Royal HaskoningDHV
*Enhancing Society Together*

# Role of Hydrogen in the Energy Transition

## *- Challenges related to Development of the H2 Value Chain*

*AIChE: 35th Annual European Seminar -*
*November 23, 2021 - The Hague*

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Theme Lead Energy & Industry
H2 Platform

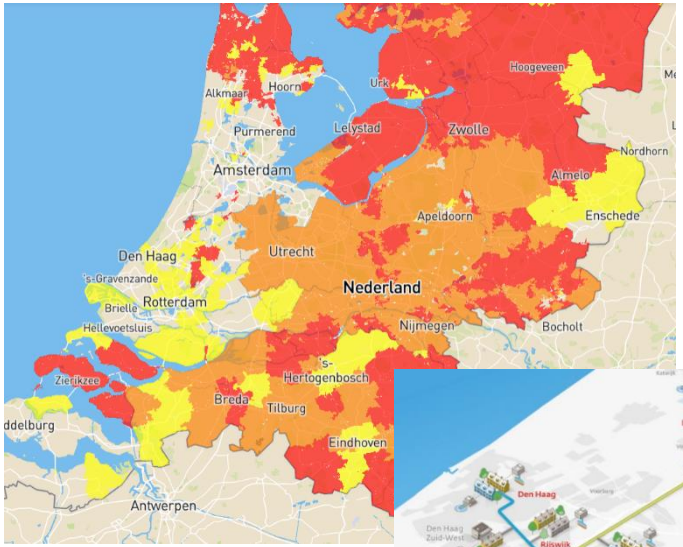
# Presentation

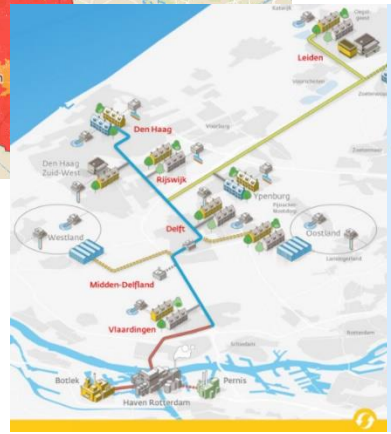
1. Energy transition requires new infrastructure
2. Role of Hydrogen in the future energy mix
3. Development of the Hydrogen value chain in NW Europe
4. Challenges and Safety aspects

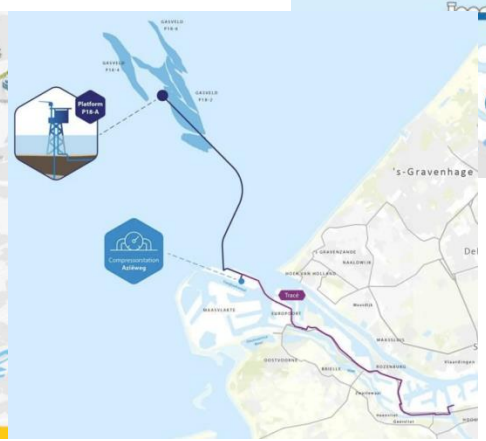
The Climate requires CO2 emission reduction.
To achieve this, we need Energy Transition and Decarbonisation of the Industry.

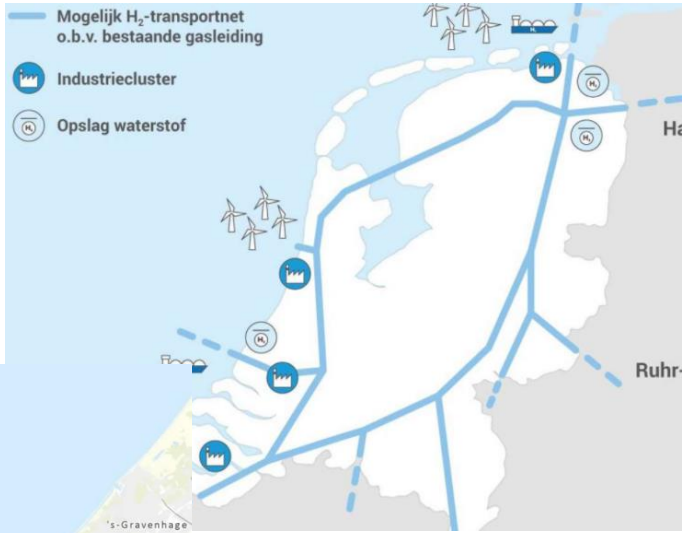
# 1. Energy transition requires new infrastructure

Strengthening, retrofitting and new networks for electricity, heat, CO2 and hydrogen



