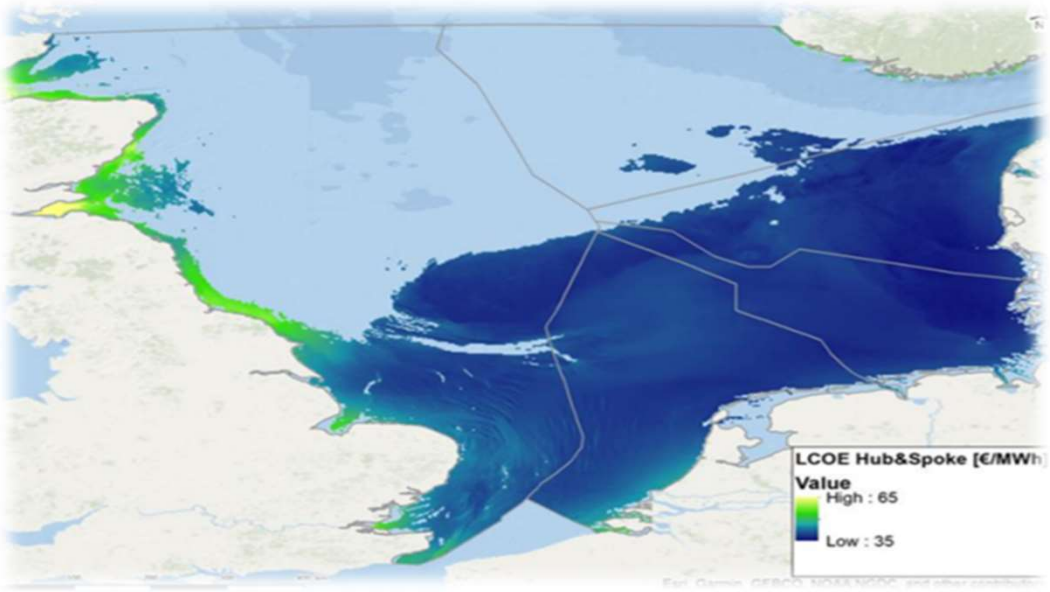
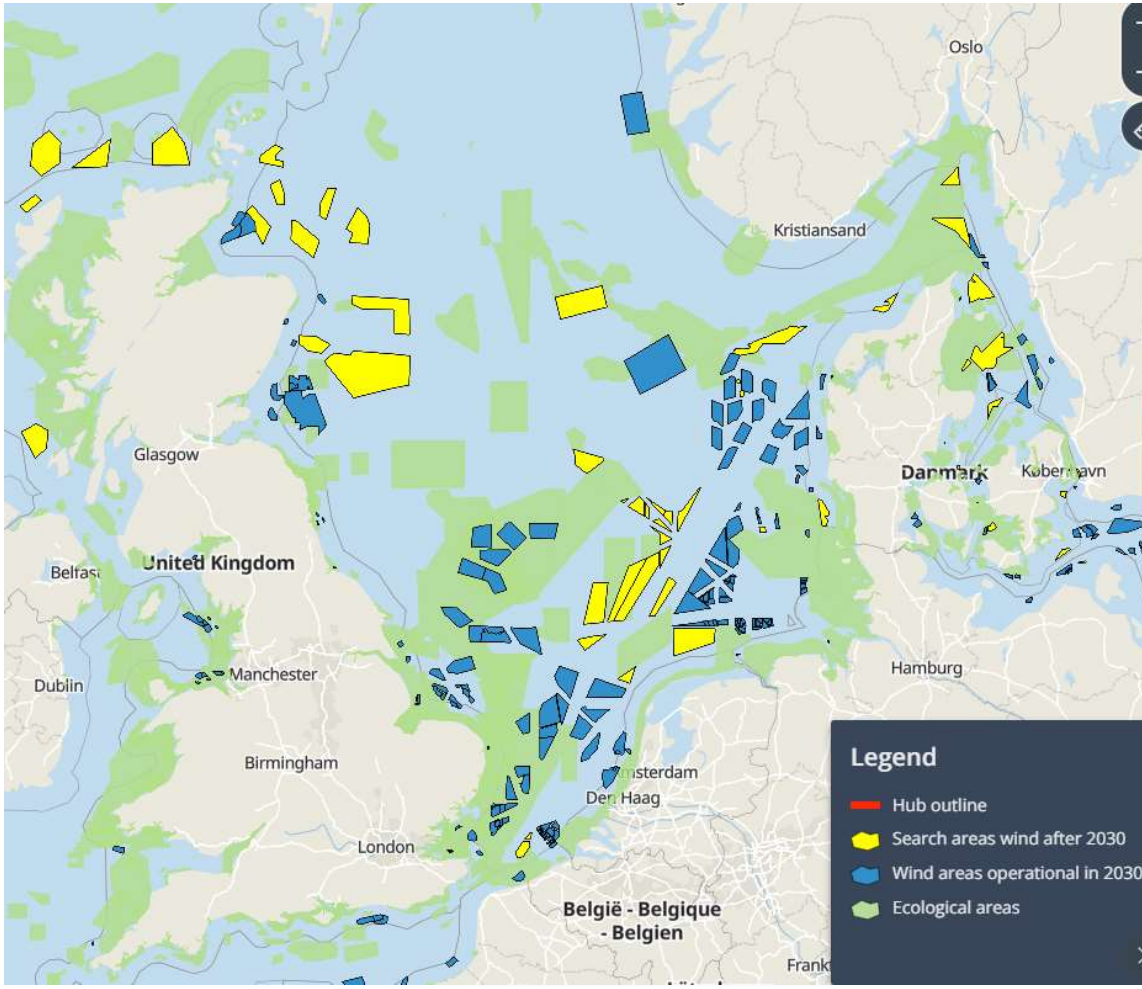
Green hydrogen production from offshore wind going offshore

