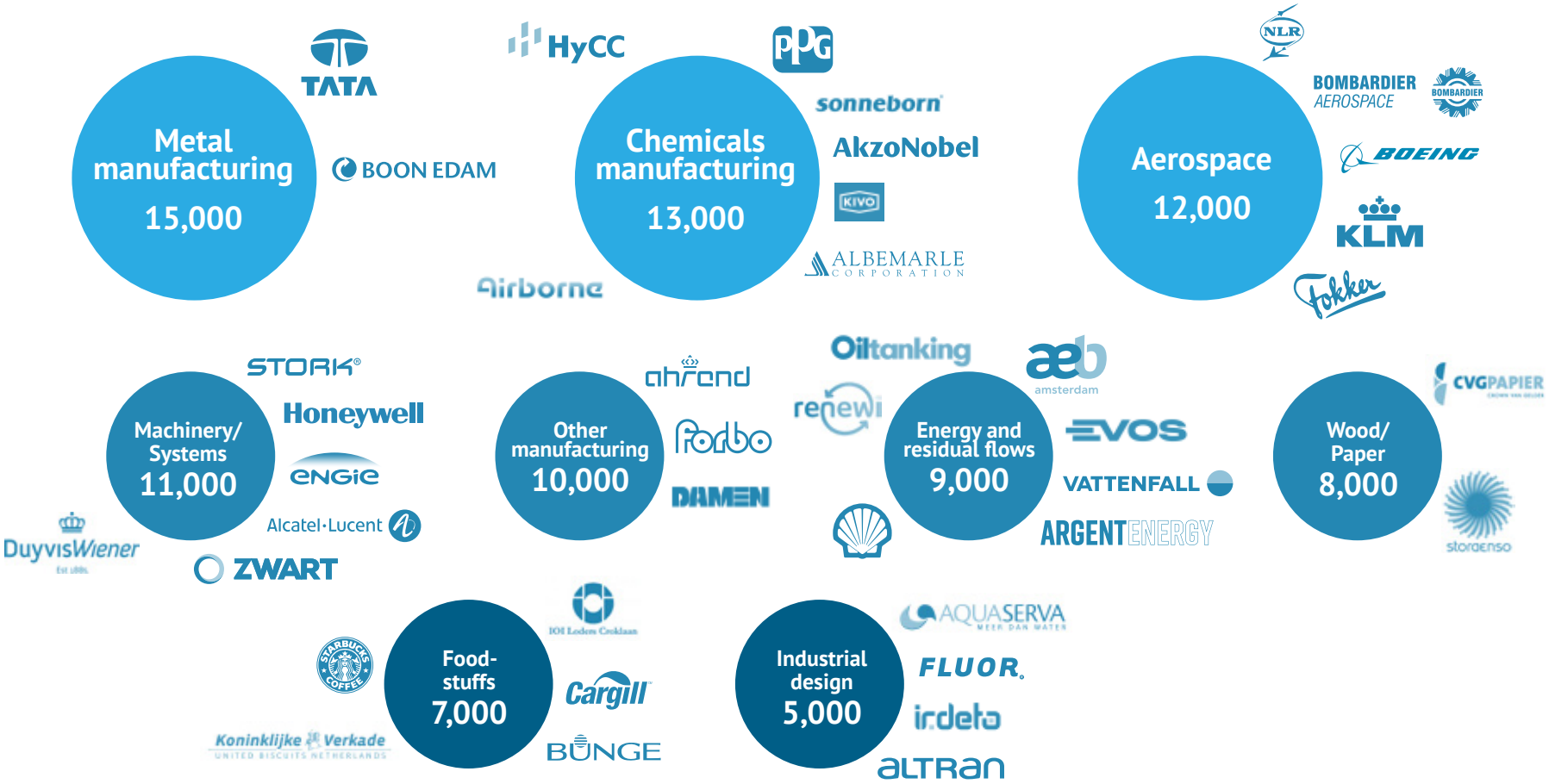
Large-scale transition and import: further introduction of hydrogen into the areas of international import and the transition to make fossil-fuel based activities climate neutral.



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

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. This industrial complex offers the critical mass to successfully make the switch to hydrogen and to develop new value chains.

EXTENSIVE AIRPORT AND SEAPORTS WITH ADVANCED KNOWLEDGE AND INFRASTRUCTURE

The seaports and the airport have an extensive network of companies active in international logistics. In addition to the many terminals, there is an extensive network of pipelines and a great deal of knowledge and experience to ensure the safe transport and transmission of fuels. The Port of Amsterdam is already one of the largest fuel import ports in the world and is investigating the possibilities of large-scale import, export and transmission of green hydrogen. A large part of the existing infrastructure can be used for this. There are many options for producing and using green hydrogen and related synthetic fuels. Using synthetic kerosene and synthetic methanol are some of the options for greening aviation and shipping. Underground fuel pipelines connect Amsterdam Airport Schiphol directly with the Port of Amsterdam.

DEVELOPING KNOWLEDGE

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. 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: HyCC, 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.

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 energy can be used directly to help meet industry's demand for electricity, or it can be converted in to hydrogen close to where it is being generated.

