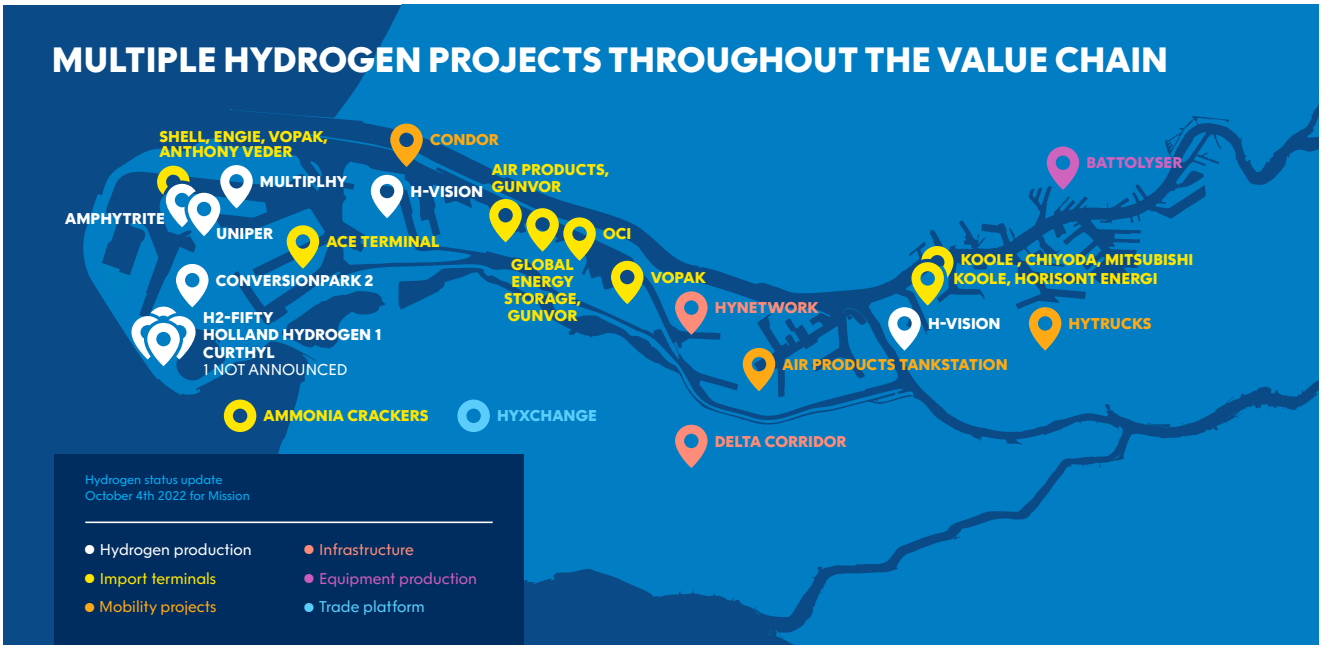
Port of Rotterdam

Port of Rotterdam developing Europe's Hydrogen Hub

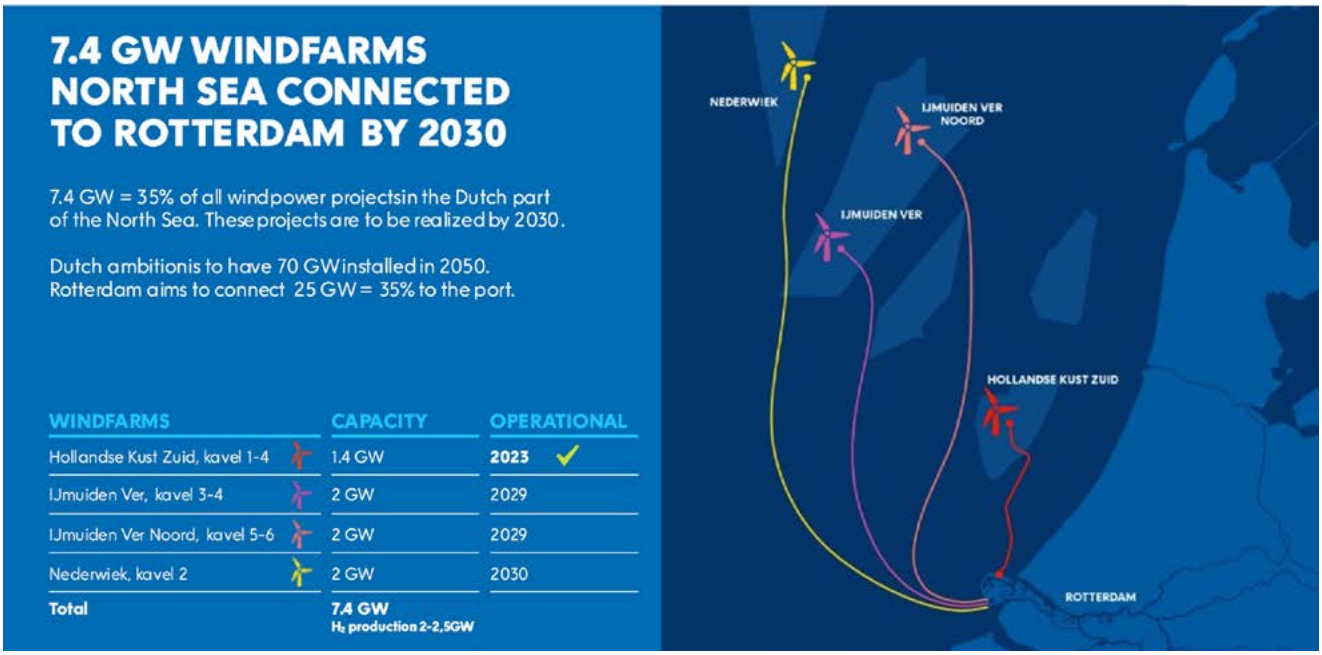
The Port of Rotterdam is working hard to realise a hydrogen ecosystem: landing green electricity from North Sea wind farms, production of green hydrogen, development of import terminals for hydrogen and hydrogen carriers, setting up import chains, infrastructure in Rotterdam and between the port and industrial clusters in the Netherlands and Germany, a hydrogen exchange and the production of electrolysers.

For the hydrogen economy to take off parties simultaneously take steps in all these areas. The first large electrolyser is being built, an ammonia terminal is tripling its capacity, and the hydrogen backbone is being built right now, to mention a few projects that are in their realisation phase. In Rotterdam, we are on the right track. An overview of the state of affairs is given below.



FROM WIND TO HYDROGEN

Significant volumes of green power will come from the seaside. By 2030, wind turbines with a capacity of 21 GW must be realised in the North Sea. For 7.4 GW thereof, it is stipulated that it will land at the Maasvlakte. In 2022, TenneT's first onshore substation was commissioned to land 1.4 GW of the Hollandse Kust Zuid wind farm. Another 6 GW will follow before the end of this decade. This will bring the total to 7.4 GW, a third of all wind projects in the Dutch part of the North Sea. The government wants to build an additional 50 GW of offshore wind farms between 2030 and 2050. The Port of Rotterdam Authority is in talks with the Ministry of Economic Affairs and TenneT on how a third of that can also land in Rotterdam, either as electricity or hydrogen produced at sea.



HYDROGEN PRODUCTION: ELECTROLYSIS

Part of this green power will be used in the western part of the port to split water (H_2O) into hydrogen (H_2) and oxygen (O). This process is called electrolysis. The green hydrogen thus obtained plays a key role in the new economy as a substitute for natural gas in industrial processes that cannot be electrified, as a building block for green chemistry, and as a transport fuel. In Rotterdam, hydrogen made from natural gas/methane (CH_4) is already widely used in refining processes.

Since hydrogen is easier to store than electricity (no large batteries are required), the production of green hydrogen is also a way to accommodate the fluctuating supply of green electricity. In the Rotterdam M4H area, an ecosystem of innovative companies is being developed. Companies like Battolyser Systems company. This company is developing plans for a plant that produces battolysers: a combination of energy storage ('battery') and an electrolyser. The battolyser can be used to store wind and solar energy, which can then be used to produce hydrogen. This technology was developed at TU Delft.

During electrolysis, about 30% of the energy cannot be converted into hydrogen. This energy is lost in cooling water. This means that with the increase in electrolysis, a lot of hot water will also become available for regional heat networks.