Rene Peters - TNO

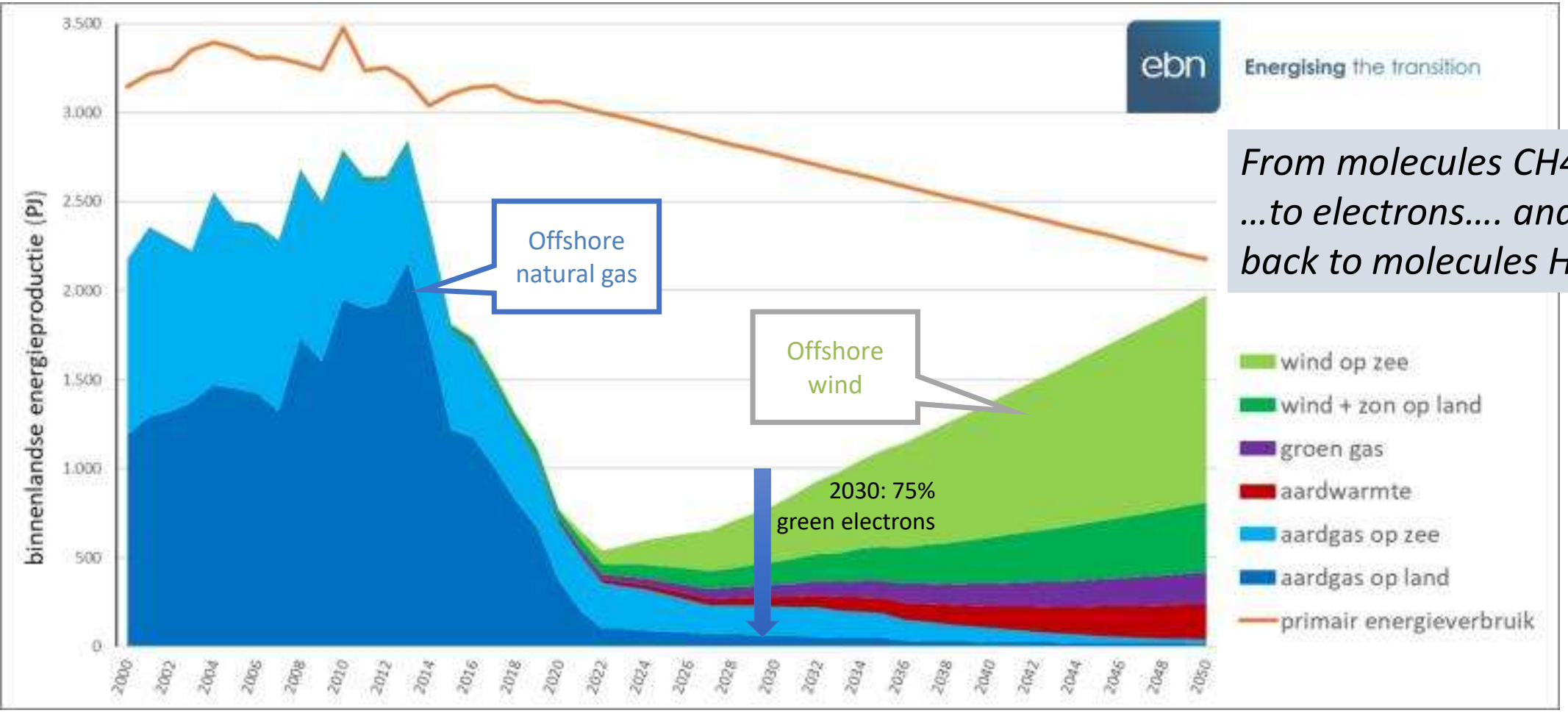
THE NORTH SEA POWERHOUSE FOR EUROPE