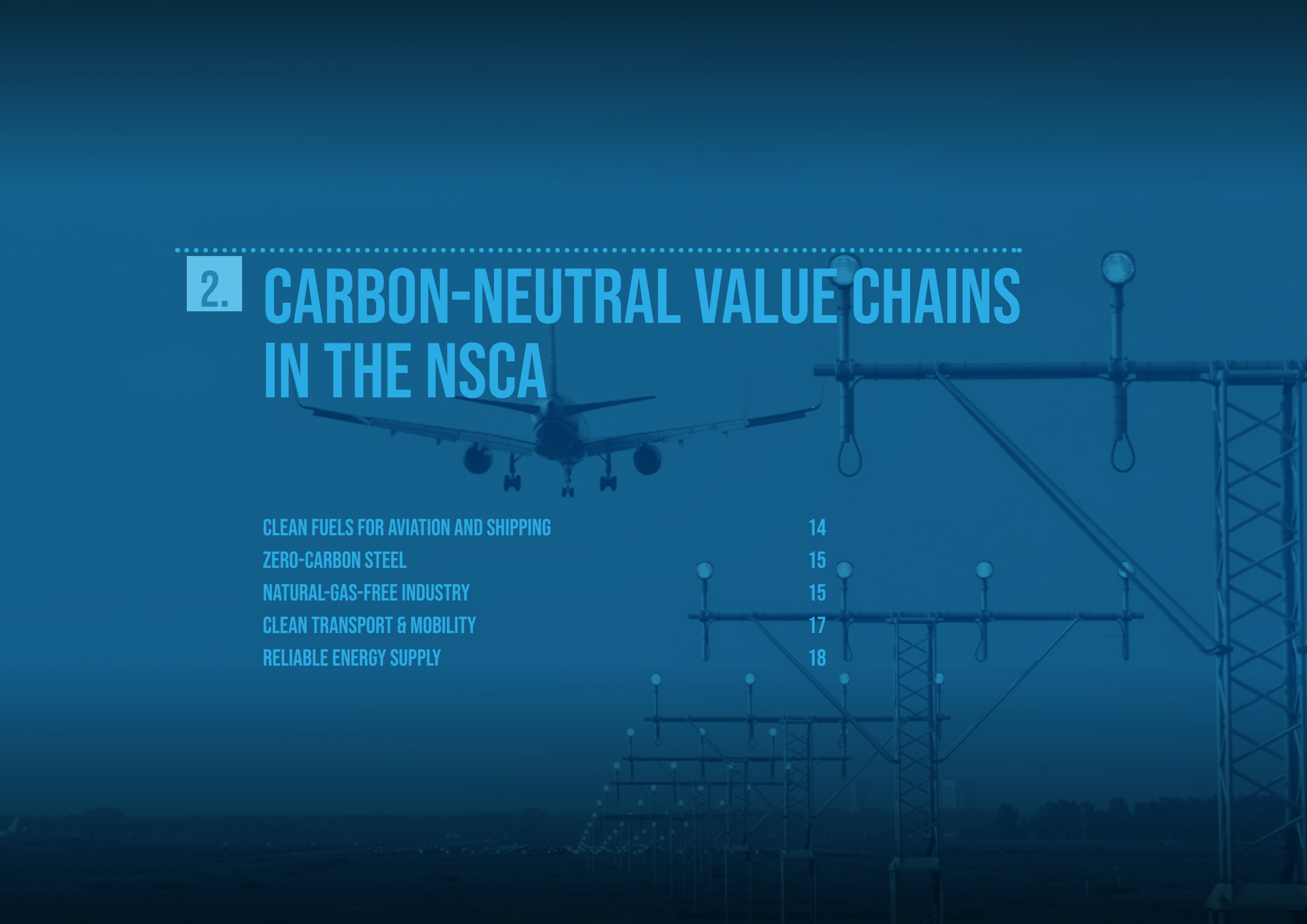
The possibility of bringing additional offshore wind power ashore in the NSCA is currently being investigated, as are the possibilities of bringing wind energy to shore in the form of hydrogen produced at sea. This could be done in the NSCA, but also in Den Helder. Located near the NSCA, the Port of Den Helder is a good base for bringing hydrogen ashore, for producing hydrogen and for transporting it further. 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. A good connection of the NSCA to the national hydrogen backbone and thus the connection to Den Helder and the other industrial clusters is essential. 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).

VALUE CHAIN COLLABORATION

Industry, the port, Schiphol and the cities need each other to complete the transition to carbon neutrality and circularity. 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, HyCC, Vattenfall, Alliander, Provincial Authority of North Holland, Municipality of Amsterdam, MRA, Zaanstad Maakstad, ORAM, Argent Energy and Projectbureau NZKG (the 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. CARBON-NEUTRAL VALUE CHAINS IN THE NSCA



CARBON-NEUTRAL VALUE CHAINS IN THE NSCA

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

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 80,000kt 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. In addition, under the name H2A, 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. The ambition is to import 1Mt of green hydrogen by 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. With Heracless, Tata Steel envisions using hydrogen as a fuel in a direct reduced iron (DRI) process. This will be done in two steps. The first DRI plant will be commissioned around 2030, the second around 2035. It is expected that by around 2030 Tata Steel's hydrogen consumption will be about 100 to 150kt, cutting carbon emissions by some 30% to 40%. In the second step, the hydrogen consumption will increase to 400kt by around 2035, and carbon emissions will decrease to zero in the period leading up to 2050.

This enormous demand for hydrogen will make Tata Steel a launch customer for the hydrogen economy in the NSCA.