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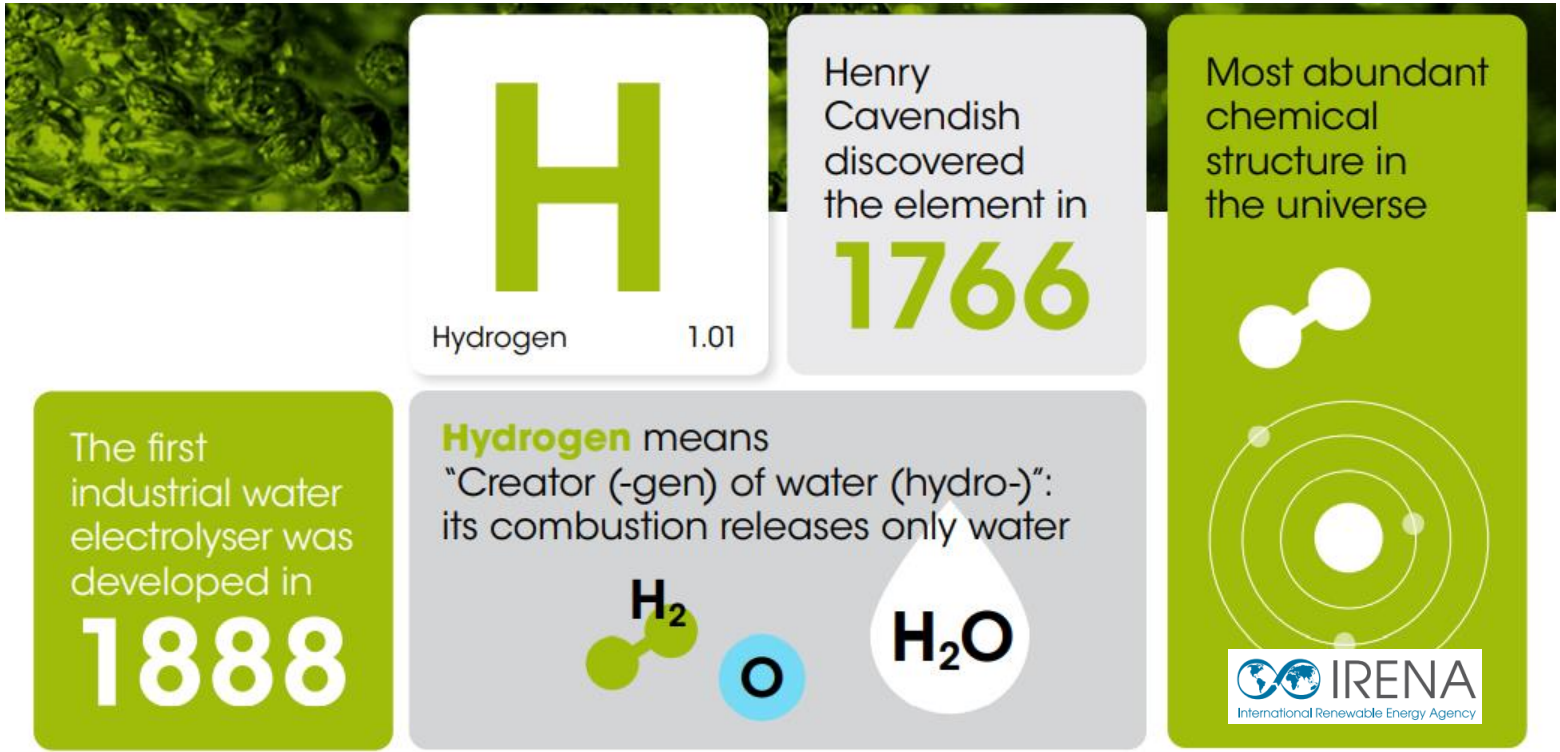
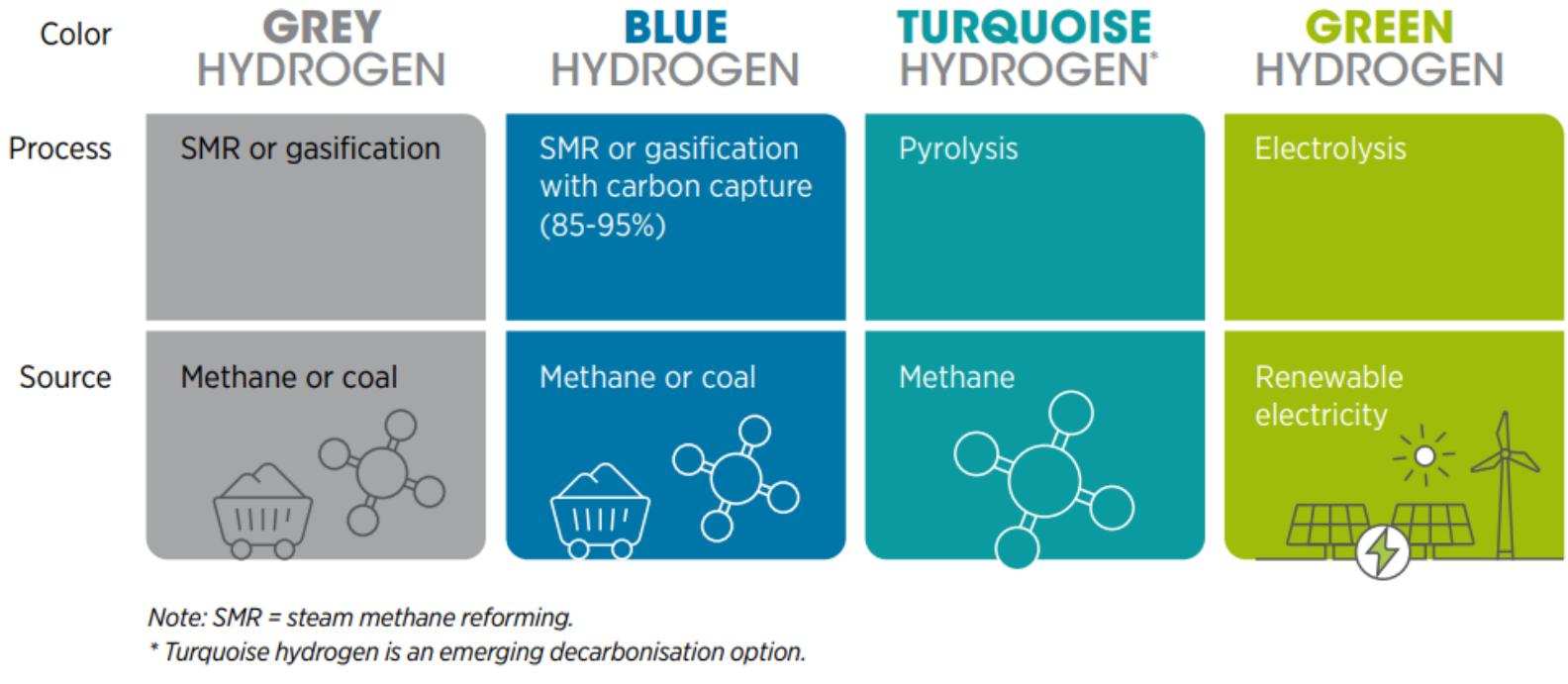
# 1. What is Hydrogen