Source: [North Sea Energy atlas]

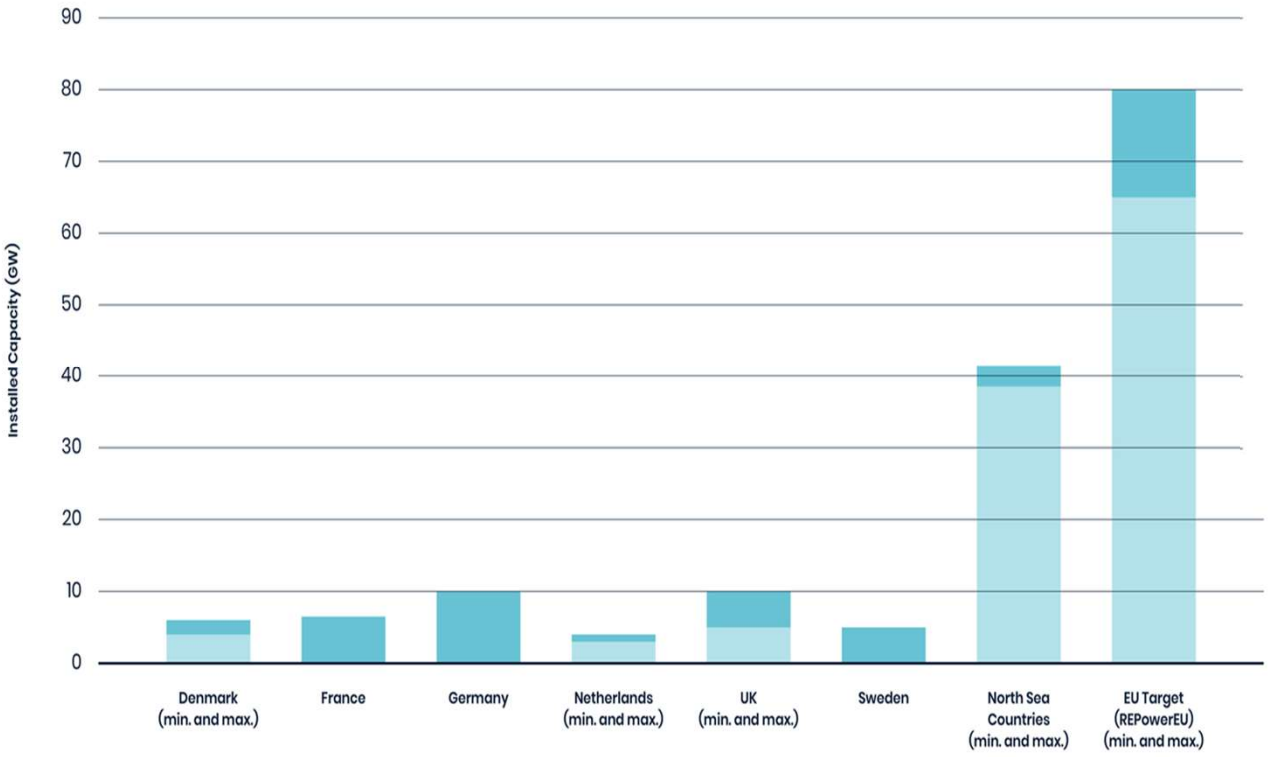
Energy Production in Transition from Gas to Wind