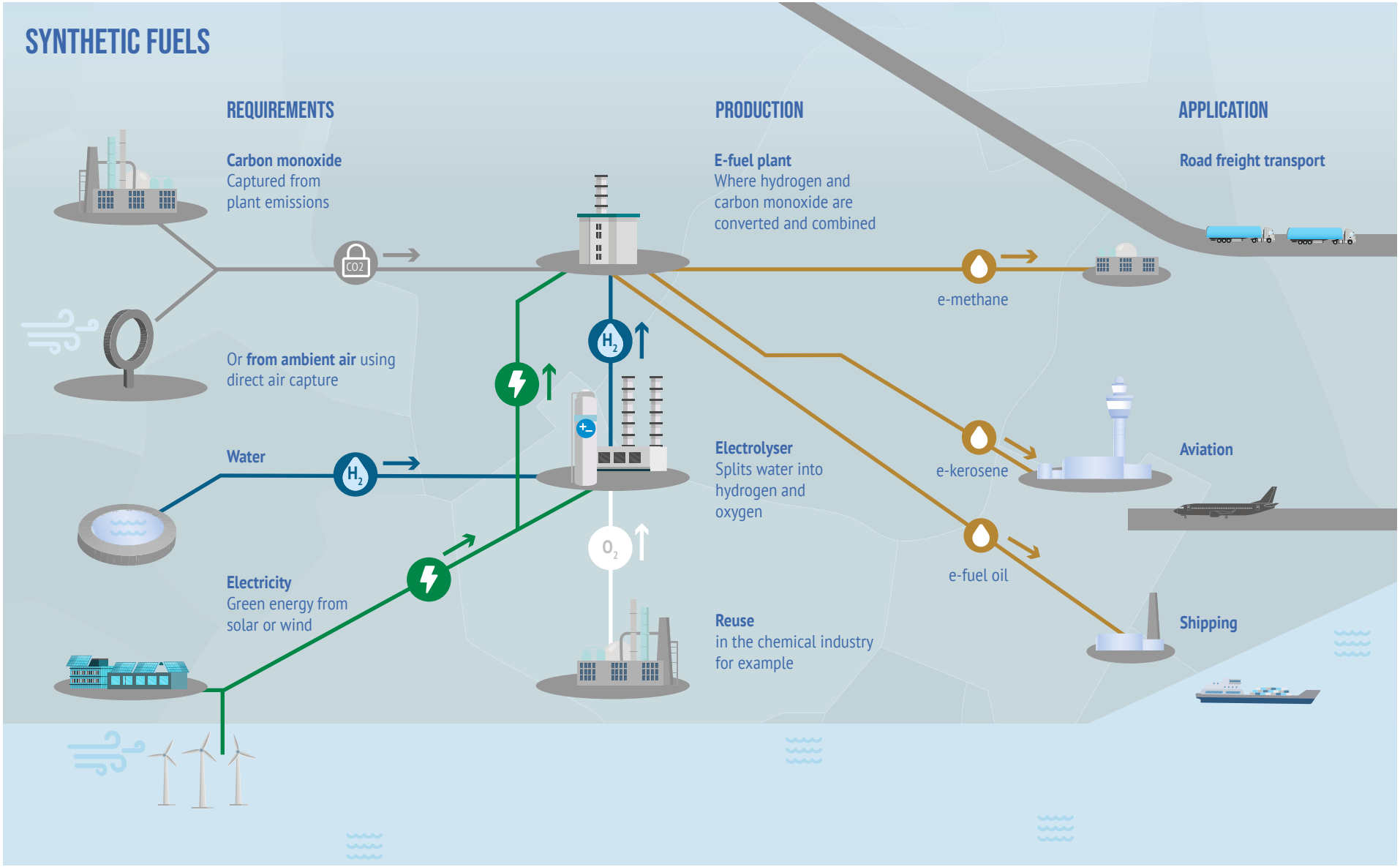
Tata Steel is also involved in the H_2ermes project, targeting the production of 15kt of green hydrogen together with HyCC. The H_2ermes project enables Tata Steel to gain practical experience with hydrogen in the short term, both for reduction applications and for heating the material in the furnaces (up to 1,200°C).

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
Shipping
e-fuel oil

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 solid 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 Noord Holland is currently working together with the Amsterdam-NSCA Hydrogen Hub on ways to aggregate demand as 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 H2BB) – that will connect the IJmond region to the Port of Amsterdam and to the national hydrogen backbone. The idea is to also connect the NSCA H2BB 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 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.

