

HYDROGEN

THE NETHERLANDS AS INTERNATIONAL HUB

› HYDROGEN – 3 WEBINARS

The role of
Hydrogen in the
energy system

Nov 14 2019

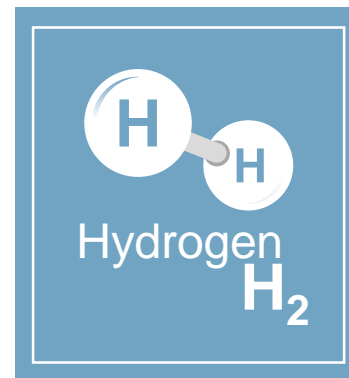
Hydrogen
production,
technologies
and applications
Nov 28, 2019

The Netherlands
as international
Hydrogen Hub

December 9, 2019

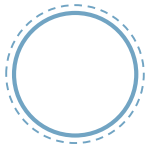
› WEBINARS HYDROGEN: HOW DOES IT WORK?

- › Ask questions by using the button below at right bottom in the video screen
- › Questions that are not answered during the webinar will be answered later.





1. THE NETHERLANDS THE INTERNATIONAL HYDROGEN HUB



Depends on implementation policy



Depends on technology progress



Depends on market and economics



Depends on belief



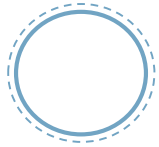
› HYDROGEN SPEAKERS

- › Rogier Elshout – moderator
- › Rene Peters - Business Director Gas Technology and Hydrogen
- › Noe van Hulst - National Hydrogen Envoy Min. Economic Affairs and Climate
- › Rene Schutte – Program Manager Hydrogen at Gasunie

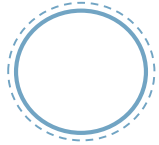


1. ANSWER

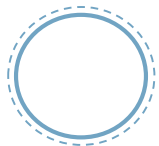
THE NETHERLANDS THE INTERNATIONAL HYDROGEN HUB



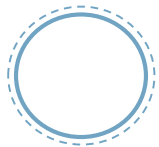
Depends on implementation policy



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Depends on market and economics