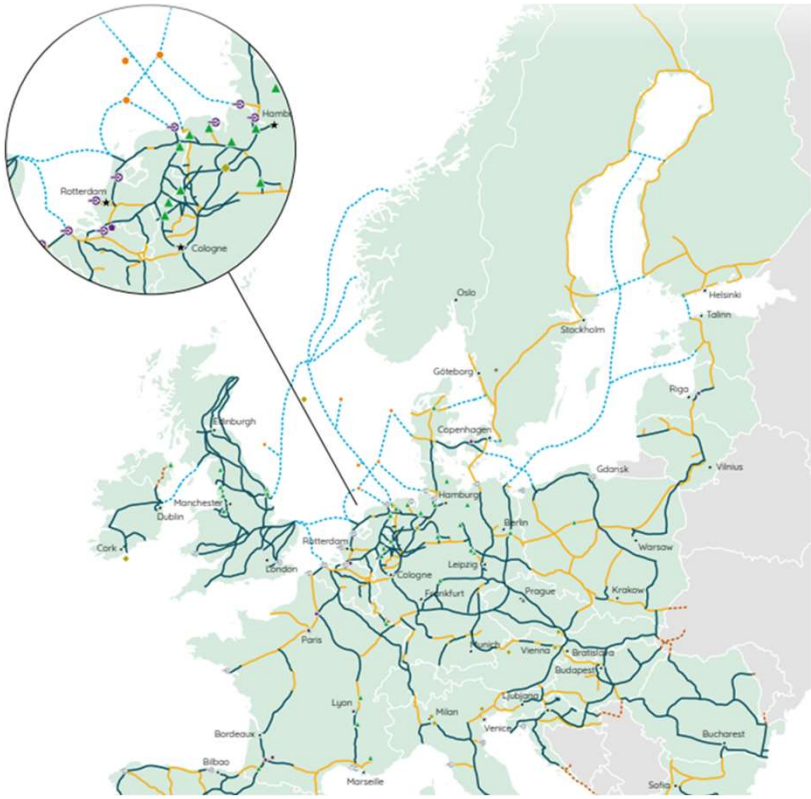


From molecules CH4 …to electrons…. and back to molecules H2

Hydrogen production
GREEN HYDROGEN AMBITIONS EU

Predicted installed capacity for hydrogen production for 2030

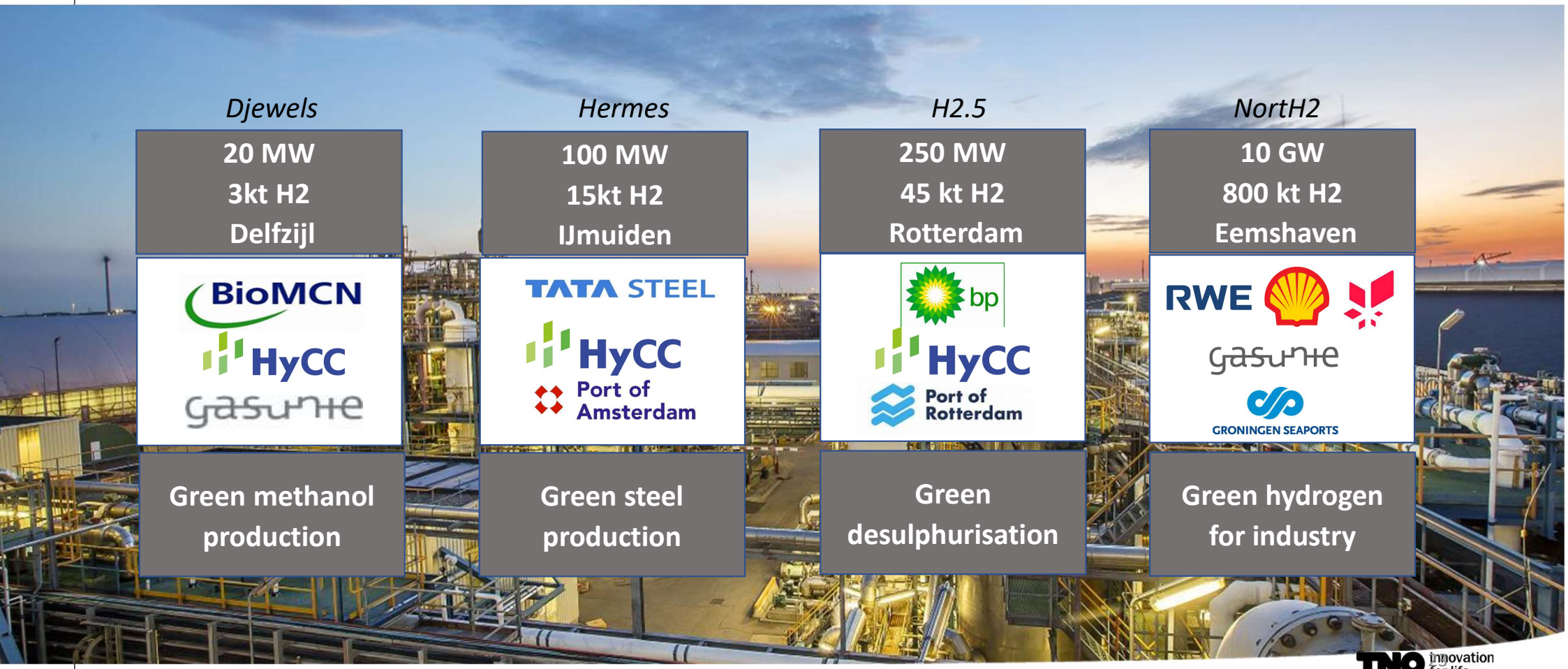




NL: 3-4 GW in 2030
8 GW in 2032

Industry "Green" H_2 initiatives (electrolysis)

PROJECTS IN FEASIBILITY STUDY PHASE



Djewels	*Hermes*	*H2.5*	*NorthH2*
20 MW 3kt H2 Delfzijl	100 MW 15kt H2 IJmuiden	250 MW 45 kt H2 Rotterdam	10 GW 800 kt H2 Eemshaven
BioMCN HyCC gasunie	TATA STEEL HyCC Port of Amsterdam	bp HyCC Port of Rotterdam	RWE gasunie GRONINGEN SEAPORTS
Green methanol production	Green steel production	Green desulphurisation	Green hydrogen for industry