3. HYDROGEN SUPPLY AND DEMAND IN THE NSCA

HYDROGEN SUPPLY AND DEMAND IN THE NSCA

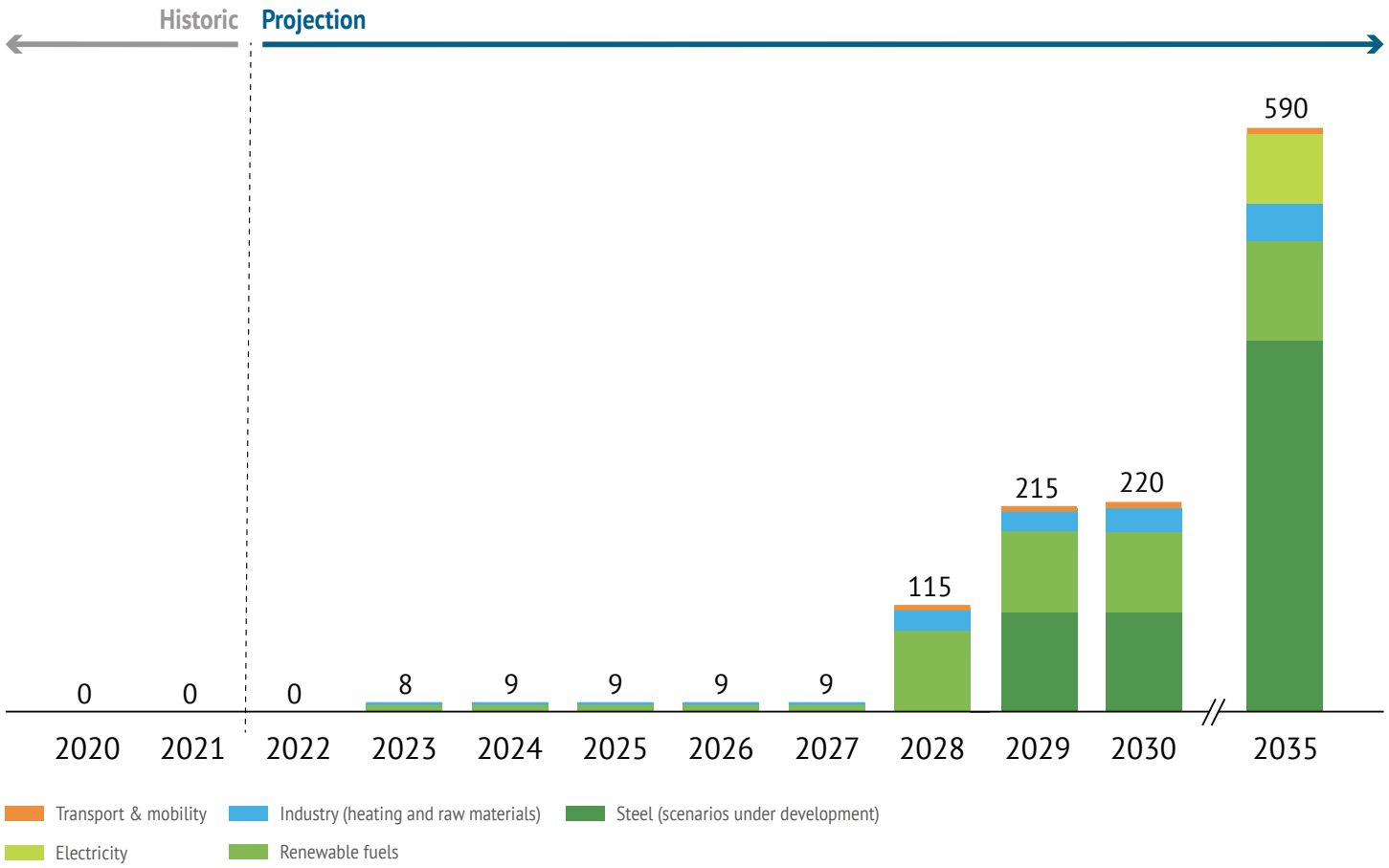
To meet the climate targets set for 2030 and 2050, the NSCA is focusing on carbon-neutral hydrogen. The ultimate goal is to use only green hydrogen. The main route to a hydrogen cluster in the NSCA therefore lies in building up production capacity for green hydrogen, with sustainable power from offshore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

The demand for hydrogen is expected to exceed its production. We want to address this expected imbalance through hydrogen production in the NSCA and by importing hydrogen, by ship and through the national backbone. 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.

DEMAND 2030–2035

EXPECTED HYDROGEN DEMAND IN THE NSCA BY INDUSTRY, 2020–2035 (IN KT H_2)