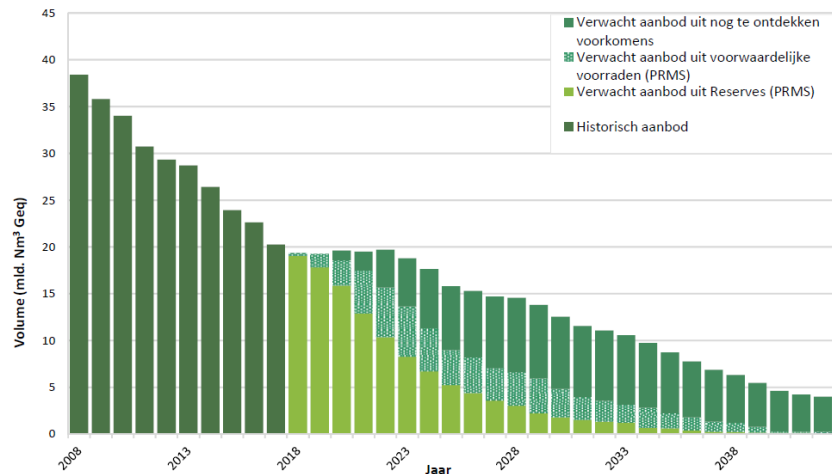
Depends on belief





HYDROGEN DRIVERS & PERSPECTIVES

DRIVERS & PERSPECTIVES FOR HYDROGEN



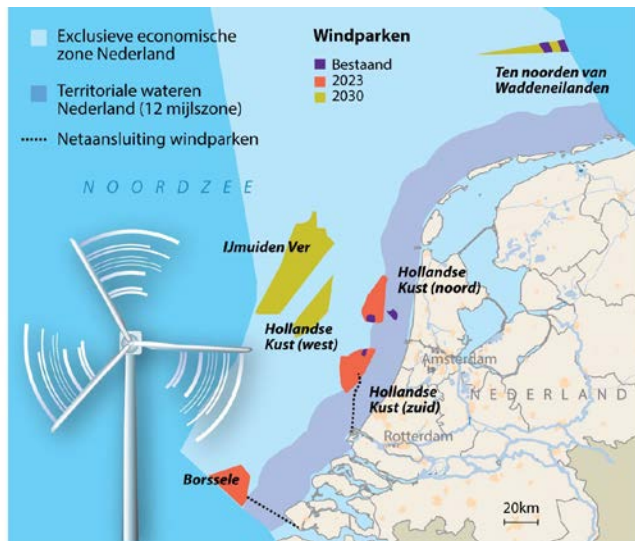
GAS PRODUCTION FROM SMALL OFFSHORE FIELDS IS IN DECLINE



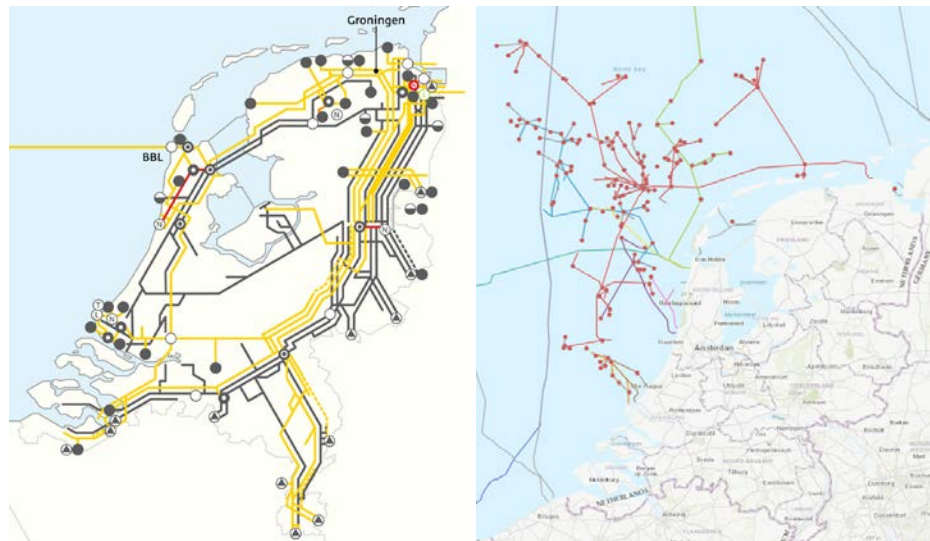
EARTHQUAKES IN GRONINGEN GAS FIELD CAUSES END OF GAS EXTRACTION WELL BEFORE 2030

MUCH MORE FOCUS ON RENEWABLE GASES

DRIVERS FOR HYDROGEN (IN THE NETHERLANDS)



LARGE OFFSHORE WIND POTENTIAL,
11.5 GW IN 2030; ~60 GW AMBITION IN 2050



EXTENSIVE ON-/OFFSHORE GAS INFRASTRUCTURE,
WORLD CLASS GAS AND OFFSHORE KNOW-HOW

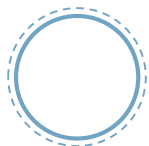
DUTCH CLIMATE AGREEMENT 2030



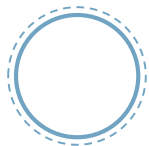
-49% CO₂ in 2030

Important role
for Hydrogen
in Industry

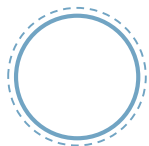
2. REUSE OF PIPELINES CAN BE VALUABLE FOR?



Transport offshore wind energy to shore



Transport of energy over large distances



Connect major Industrial hubs



HYDROGEN PRODUCTION INITIATIVES INDUSTRY AND BUILT ENVIRONMENT

INDUSTRY RENEWABLE H2 INITIATIVES; ELECTROLYSIS ONSHORE

› All initiatives in study phase, FID expected beyond 2021

20 MW
3kt H2
Delfzijl

Nouryon
BioMCN
gasunie

100 MW
15kt H2
Ijmuiden

Nouryon
TATA STEEL
 **Port of Amsterdam**

250 MW
45 kt H2
Rotterdam

Nouryon
 **bp**
 **Port of Rotterdam**

1000 MW
150 kt H2
Zeeland

Ørsted
 **DOW**
 **YARA**

INDUSTRY LOW-CARBON (BLUE) H2 INITIATIVES (WITH CC(U)S)