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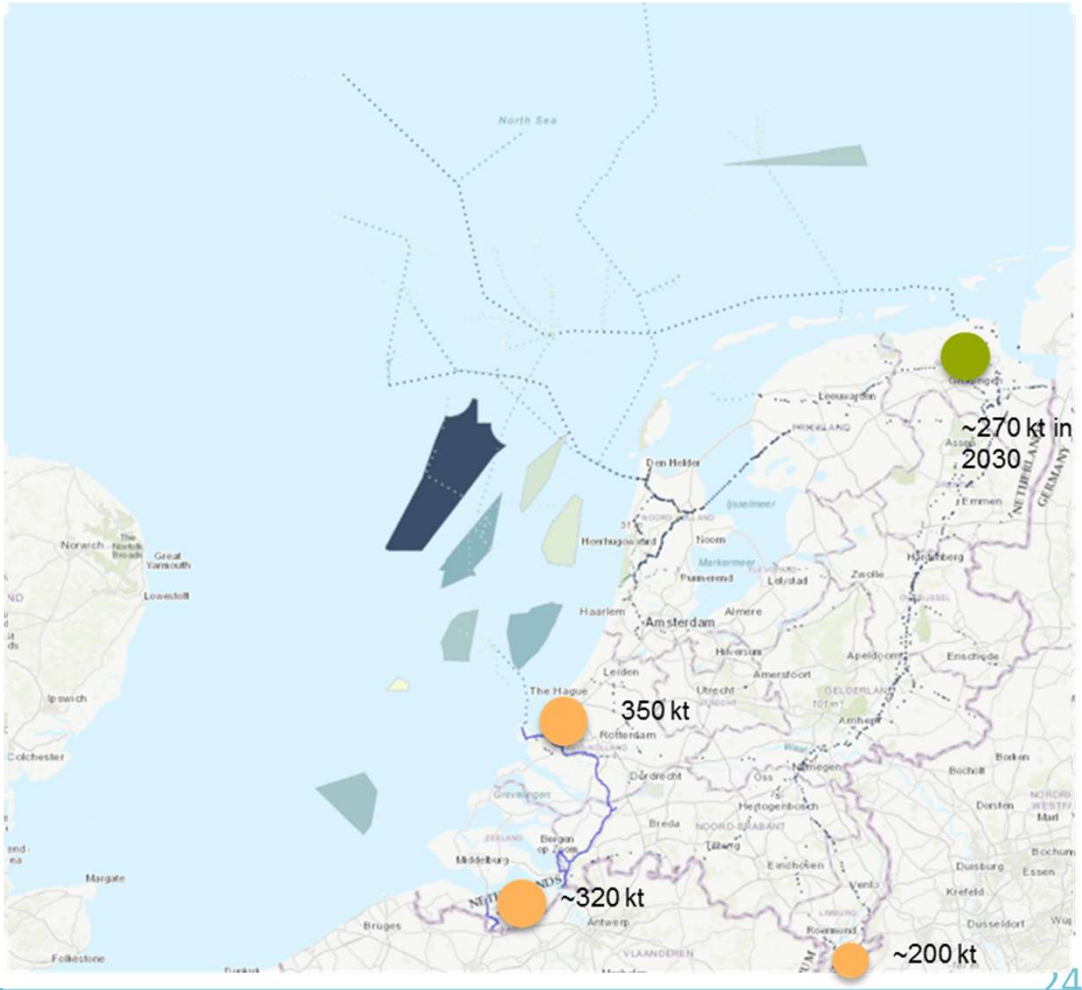
Hydrogen supply and demand

- Current production: 180 PJ
  - Pure hydrogen and hydrogen in residual gases
  - Source: Natural gas and oil product processing
- Existing demand (now grey H2)
  - Fertilizer 60 PJ
  - Refineries 65 PJ