The amount of CO_2 reduction when using hydrogen ranges from 5 tonnes (when producing and using synthetic fuels) to 28 tonnes of CO_2 (when producing steel). As a general rule, 1 tonne of green hydrogen cuts carbon emissions by 10 tonnes.

Holland Hydrogen 1, Shell

A so-called conversion park has been set up at Maasvlakte 2 for the production of green hydrogen. Various companies have plans to build green hydrogen plants here with a capacity of 200-250 MW each. Shell has started construction of the Holland Hydrogen I. BP and HyCC (H2-Fifty) and Air Liquide (CurtHYL) are currently developing their plans.
By grouping the plants, they can use common facilities such as a power connection, water supply and connection to the new hydrogen pipeline. Uniper also has plans to produce a 500 MW green hydrogen next to its current Maasvlakte coal-fired power plant and Eneco has applied for the permit to construct the 'Eneco Electrolyser', a 800MW green hydrogen plant to be developed next to the Enecogen power plant in the Europoort.

As the plots at the first conversion park have been allocated, space is now being created for an electrolysis cluster elsewhere on the Maasvlakte. In April 2023, an 11-hectare site was reserved for an electrolyser up to 1 GW for the party winning the tender for IJmuiden Ver wind farm Zone Beta. This tender promotes 'integration of wind energy into the energy system'. The production of

hydrogen directly on the coast is a logical solution, as it avoids additional load on the onshore high-voltage network. The Netherlands Enterprise Agency (RVO) announced that it has received several applications. The Minister for Climate and Energy expects to announce the winner of the permit in June 2024.

A plant of this capacity should become the next generation of green hydrogen plants. The ambition of the Port Authority is to achieve 2 to 2.5 GW of electrolysis by 2030. That will be within reach with this development. The Dutch government is aiming for 4 GW electrolysis nationwide by 2030.

GREEN HYDROGEN PRODUCTION STARTS AT DEDICATED SITES FOR ELECTROLYSIS

Ambition Rotterdam
2030: 2.5GW (onshore)
2050: 20GW (onshore & offshore)

Conversion park 1

PROJECT (COMPANY)	CAPACITY	PLANNED FID	OPERATIONAL
H2-Fifty (bp&HyCC)	250MW	2024	2027
Holland Hydrogen I (Shell)	200MW	**2022** ✓	2025
CurtHyl (Air Liquide)	200MW	2024	2027
Confidential	200MW	2025	2028

Conversion park 2

IJmuiden Ver GW -scale project	1000MW	2025	2029

Local developments

PROJECT (COMPANY)	CAPACITY	PLANNED FID	OPERATIONAL
H2Maasvlakte (Uniper)	500MW	2025	2029-2030
Eneco Electrolyser (Eneco)	800MW	2025	2029

HYDROGEN IMPORTS

Making the economy more sustainable requires much more green power and hydrogen than can be produced in this part of the world. The Dutch part of the North Sea alone would have to be about three times larger to provide the Netherlands with enough green energy. Energy imports therefore remain necessary, and countries with plenty of wind, sun and space in particular are the future exporters of green hydrogen. Moreover, the low cost of producing green power in countries like Morocco, Chile, Brazil or Australia globally outweighs the transport costs of hydrogen. Just as Rotterdam now imports fossil energy on a large scale for the Netherlands, Germany and Belgium, it will soon have to do the same with renewable energy in the form of hydrogen.

The Port Authority has therefore spent the past two years, at the request of the State, searching worldwide for countries and companies that want to produce hydrogen and export it to the Netherlands. The potential is huge. In some 20 regions from Australia to Texas and from Chile to Spain, there is a strong interest in producing hydrogen for the global market and cooperation agreements have been signed to set up hydrogen import chains. The main challenge in getting these new import flows going is that the entire chain must be established at the same time. Production of green electricity, conversion into hydrogen, temporary storage, transport by tanker, storage in Rotterdam, transport by pipeline to end user and use.

Developing this import of hydrogen via Rotterdam will allow tank terminals to gradually switch from fossil to renewable, thus making renewable energy available for local industry. This ensures that Rotterdam remains an attractive location for industry, which is good for prosperity.