H-Vision: decarbonisation of natural gas and refinery gases for hydrogen as fuel/feedstock



Hydrogen-to-Magnum:
Zero-emission dispatchable power from a hydrogen fueled power plant



Carbon from waste gasification, and hydrogen for methanol



Use of steel industry off-gases to produce naphta (green chemicals)

HYDROGEN IN THE BUILT ENVIRONMENT

Pilots H2 for heating in the build environment:

- 2017 Ameland – H2 admixing up to 20%
- 2019 Rozenburg – flat building heated with H2
- 2021 Hoogeveen – 80 houses heated with H2
- 2025 Stad aan 't Haringvliet – village heated with H2

Hydrogen network at
Green Village Living lab
facility at TU Delft:



2. ANSWER

REUSE OF PIPELINES CAN BE VALUABLE FOR?

- ☐ Transport offshore wind energy to shore
- ☐ Transport of energy over large distances
- ☐ Connect major Industrial hubs



HYDROGEN INFRASTRUCTURE TRANSPORT, DISTRIBUTION, STORAGE

3. THE BIGGEST CHALLENGE FOR LARGE SCALE HYDROGEN TRANSPORT IS?



Technology



Infrastructure



Supply and demand



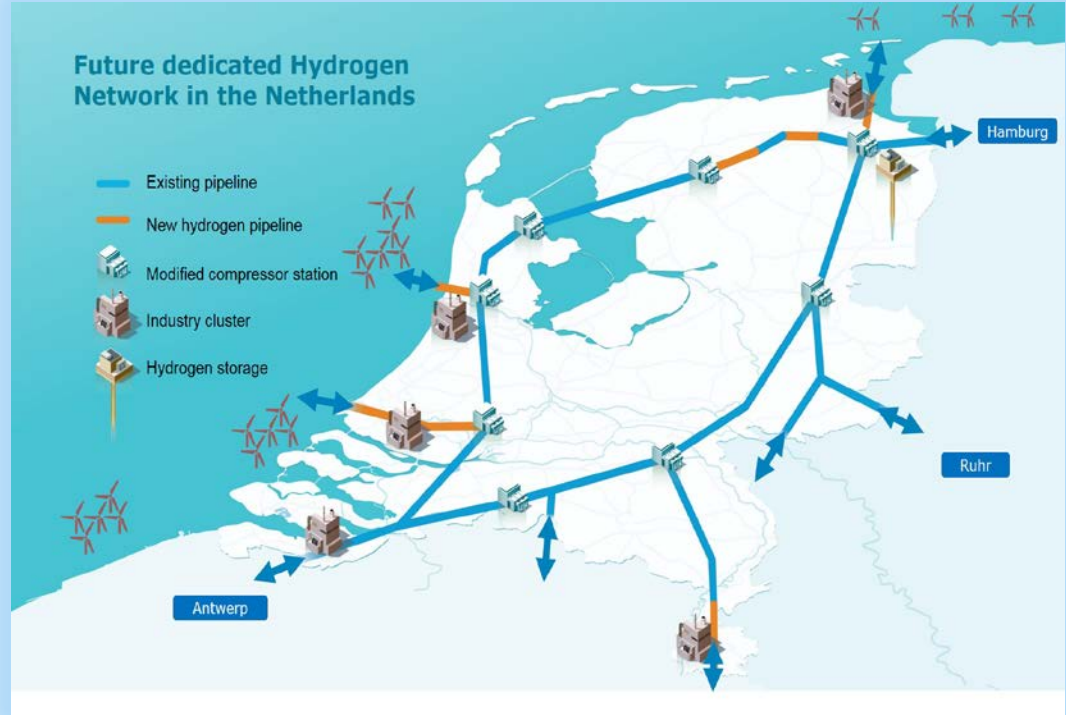
Safety



CONVERSION (PART OF) NATURAL GAS TRANSPORT INFRA



3500 km high pressure (65 bar)
8000 km medium pressure (40 bar)
88000 km low pressure (regional)



THE FUTURE TRANSPORT SYSTEM IS BEING INTEGRATED

- › Gasunie & TenneT infrastructure outlook - integrated gas and electricity grid needed (natural gas and H2)
- › Further integration with European grid and offshore grid is necessary for success (offshore wind)