EXPECTED H2 DEMAND GROWS TO 220KT BEFORE 2030 AND 590KT AROUND 2035



BOTTOM-UP ANALYSIS

Notes

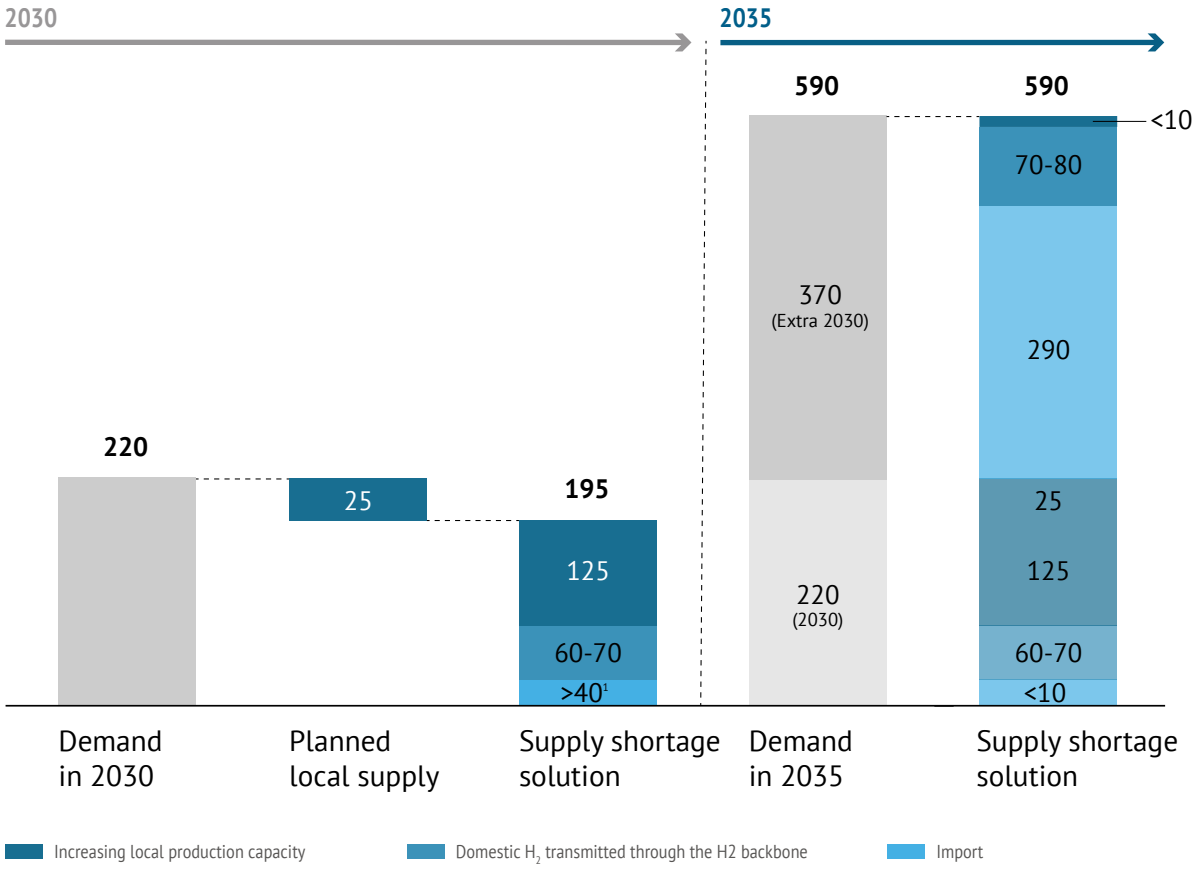
- Up to 2027, demand will mainly come from several small-scale renewable fuel production plants and transport & mobility pilot projects
- By 2030, the first large installations for sustainable fuel will have started operations and Tata Steel will have replaced the first of two blast furnaces with DRI technology.
- By 2035, Tata Steel aims to commission the second DRI plant, which will result in a much higher demand for hydrogen
- Tata Steel specifically envisions using green hydrogen. Using blue hydrogen makes less sense: in that case it would make more sense to integrate CCS into the steel production process instead

(Source: Tata Steel, Synkero, Vattenfall, NSCA project office, Port of Amsterdam, press releases, Roland Berger)

SUPPLY 2030–2035

SUPPLY IN NSCA COMPRISES LOCALLY PRODUCED AND IMPORTED HYDROGEN

POTENTIAL SOLUTION FOR THE SUPPLY SHORTAGE IN NSCA, 2030 (IN KT H_2)



SOLUTION FOR THE SUPPLY SHORTAGE

1. **Increasing local production capacity**
- Increasing/accelerating the development of local electrolysis capacity
- Limited grid capacity and available space will limit local production to approx. 1GW or approx. 150kt H_2

2. **Domestic H_2 transmitted through the H2 backbone**
- Supply of hydrogen from projects in the Netherlands such as NorthH_2, H_2Gateway and H_2opZee, *transmitted through the hydrogen backbone*, which will be completed by 2027
- Competition with other demand regions (e.g. Rijnmond and Chemelot) could possibly limit availability

3. **Import**
- Development of the infrastructure for the import of hydrogen, like in the H2A and EOS projects
- Transporting hydrogen requires carriers or compression/liquefaction, which can be expensive

[1] Imports must first be established before starting to develop the infrastructure.

(Source: NSCA project office, Roland Berger)

4. DEVELOPMENT AGENDA FOR THE AMSTERDAM-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.

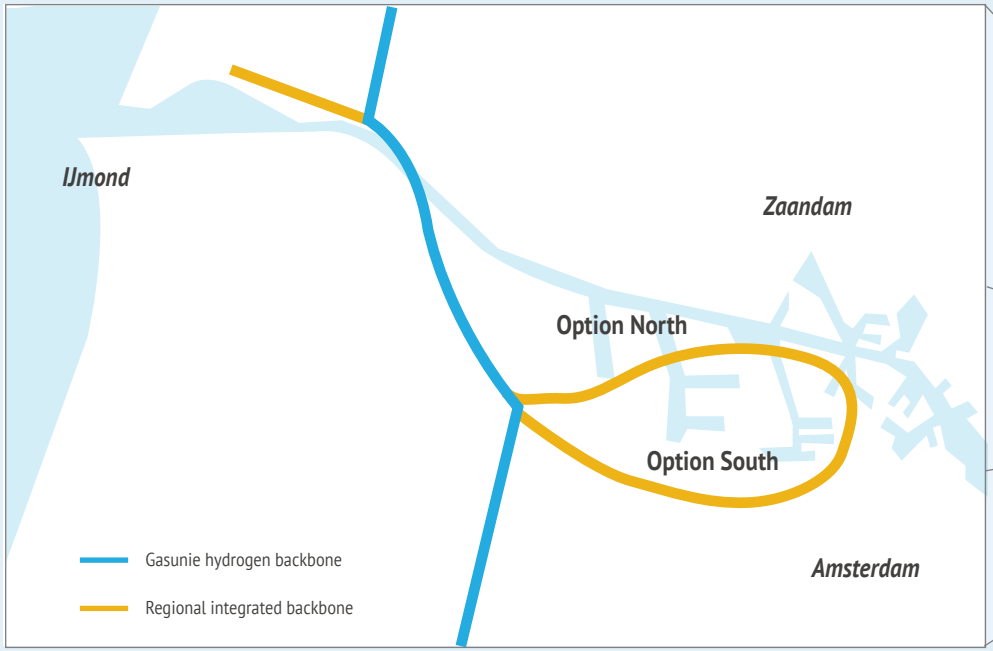
HORIZON 1: KICK-START PROJECTS (2021-2025)