## Clean, lightest and most abundant element on earth



# 1. Types of Hydrogen

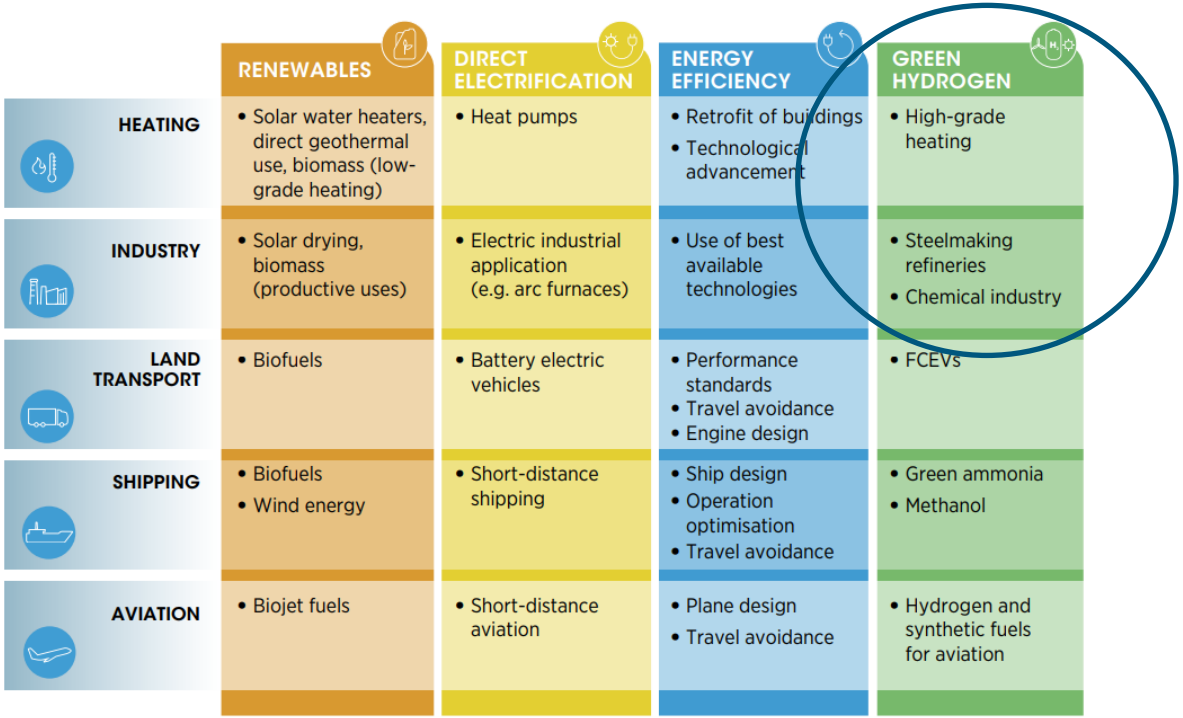
## Colors of hydrogen depending on the source of production




*Note: SMR = steam methane reforming.*
** Turquoise hydrogen is an emerging decarbonisation option.*

# 2. Role of Hydrogen in the future energy mix

## Molecules complementary to electrons to decarbonize end users



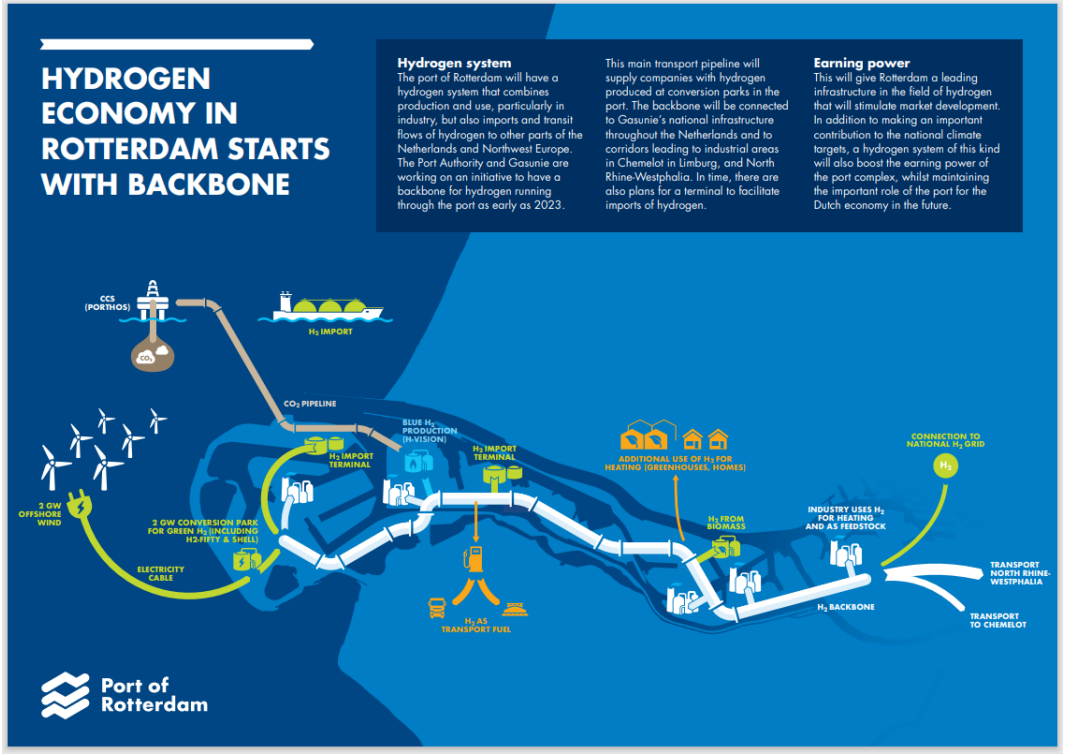
| | RENEWABLES | DIRECT ELECTRIFICATION | ENERGY EFFICIENCY | GREEN HYDROGEN |
|---|---|---|---|---|
| HEATING | • Solar water heaters, direct geothermal use, biomass (low-grade heating) | • Heat pumps | • Retrofit of buildings<br>• Technological advancement | • High-grade heating |
| INDUSTRY | • Solar drying, biomass (productive uses) | • Electric industrial application (e.g. arc furnaces) | • Use of best available technologies | • Steelmaking refineries<br>• Chemical industry |
| LAND TRANSPORT | • Biofuels | • Battery electric vehicles | • Performance standards<br>• Travel avoidance<br>• Engine design | • FCEVs |
| SHIPPING | • Biofuels<br>• Wind energy | • Short-distance shipping | • Ship design<br>• Operation optimisation<br>• Travel avoidance | • Green ammonia<br>• Methanol |
| AVIATION | • Biojet fuels | • Short-distance aviation | • Plane design<br>• Travel avoidance | • Hydrogen and synthetic fuels for aviation |