Electricity grid



Hydrogen grid



Methane grid



TenneT and Gasunie infrastructure outlook (2018)

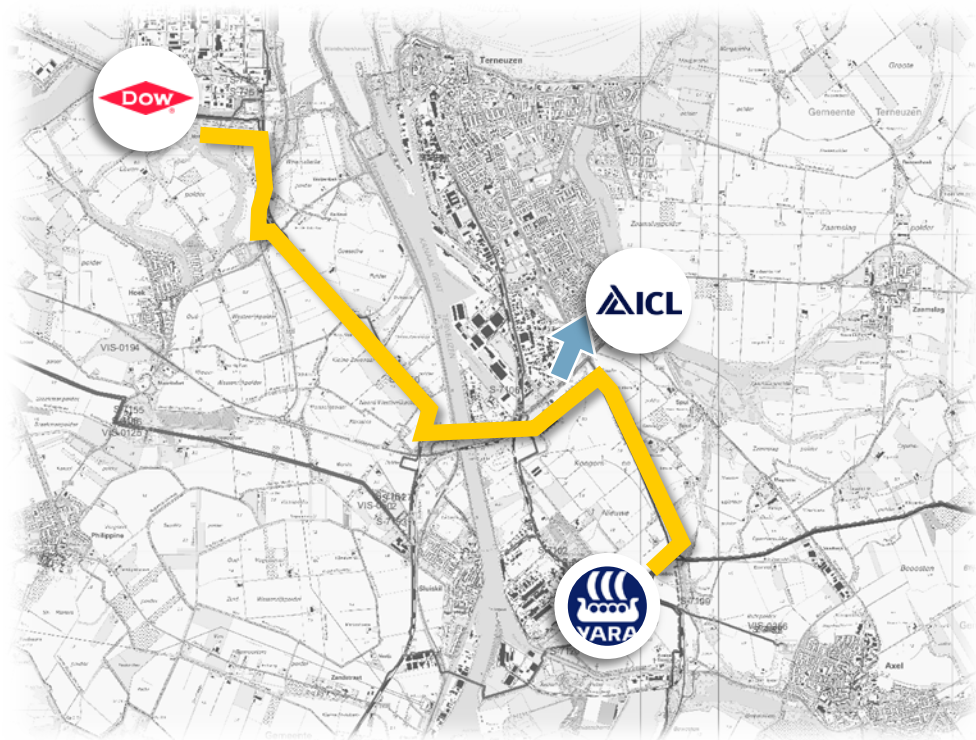
Electricity grid capacity: 20 GW; gas grid capacity: 350 GW in the Netherlands

› IT'S ALREADY HAPPENING...

An existing 12 km gas pipeline between Dow and Yara has been converted into a hydrogen pipeline by Gasunie in 2018.

But legislation is still lagging behind:

- › 0.02% H₂ permitted in transport
- › 0.5% H₂ permitted in distribution



OPTIONS FOR STORAGE

Power-to-gas (hydrogen)

- Hydrogen via power-to-gas is the only realistic option for storing electrical energy above 10 GWh for a long time.