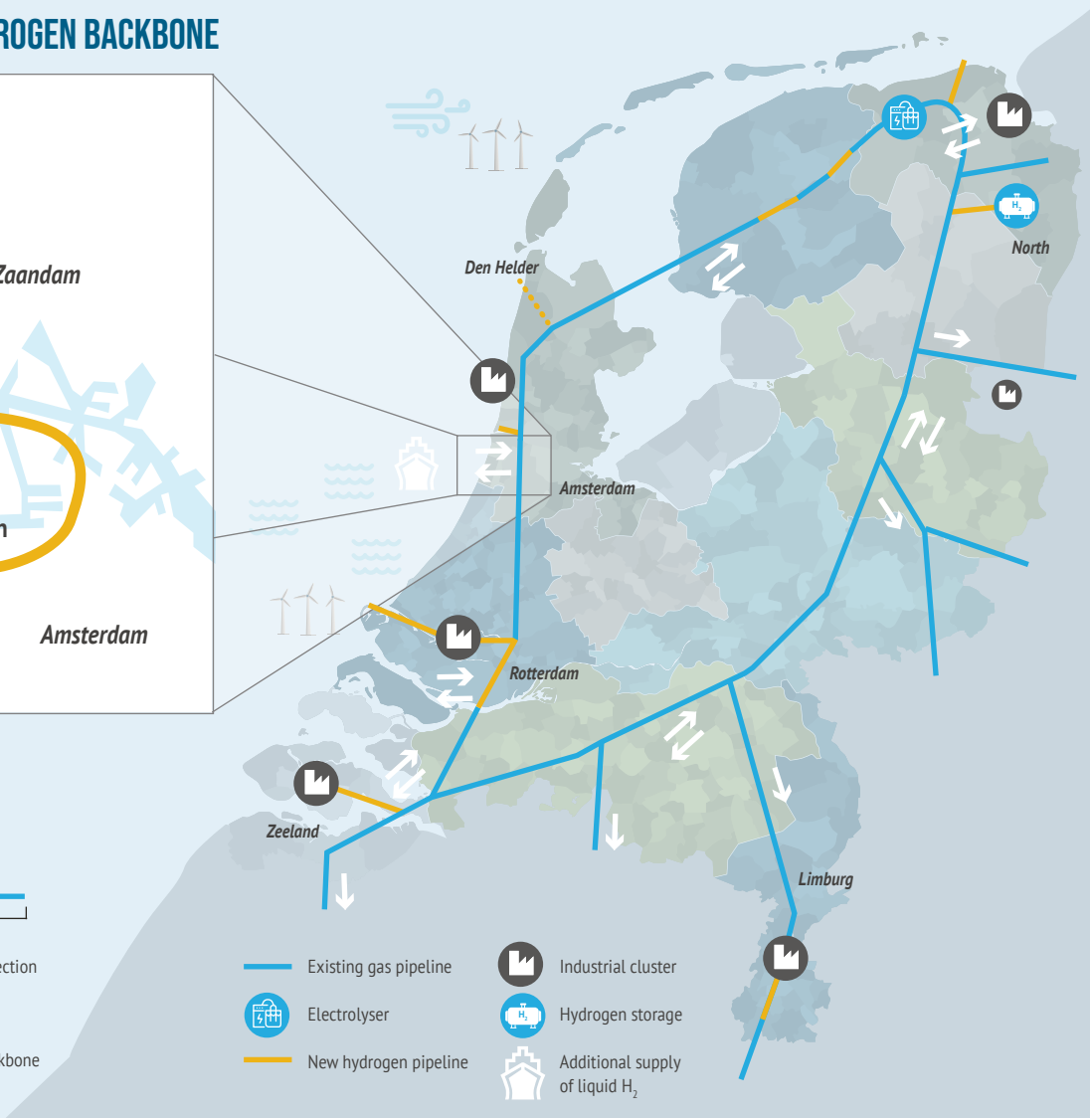
This is a period characterised by local hydrogen-related developments. The use of small-scale, locally produced green hydrogen is mainly directed towards heavy transport by road and water. During this period, hydrogen is used to address local grid congestion problems. Other activities in this phase are 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 route for the national hydrogen backbone and options 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.

FLAGSHIP PROJECT: REGIONAL HYDROGEN BACKBONE (H2BB)

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. The H2BB will provide access to the local low-pressure hydrogen infrastructure in the ports of Amsterdam and Zaanstad.

CONNECTING THE REGIONAL BACKBONE TO THE GASUNIE HYDROGEN BACKBONE





Phases

2025 2026 2027 2028 2029 2030

- Regional backbones operational, including northern Netherlands-Germany connection
- 5 industrial clusters connected to each other and H_2 storage
- Backbone connected with regions in Germany and Belgium and to European backbone

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

The medium term is characterised by an upscaling of hydrogen use across the Netherlands. 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