*Based on: IRENA, IEA and REN 21, forthcoming, and IRENA, 2020b.*

# 3. Development of the Hydrogen value chain

Rotterdam Industrial Complex:

- Backbone – H2 pipeline for delivery to customers
- Conversion park – electrolysers
- CCUS – to turn grey into blue hydrogen production
- Import terminals – receival of green H2 and green ammonia




Source: 04-2021. Waterstof economie in Rotterdam, HbR

# 3. Development of the Hydrogen value chain

Roadmap with massive H2 import from 2030 onwards
from 2 mill. tonnes in 2030 → 20 mill. tonnes in 2050

## Rotterdam roadmap 2030 - 2050

**Backbone**
Access to this main transport pipeline through the port will be open for suppliers and purchasers of hydrogen. The backbone will transport both green and blue hydrogen. It is expected to go into operation in 2023.

**Conversion park**
The first conversion park for hydrogen production will open on the Maasvlakte in 2023. Hydrogen is produced centrally here and transported to companies through the backbone.

**Import terminal**
The Port Authority has teamed up with a range of partners to launch a research project for the establishment of a hydrogen terminal in the port. The terminal is expected to be operational by 2030.

**Grey, blue and green**
Hydrogen has to be produced. This is already being done in the port of Rotterdam on the basis of natural gas. However, $CO_2$ is released during the production of this *grey hydrogen*.

Low-carbon production can be achieved by capturing and storing the $CO_2$ below the seabed in depleted gas fields. $CO_2$ can also be used in greenhouses as a growth accelerator. This is known as *blue hydrogen*.

A third option is carbon-free *green hydrogen*, which is produced by electrolysing water using green power, for example from offshore wind farms. No $CO_2$ is released and combustion does not emit any greenhouse gases either.

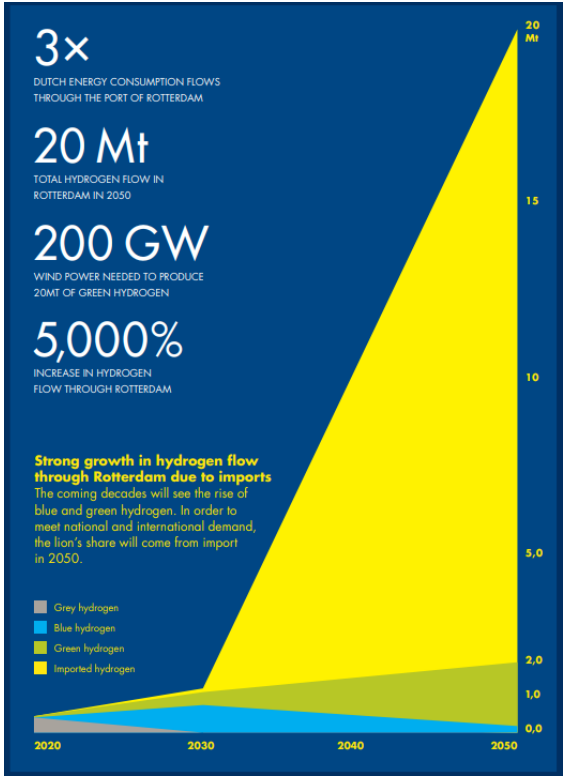
**Upscaling of electrolysers**
Hydrogen is produced with electrolysers at the conversion park.
Shell is planning to start operations with a 150–250 MW electrolyser here in 2023. Nouryon, BP and the Port of Rotterdam Authority are working together in the H2-Fifty project on the development of a 250 MW electrolyser for 2025.

**Blue hydrogen**
The H-vision consortium is developing installations for the large-scale production of blue hydrogen in the electricity sector and as a substitute for natural gas in the petrochemical industry. The $CO_2$ released during production is stored and/or used in greenhouses.

**Transport**
A consortium is being set up with the aim of having 500 hydrogen-powered trucks by 2025. Under the name RH2INE, seventeen parties are collaborating on a climate-neutral transport corridor between Rotterdam and Genoa based on hydrogen.