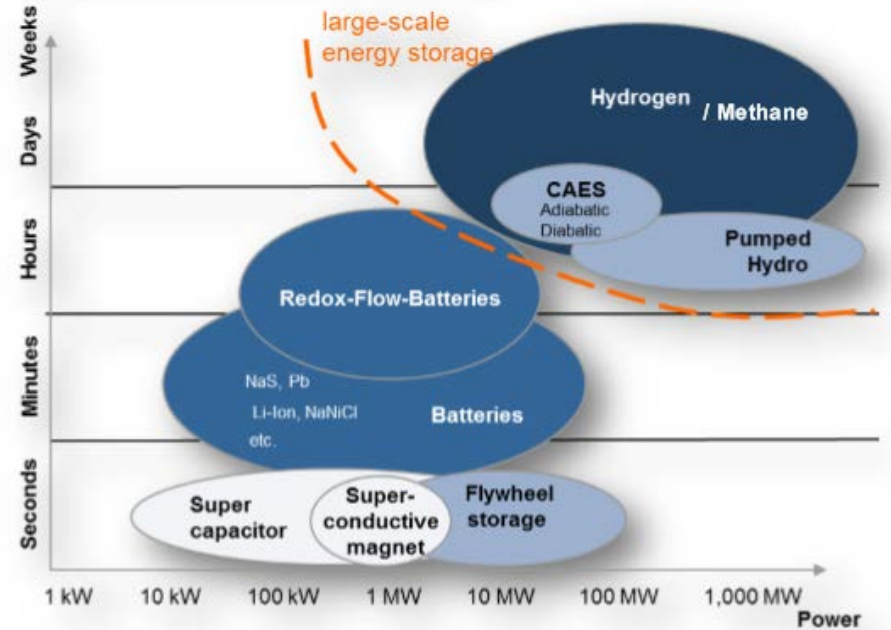
In salt caverns, up to ~0.3 TWh

- Proven technology (Germany, UK, USA)

In empty gas fields, up to ~7 TWh

- Still at the research stage
- Projects HyUnder / SunStorage

Segmentation of electrical energy storage



INDUSTRY INITIATIVES

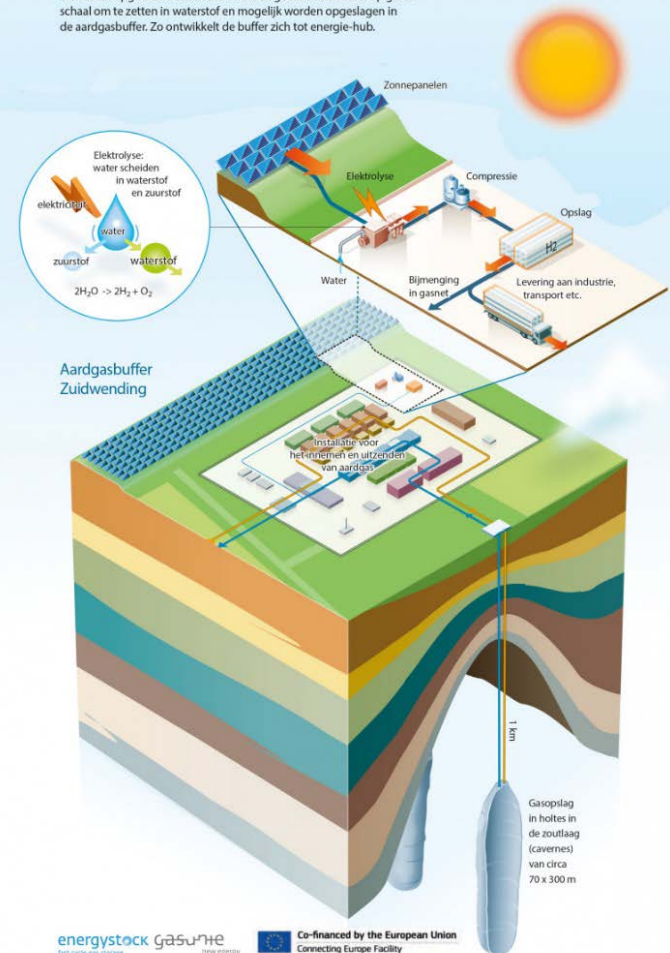
Storage: HyStock Zuidwending

Large-scale energy storage in the form of hydrogen in salt caverns.

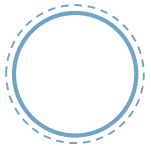
The Netherlands is perfectly situated to playing an important role in large-scale underground energy storage.

HyStock pilotproject

Op Aardgasbuffer Zuidwending wordt in een pilotproject water met behulp van zonneenergie omgezet in waterstof. In de toekomst kan het overschot aan duurzaam opgewekte elektriciteit worden gebruikt om water op grote schaal om te zetten in waterstof en mogelijk worden opgeslagen in de aardgasbuffer. Zo ontwikkelt de buffer zich tot energie-hub.