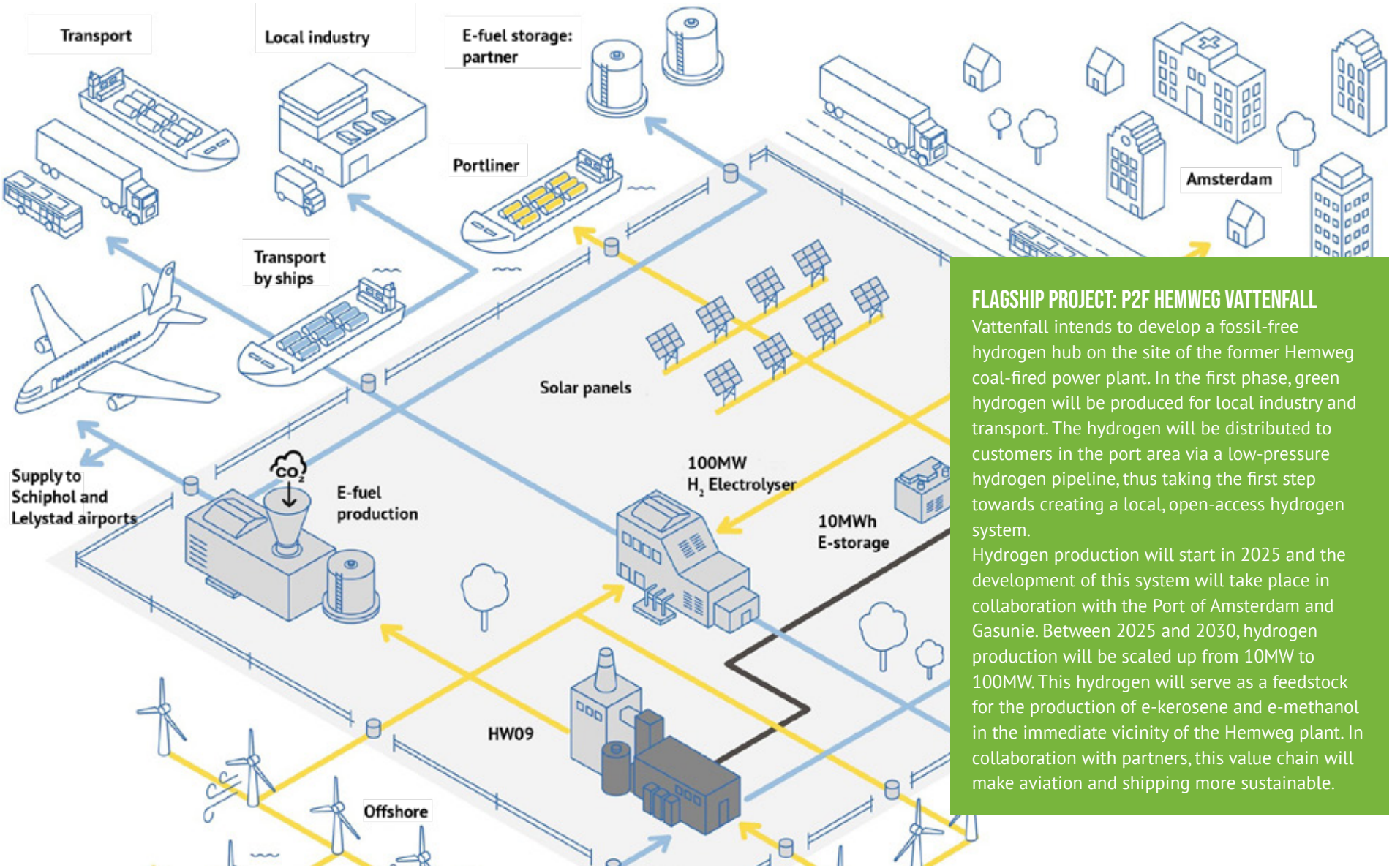
With the H_2ermes project, HyCC, Tata Steel and the Port of Amsterdam are looking into setting up a 100MW hydrogen plant on the Tata Steel site in Ijmuiden (with possible upscaling to 500MW). This plant will be able to produce up to 15kt of green hydrogen per year using sustainable electricity. Oxygen and zero-carbon heat are also produced in this process. The expertise for the plant comes from HyCC, 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: HERACLESS

Tata Steel will produce sustainable steel using green hydrogen. They will do this using direct reduced iron (DRI) technology using natural gas or hydrogen, in combination with electric arc furnaces, to produce iron. Two DRI plants will replace the current blast furnaces. The first blast furnace will be replaced by a DRI plant before 2030; the second will be replaced by around 2035. In the period between 2030 and 2035, natural gas will be phased out and the DRI plants will eventually make maximum use of green hydrogen. The speed of this development depends on the availability of green hydrogen. With Heracless, Tata Steel expects to be able to cut carbon emissions by some 4Mt by 2030. And with a reduction in nitrogen and particulate matter of approximately 80% and 55%, respectively, the technology will also reduce pressure on the local environment and community.

FLAGSHIP PROJECT: SYNTHETIC FUELS

The Port of Amsterdam wants to import, store, tranship and export hydrogen and synthetic fuels, as well as providing space to produce a certain, limited amount of synthetic fuel. 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, to operate under the name Synkero. This could produce approximately 50,000 tonnes of e-kerosene per year by 2027. In addition, Argent Energy, located at the Port of Amsterdam, is committed to expanding biodiesel production and other sustainable transport fuels. The Amsterdam-NSCA Hydrogen Hub 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: HYDROGEN IMPORT

To meet the Dutch hydrogen demand, imports from areas with a surplus of sustainable energy will be required. The Port of Amsterdam is working on the realisation of a hydrogen import hub via various routes.

H2A: together with terminal operator Evos, the Port of Amsterdam is investigating the possibilities for importing 1Mt of green hydrogen by 2030. Under the name H2A, the parties are exploring the various options, such as import via liquid organic hydrogen carriers (LOHCs).