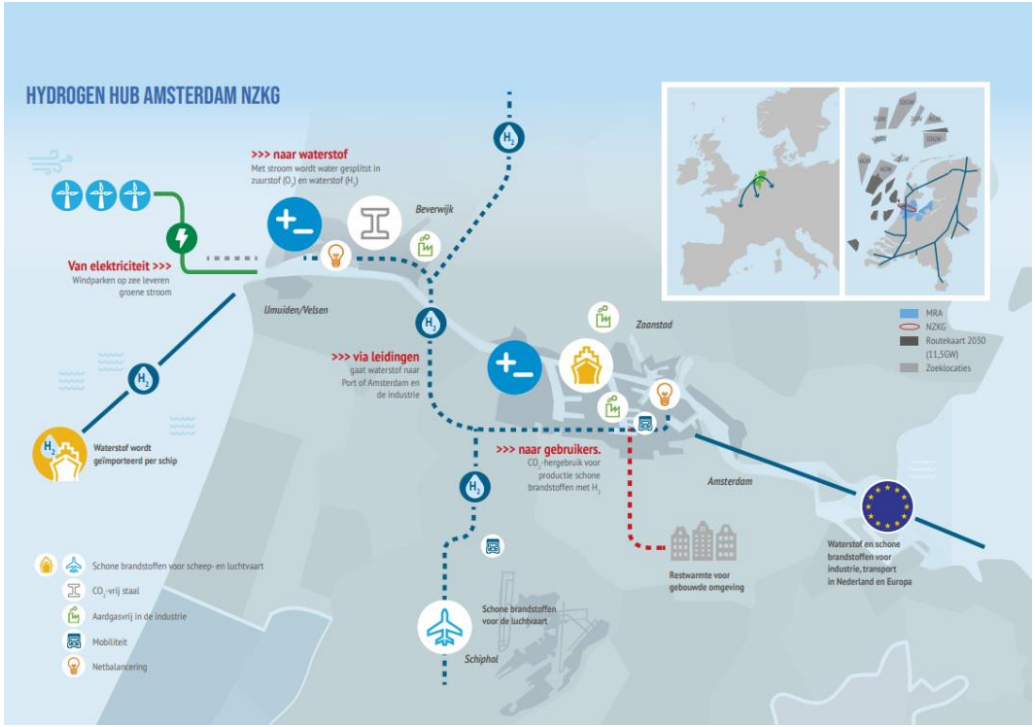
**Key role**
Hydrogen will play a key role in the new energy system. In addition to its increasing role in the process industry as a substitute for natural gas to generate high temperatures, hydrogen is becoming a major factor in the sustainable chemical industry and the production of bio- and synthetic fuels.

Hydrogen is also developing into an important energy carrier in air and sea transport, and in heavy road haulage, but it will also find its way into heat supplies for greenhouses and homes.



# 3. Development of the Hydrogen value chain

Amsterdam – North Sea Canal Area with focus on TATA steel, marine and air transport




Source: 19-10-2021. Cluster Energie Strategie Noordzeekanaalgebied (CES **NZKG**)

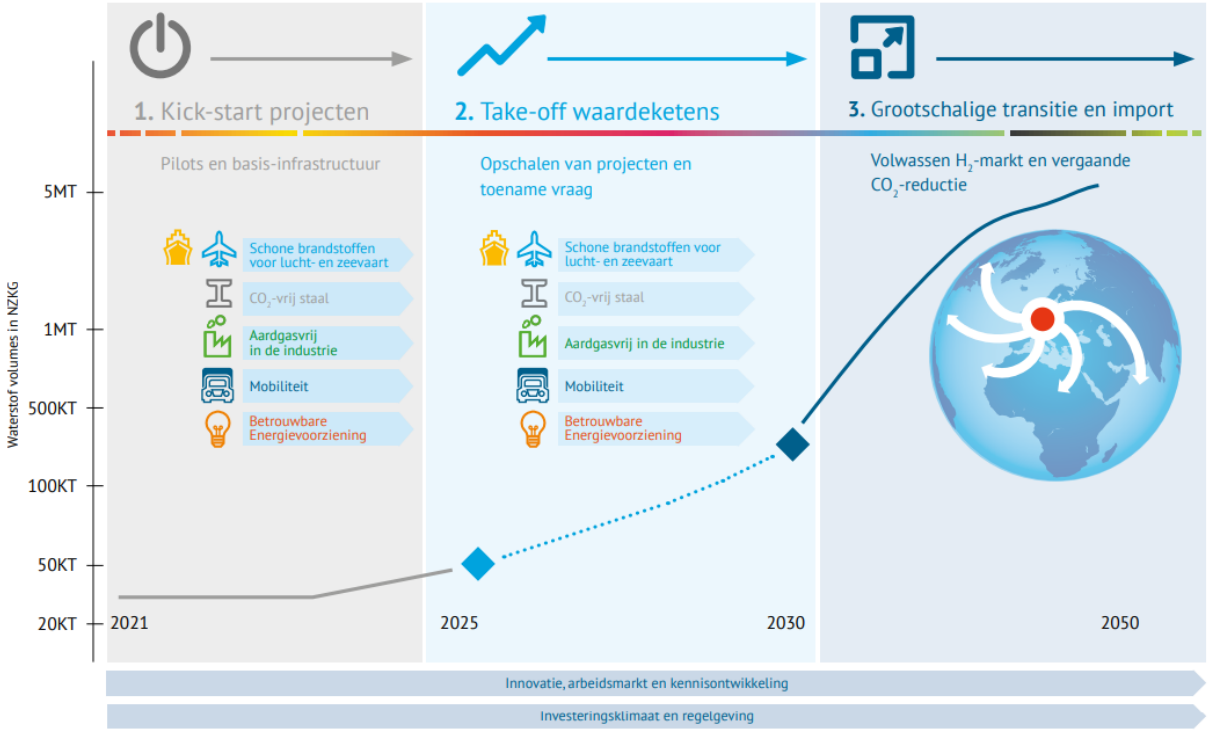
# 3. Development of the Hydrogen value chain

## Amsterdam Roadmap from 0.5 mill. tonnes in 2030 → 5 mill. tonnes in 2050

**Kick-start van projecten:** actieve stimulering van nieuwe projecten en realisatie van de basisinfrastructuur.

**Take-off waardeketens:** opschaling van projecten en vergaande invoer van waterstof in onze waardeketens.

**Grootschalige transitie en import:** doorgroei van waterstof naar internationale import en transitie om fossiele activiteiten klimaatneutraal te maken.