3. ANSWER THE BIGGEST CHALLENGE FOR LARGE SCALE HYDROGEN TRANSPORT IS?



Technology



Infrastructure



Supply and demand

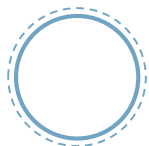


Safety

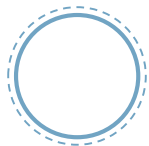


HYDROGEN OFFSHORE PRODUCTION

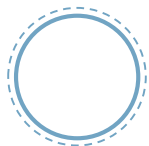
3. OFFSHORE HYDROGEN PRODUCTION IS REQUIRED



When offshore wind power is limited by onshore grid capacity



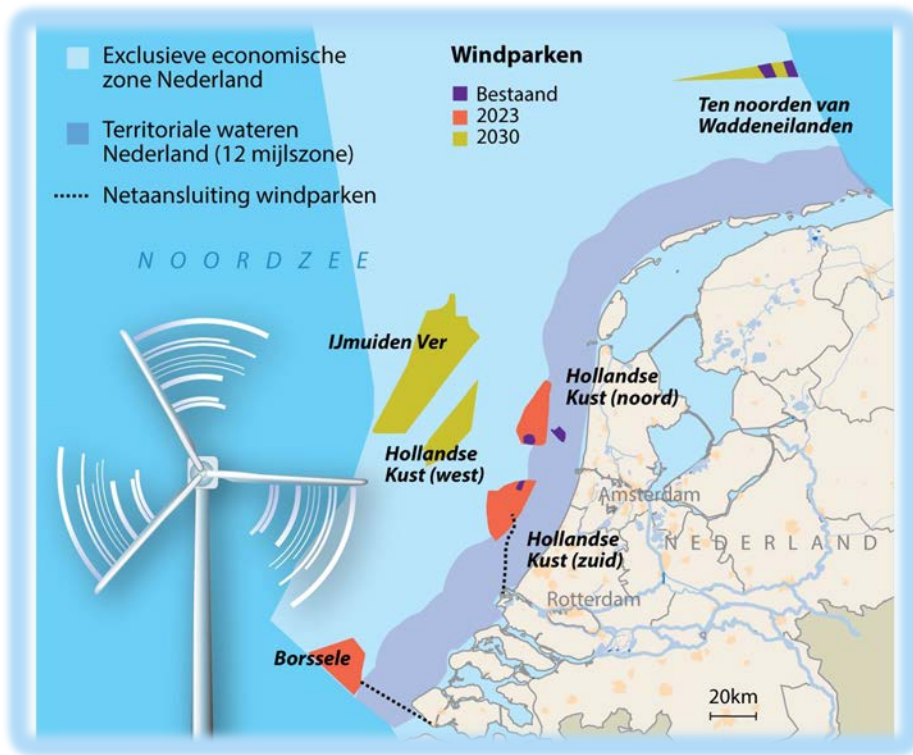
To transport offshore wind energy over large distances