EOS: the Port of Amsterdam is also working with terminal operator Zenith on the EOS project, in which the import of cryogenic liquid hydrogen (LH_2) is being studied. These projects are key to developing an international hydrogen value chain on a commercial scale. These value chains are expected to be scaled up around 2030, depending on the availability of green hydrogen worldwide and how the demand for hydrogen develops 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.

WHAT IS REQUIRED TO REALISE THE AMSTERDAM-NSCA HYDROGEN HUB?

The Amsterdam-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. Developments regarding hydrogen in the NSCA play an important role in living up to the agreements and meeting the targets set out in the Dutch Climate Agreement and the European Green Deal. It is therefore important that the following preconditions be realised.

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 Amsterdam-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 (H2BB) between IJmuiden and Amsterdam. For this, having sufficient numbers of technically trained personnel available is of great importance.
- 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 the power grid capacity in the NSCA and to guarantee robust connections.
- Clarity on the timeline for establishing the landing points for offshore wind farms, as well as 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 H2A.

BOOSTING SUPPLY AND DEMAND

- Creating the Amsterdam-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.
- Additional subsidy schemes are needed to incentivise companies to use hydrogen, starting in promising industries where major sustainability gains can be realised, such as in steel (Tata Steel), chemicals (HyCC), manufacturing, and transport & mobility (Schiphol, Port of Amsterdam). Support for projects such as P2F Hemweg and Synkero is thus of great importance to the NSCA.
- 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.

SPATIAL AND ENVIRONMENTAL INTEGRATION

- 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).
- Licensing processes for key hydrogen production, transport and usage projects need to be accelerated.

5. APPENDIX: PROJECTS

PROJECTS RELATING TO LARGE-SCALE HYDROGEN PRODUCTION

No.	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, HyCC and Port of Amsterdam	100MW (with possible upscaling to 500MW)	In study phase Operational in 2025
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
3	H2era: electrolysis at the Port of Amsterdam	Port of Amsterdam	HyCC, Port of Amsterdam	Up to 500-600MW	Exploratory phase

PROJECTS CONCERNING BUILDING THE INFRASTRUCTURE (HYDROGEN BACKBONE AND STORAGE)

No.	Description of project	Location	Parties involved	Size	Duration/status
4	Regional integrated backbone (H2BB)	NSCA	Gasunie, Port of Amsterdam		Potential pipeline routes being studied Completion in 2025
5	Rietlanden: a transhipment terminal at the Port ofAmsterdam 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

No.	Description of project	Location	Parties involved	Size	Duration/status
6	H2avennet: low-pressure hydrogen infrastructure at the Port of Amsterdam	Port of Amsterdam	Port of Amsterdam, Gasunie, Municipality of Amsterdam		Potential pipeline routes are being studied. H2avennet is expected to be operational by Q2 2026
7	ZaannetH2: low-pressure hydrogen infrastructure in the Zaanstad region	Zaanstad	Zaanstad Maakstad, Liander, Port of Amsterdam		Exploratory phase

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

No.	Description of project	Location	Parties involved	Size	Duration/status
8	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 gas-fired plant at Hemweg 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

No.	Description of project	Location	Parties involved	Size	Duration/status
9	Tata Steel hydrogen vehicles pilot: using hydrogen to power its own vehicles	IJmuiden	Tata Steel		
10	Decarbonise waste collection and sweeper fleet using hydrogen	Municipality of Amsterdam	Municipality of Amsterdam	6 waste collection vehicles	Realisation in 2022

No.	Description of project	Location	Parties involved	Size	Duration/status
11	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
12	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
13	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
14	Crew transfer and Windcat	IJmuiden	CMB (Belgium), Vattenfall, Windcat workboats		2022
15	Several company vehicles of Port of Amsterdam on hydrogen	Port of Amsterdam	Port of Amsterdam		Completed
16	ZOOF: retrofit of an urban pusher tug for hydrogen propulsion		ZOOF		2022
17	Hydrogen demos for GSE and logistics at and around Schiphol (TULIPS)	Amsterdam Airport Schiphol	SNBV, Port of Amsterdam, KLM, HyCC, 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

No.	Description of project	Location	Parties involved	Size	Duration/status
18	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
19	AMCEL	Amsterdam	University of Amsterdam (HIMS), Amsterdam University of Applied Sciences Industry sector (Avantium and others) AMOLF		Operational
20	Voltachem	Petten Delft	TNO and industrial and academic partners		Operational
21	AMS Institute	Amsterdam	Delft University of Technology, Wageningen University & Research, MIT		Operational
22	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

No.	Description of project	Location	Parties involved	Size	Duration/status
23	ILCA, Matrix Innovation Centre	Amsterdam	University of Amsterdam, VU University Amsterdam, Municipality of Amsterdam, Amsterdam Science Park, Dutch Research Council, Rabobank		Operational
24	Joint Research Centre in Petten: the hydrogen safety research centre for the EU	Petten			Operational

OTHER PROJECTS

No.	Description of project	Location	Parties involved	Size	Duration/status
25	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 2027
26	Bio Energy Netherlands: produces green hydrogen from biogas	Amsterdam	Bio Energy Netherlands	360 tons of hydrogen per year	Exploratory phase
27	Argent Energy: expanding production of biodiesel and other sustainable transport fuels	Port of Amsterdam	Argent Energy, Port of Amsterdam		Exploratory phase
28	Heracless: hydrogen route Tata Steel	IJmuiden	Tata Steel	100-150kt H_2 demand in 2030, from 2035 approx. 400kt	Timeline

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