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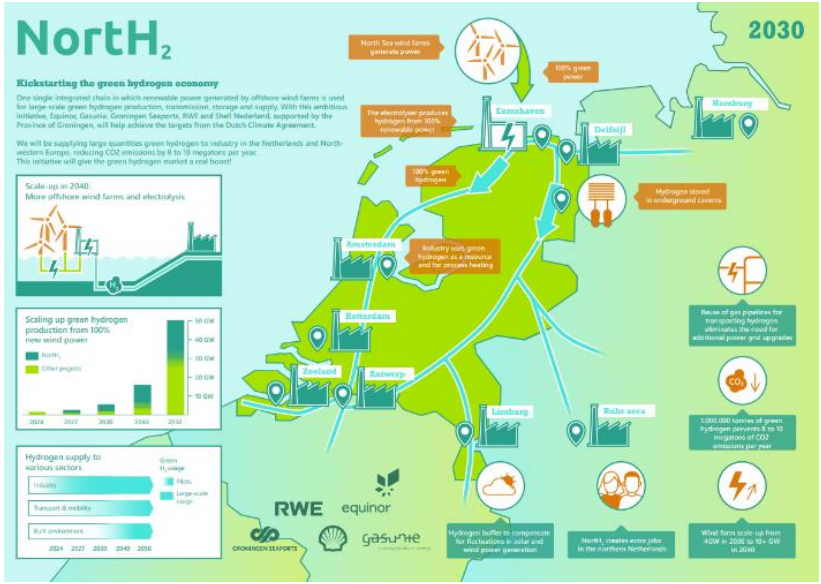
# 3. Development of the Hydrogen value chain

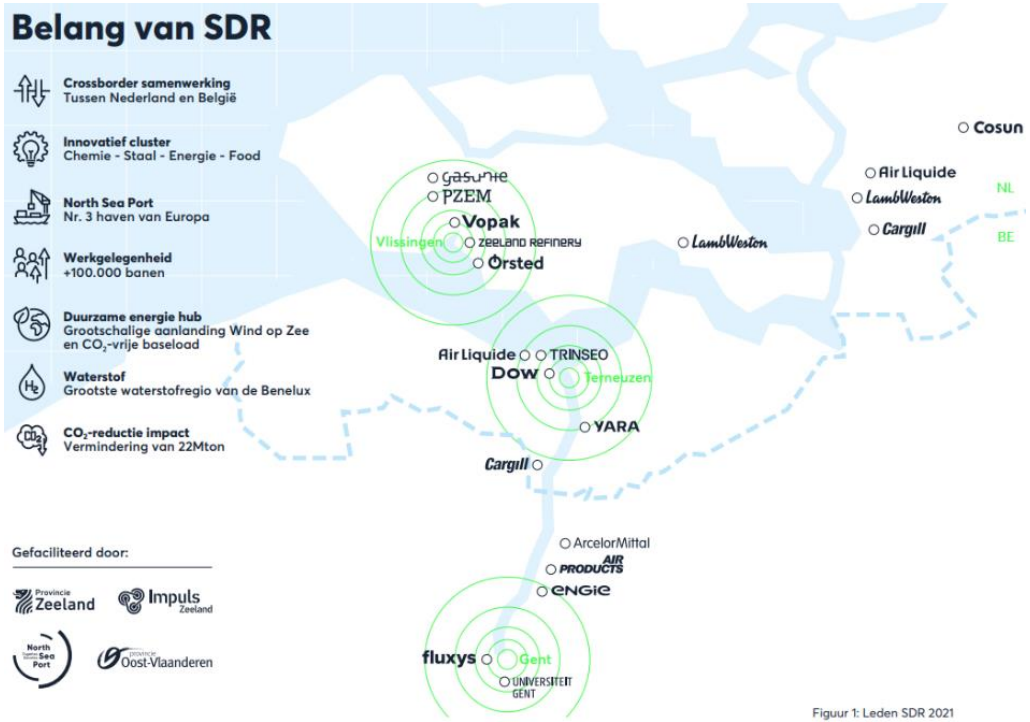
## North Netherlands roadmap - focus on large scale production, kickstarting backbone of Gasunie


Source: 01-2020 Waterstof backbone Delfzijl, Groningen seaports
10-2020 Investeringsplan waterstof noord nederland, Waterstof coalitie noord nederland
01-2021 Kickstarting the green hydrogen economy, NortH2

# 3. Development of the Hydrogen value chain

## Schelde Delta Region – Belgian /Dutch development of blue H2 with CCS, followed by green H2 with North sea wind produced green electricity