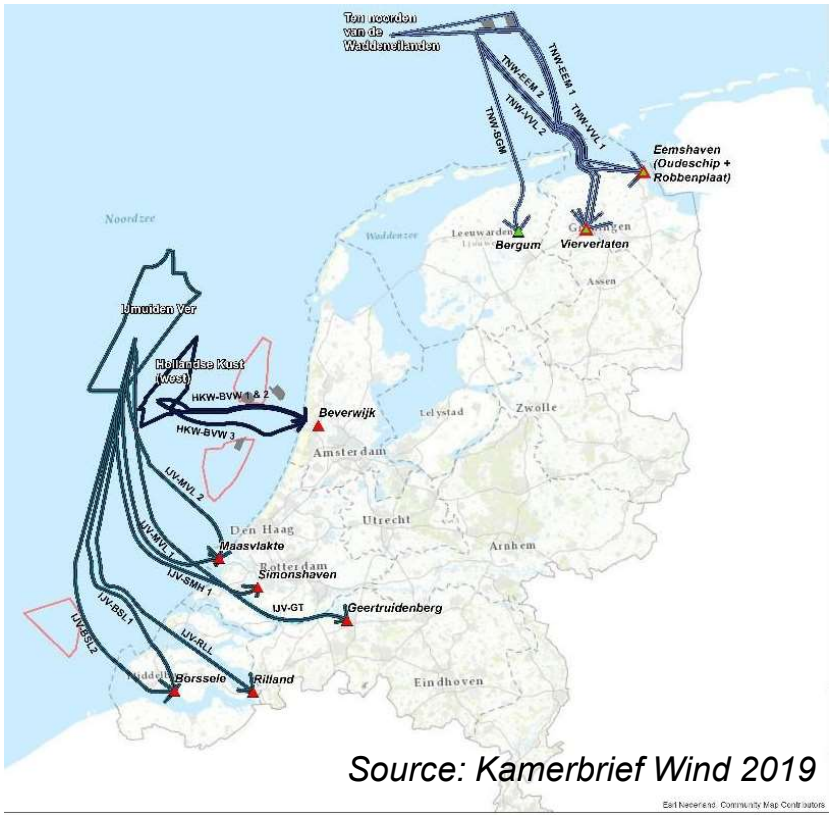
1 GW wind @ 5000 full load hrs → H_2

~ 100 kTon H_2
= 12 PJ of H_2 > 15 GW wind needed!
= 3.4 TWh of H_2

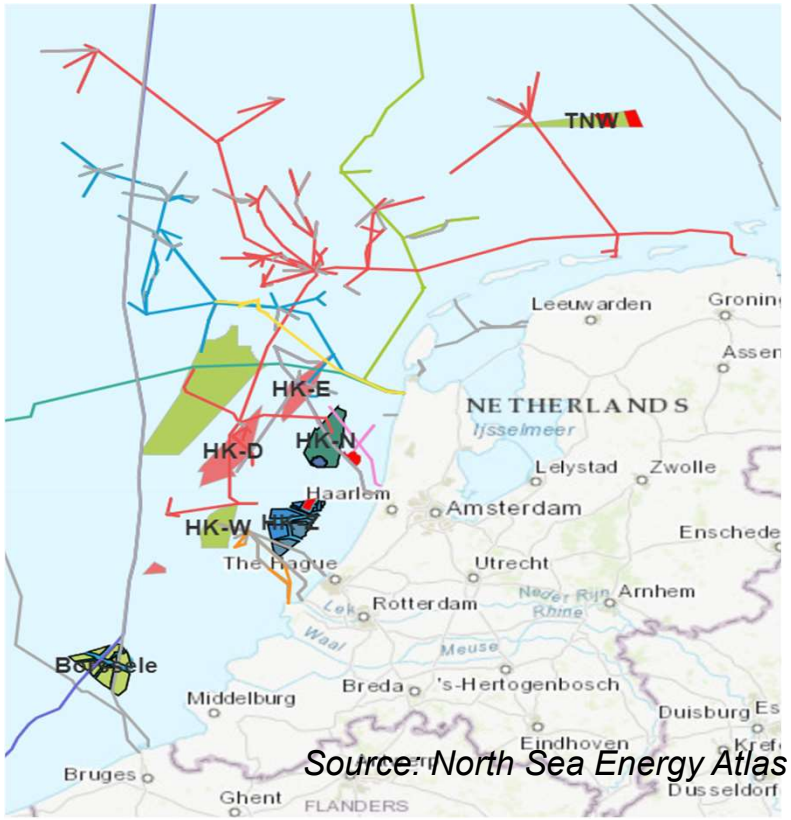


Offshore wind in The Netherlands: from 3 to 70 GW

Bringing offshore energy to shore gets increasingly complicated towards 2030



Source: Kamerbrief Wind 2019



Source: North Sea Energy Atlas

- Options for power connections to land until 2030. Large challenges on timing, capacity, stability, cost.
- Offshore infrastructure will become available for alternative use (H2, CO2) when gas production stops.