To connect offshore Energy Hubs to shore

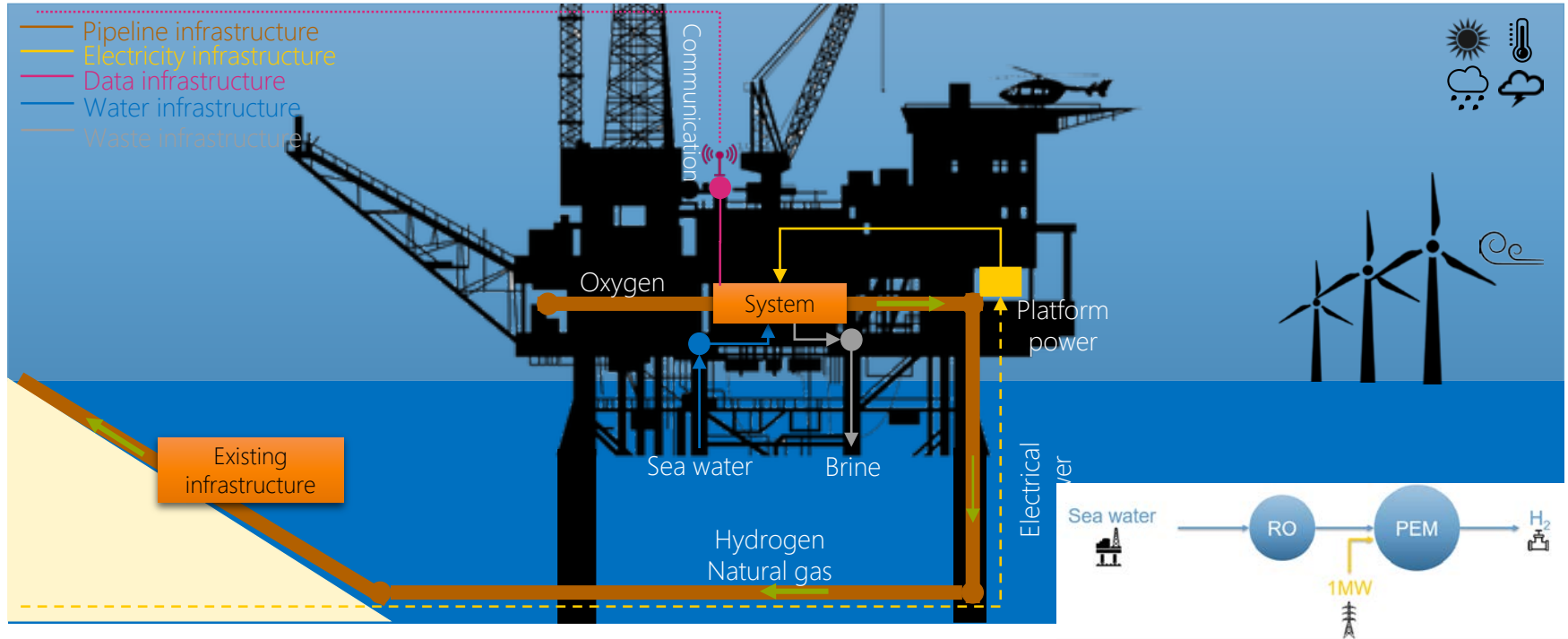


OFFSHORE WIND MEETS GAS



3000 km offshore

POSHYDON – OFFSHORE HYDROGEN PRODUCTION PILOT



NEPTUNE
ENERGY

nexstep

TNO

1 MW PEM unit
200 Nm³ H₂/hr

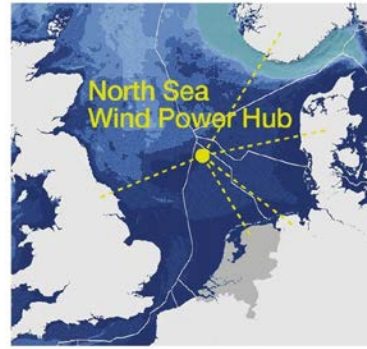
› VIDEO POSHYDON

Video via youtube (3.5 min):

<https://www.youtube.com/watch?v=lcmnY34LLBc>

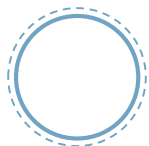


SCALE-UP: FROM PLATFORM TO ENERGY ISLANDS?

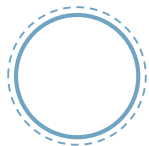


Large-scale offshore wind
integration beyond 2030

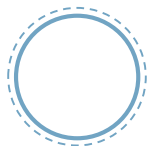
3. ANSWER: OFFSHORE HYDROGEN PRODUCTION IS REQUIRED



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To transport offshore wind energy over large distances



To connect offshore Energy Hubs to shore





HYDROGEN INTERNATIONAL PERSPECTIVE

› FUTURE PERSPECTIVE: OFFSHORE HYDROGEN TRANSPORT



› Kawasaki: cryogenic transport of LH2

Other options:

- › Compressed Hydrogen
- › Liquid Organic Hydrogen Carriers
- › NH3 or Methanol
- ›

› POLICY DEVELOPMENT AND INTERNATIONAL COLLABORATION

Policy Developments

- › National hydrogen program and innovation agenda
- › Elaborate options for market organization / initiation of hydrogen market
- › Guarantees of Origin system for renewable and low-carbon hydrogen

International collaboration

- › Bilateral projects with neighboring countries, such as Germany
- › Active partnerships:
 - › IEA Hydrogen TCP
 - › IPHE and Mission Innovation
 - › Hydrogen Ministerial and Clean Energy Ministerial (CEM)

› WEBINARS HYDROGEN

- › Please fill in the evaluation visible on your screen
- › View the webinars on demand and sign up for the next webinar: www.tno.nl/hydrogen
- › Visit and participate in TNO's hydrogen breakout session at het **European Industry and Energy Summit (EIES)** in Amsterdam 11 december 2020



› **THANK YOU FOR
YOUR
ATTENTION**