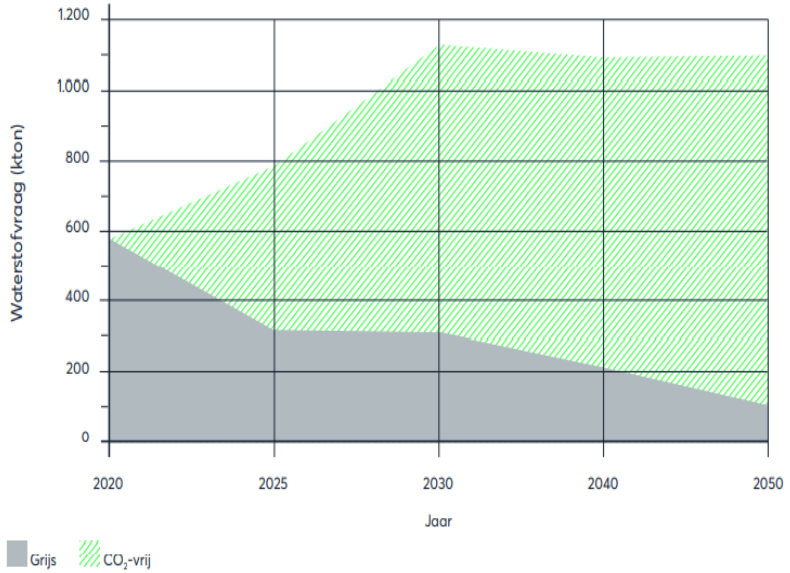


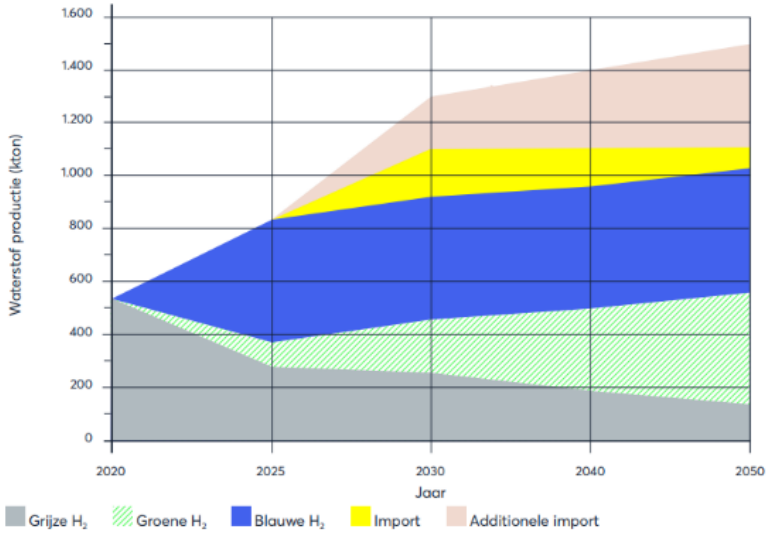

Figuur 1: Leden SDR 2021

Source: 09-2021 Schelde Delta Regio Cluster Energie Strategie

# 3. Development of the Hydrogen value chain

## Schelde Delta Region – Demand and Supply development with Grey, Blue, Green & Import hydrogen




Grafiek 6: Ontwikkeling aanbod grijze en $CO_2$-vrije waterstof op basis van 4.000 vollasturen per jaar voor elektrolysers

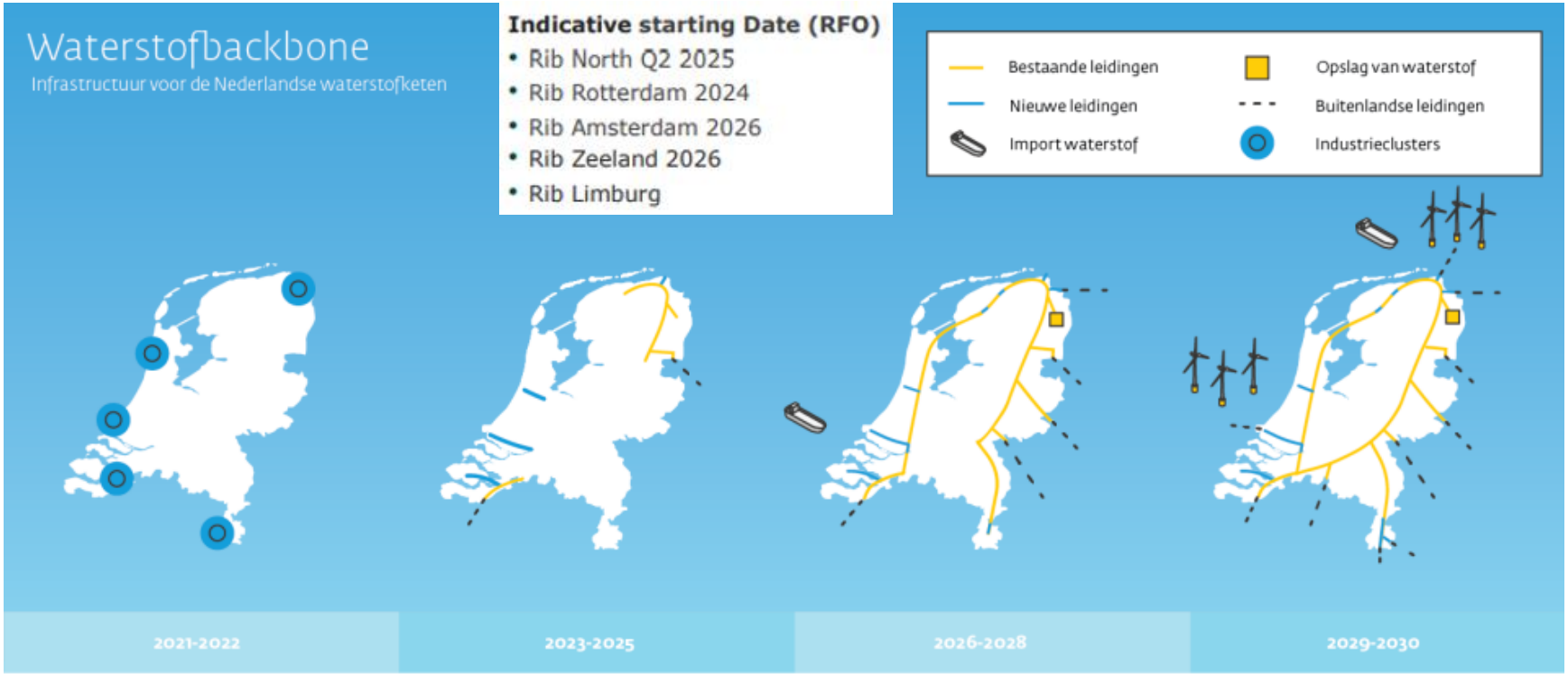
Smart Delta Resources
versie 1.0 | september 2021