Hydrogen can be transported in different forms, each with its own advantages and disadvantages. Unlike, for example, oil that is liquid at 'normal' temperatures, hydrogen requires extreme cooling (to -253 degrees) to make it liquid. An alternative is to 'pack' (and 'unpack') hydrogen inside another molecule, such as ammonia (NH_3), methanol (CH_4O) or a Liquid Organic Hydrogen Carrier (LOHC).

IMPORT TERMINALS

The first imports of (green/blue) hydrogen are expected in 2024/2025. In 2022, OCI decided to expand the capacity of its existing ammonia terminal in Europoort to 1,2 Mtpa by upgrading the existing installations. This expansion will be operational by 2024. DCMR, the Environmental Protection Agency also granted a permit to install an additional new storage tank according to new safety rules, the updated PGS12 guideline. This describes the Best Available Techniques (BAT) for ammonia storage and transfer. When installed this should enable OCI to expand their capacity to 3Mtpa. Eight more projects for import terminals for ammonia, LOHCs or liquid hydrogen have also been announced. The plans for the import of hydrogen add up to a volume of 4 Mtonnes by 2030. Combined with local hydrogen production (green and H-vision) of 0.6 Mtonne, Rotterdam can provide almost 25% of the European Commission's ambition (RePower EU) to produce and import 20 Mtonnes of hydrogen, around ten years from now. Initiatives for import terminals include those by HES, Vopak and Gasunie (under the name ACE, on the site of EMO's current coal terminal) and at the existing terminals of Gunvor and Koole.