smartdeltaresources.nl

_Together for a future proof industry

# 3. Development Hydrogen Backbone - Netherlands

## Gasunie backbone – roll out to industry clusters and Belgium and Germany in 2024-2026



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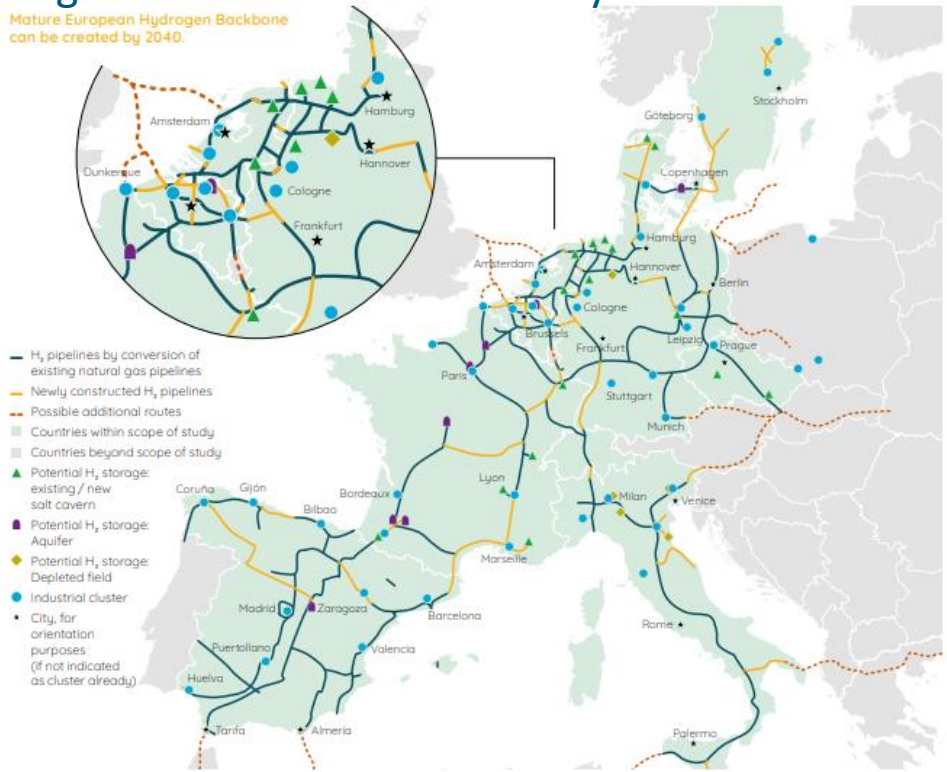
# 3. Development Hydrogen Backbone - Europe

## Mature European Hydrogen Backbone can be created by 2040




Source: European Hydrogen Backbone Initiative (supported by Guidehouse)

# 4. Challenges and Safety aspects

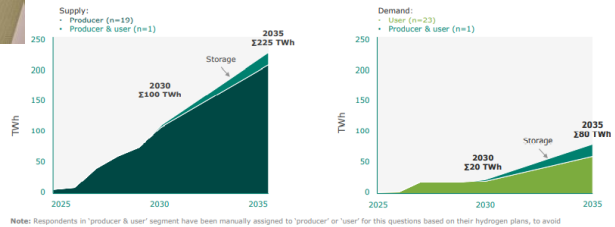
## Financial support for infrastructure and production plants, technology development & clear proposition to make hydrogen a reliable and attractive alternative for users

Legal framework &
financial support,
for first projects by EU
& Dutch Government


NWP Nationaal Waterstof Programma

Scaling up of electrolysers,
2/10 MW now
100/200 MW in 2025
1GW in 2030

Development of demand,
user offtake is lagging behind by a factor 5



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# 4. Challenges and Safety aspects

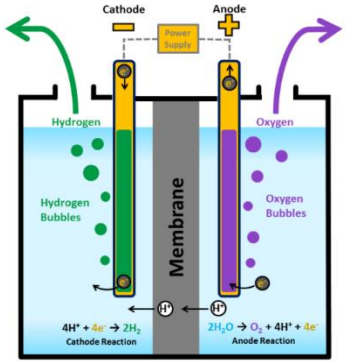
## Safety knowledge of Chemical industry to be transferred to new applications and sectors

**Production**

Grey Hydrogen : Safety aspects of H2 production and use are well known and managed in Petrochemical Industry for decades

Blue Hydrogen : Safety aspects of large-scale CO2 capture, transport and underground storage need to be addressed

Green Hydrogen : Large-scale electrolysis is new, R&D ongoing and safety aspects to be addressed, such as : H2 diffusion inside membrane, how this will influence explosion risks, safety distances, when scaling up?



# 4. Challenges and Safety aspects

## Safety is license to operate for use of Hydrogen outside the “gates” of Petrochemical industry

**Storage and Transport:**

Retrofitting existing gas pipelines – brittleness of steel pipes, replacement flanges and instrumentation by HyWay27 of Gasunie

Roll out of retail network for vehicles - safety guidelines and manuals under development by WVIP

Retail stations for heavy duty vehicles and cars – site selection, safe design, user guidelines

Tube trailers with pressure of 200, 350 of 500 bar – safe design standards

Above and underground storage – gas or liquid form, i.e. storage in salt caverns by HyStock

Liquefaction and marine transport – new and R&D ongoing

Green ammonia – safety aspects are known, but large-scale is new

**Users:**

Human factor, new users without HSE mindset

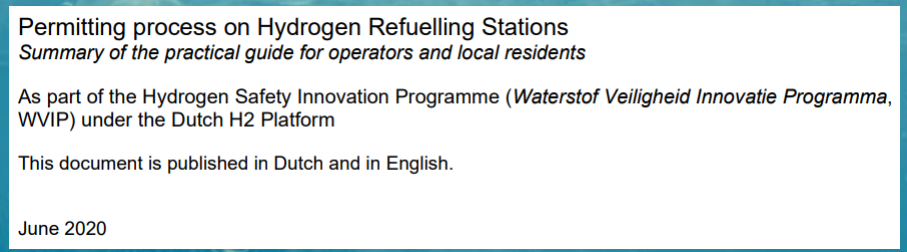
Need for training and user guidelines

# 4. Hydrogen Safety Innovation Programme (WVIP)

## New developments & retrofitting existing facilities require new safety standards & guidelines

Dutch H2 Platform works on safety in the Hydrogen Safety Innovation Program (WVIP)
A programme initiated by the H2 Platform with TKI Gas, Industrial parties, Ministries of Economic Affairs & Climate and Infrastructure & Water Management.
Development of clear regulations and guidelines for small- and large-scale applications of hydrogen in society.

H2Platform
OP WEG MET WATERSTOF



Permitting process on Hydrogen Refuelling Stations
*Summary of the practical guide for operators and local residents*

As part of the Hydrogen Safety Innovation Programme (*Waterstof Veiligheid Innovatie Programma*, WVIP) under the Dutch H2 Platform

This document is published in Dutch and in English.

June 2020

Any questions ?
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