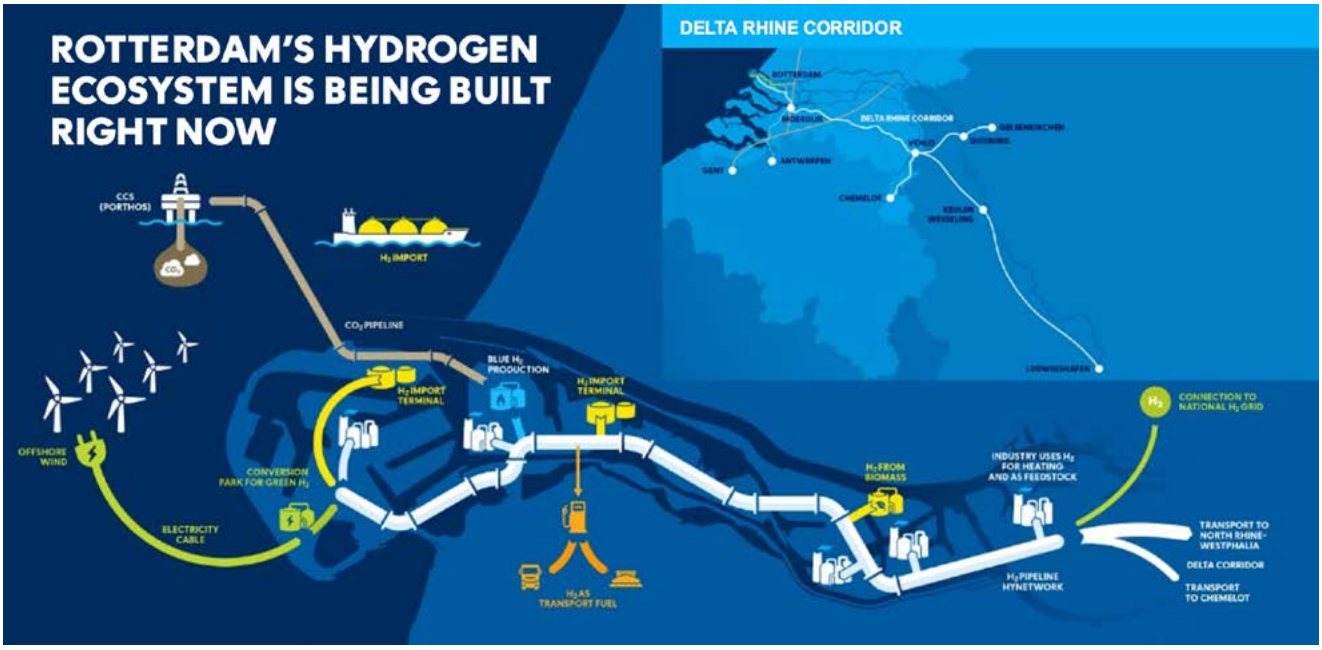
HYDROGEN CRACKER UNITS

If hydrogen is imported in the form of ammonia, some of it can be used by industries that use ammonia as a raw material (e.g. for fertiliser production) but most of it will need to be cracked in Rotterdam or by hinterland customers to convert it back to hydrogen. A study by Fluor showed in 2023 that it is technically and economically feasible to safely convert ammonia into 1 million tons of hydrogen per year using a large-scale cracker. The study was commissioned by the Port of Rotterdam Authority and 17 companies from the region. It is expected that terminals will develop cracking units on their own site, which Port of Rotterdam will support.

INFRASTRUCTURE: HYDROGEN NETWORK

The construction of the national hydrogen network begins in Rotterdam's port and started in the second half of 2023. The network, which is open to all suppliers and buyers of hydrogen, will eventually reach 1,200 kilometres in length and offer five Dutch industrial clusters access to green hydrogen. The Delta Rhine Corridor will also provide a connection to Germany. The pipeline integrates local production, import terminals, customers in the port area and transit towards the hinterland. From 2030 onwards, the hydrogen network, which will cost some 1.5 billion euros, will connect the major industrial regions in the Netherlands and surrounding countries such as Germany and Belgium.

The first part of the hydrogen network in Rotterdam will extend from the Maasvlakte to Pernis. That is a section of more than thirty kilometres that is expected to be operational by 2025. The investment for the first part will be more than 100 million euros. The capacity of the Rotterdam pipeline will be approximately 1.4 Mtonnes per year. Shell will be the first client of the Rotterdam Hydrogen Network. Hydrogen produced in Shell's electrolyser at the Maasvlakte will then be transported to Shell Pernis via the pipeline.



DELTA RHINE CORRIDOR

The Delta Rhine Corridor is a bundle of pipelines between the port and industrial clusters of Rotterdam, Chemelot and North Rhine-Westphalia. The project aims to enable the transition in inland clusters on the one hand, and maintain Rotterdam's position on the other. The supply of energy and raw materials for German industry is an important pillar of Rotterdam's current market position. For now the Delta Rhine Corridor involves 3 pipelines to transport hydrogen, CO_2 and ammonia and 3 direct current connections to bring energy from offshore wind farms ashore. An international consortium of private and public parties, active in the Netherlands and Germany, will most likely be responsible for the realisation and operation of the Delta Rhine Corridor; the open access hydrogen pipeline is the responsibility of state-owned Gasunie. The central government has given the project the status of 'project of national importance'. The pipelines can be operational around 2029.

HYXCHANGE EXCHANGE

In cooperation with Gasunie and the other Dutch sea ports, work is under way to develop a hydrogen exchange. The aim is to facilitate the hydrogen market by offering products such as a hydrogen price index, trading in 'carbon-content certificates' and a spot market. The exchange will be developed step by step. HyXchange published in 2023 the first version of a variable price indicator for hydrogen, based on the times with the lowest electricity prices and a high share of sustainable electricity. The indicator is a tool for estimating the variable production costs for green hydrogen in the Netherlands.

More info?
Please contact: Mandy Ros, Corporate & External Affairs, **e** mj.ros@portofrotterdam.com

The port of Rotterdam is a cornerstone of the Dutch and European transport and economic systems. In addition to the significant economic and social value the port holds in the Rotterdam-Rijnmond region, it also benefits the logistics sector and businesses that import and export in the rest of the Netherlands and Europe through employment, added value, revenue and business locations.

The Port of Rotterdam Authority's core tasks are the sustainable development, management and operation of the port and maintaining the smooth and safe handling of shipping. The aim of the Port of Rotterdam Authority is to strengthen the port's position as a logistics hub and future-proof industrial complex. In doing so, it's not size, but rather quality that takes precedence. The Port of Rotterdam Authority takes responsibility for the impact of the activities in the port on the climate and immediate surroundings. The health and safety of current and future generations are an integral consideration in our decision-making, including in our cooperations with businesses.

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