Future energy System at the North Sea
CO2 storage, Power to hydrogen, H2 storage

Wind farm

Electricity

H2 production

CO2 injection

H_2

Electrolysis

CO_2

Electricity

H_2 storage

CO_2 storage

Power plant

Hydrogen

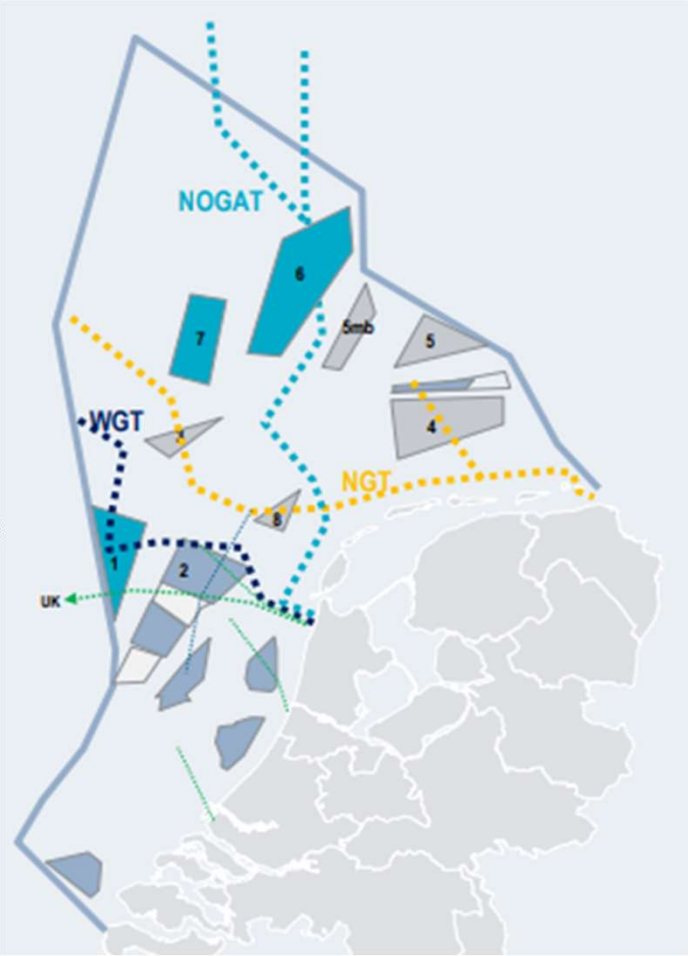
Gas Platform

Natural Gas

gasmeetswind
NORTH SEA ENERGY SYMPOSIUM

Why offshore hydrogen production?

- Future wind parks are developed further offshore (> 100 km)
- Energy transport via electricity from HVAC > HVDC (525 kV) costly
- Landing capacity of power cables increasingly more complex
- Space limitations for large scale electrolyser facilities onshore (10 ha/GW)
- Capacity of onshore electricity grid is limited
- Grid balancing with increasing intermittent production is challenging
- Offshore pipelines available for reuse for H2 from 2030 onwards
- Cost saving in offshore H2 production and transport significant
  - Distance > 100 km or when HVDC is required
  - Scale > 2 GW, as capacity of trunk lines well beyond 10 GW
- Benefits: pipelines are cheaper, faster to implement, have lower ecological impact and are more reliable than HVDC cables
- But: little options for use of produced heat and oxygen….
- And offshore electrolysis is more expensive than onshore

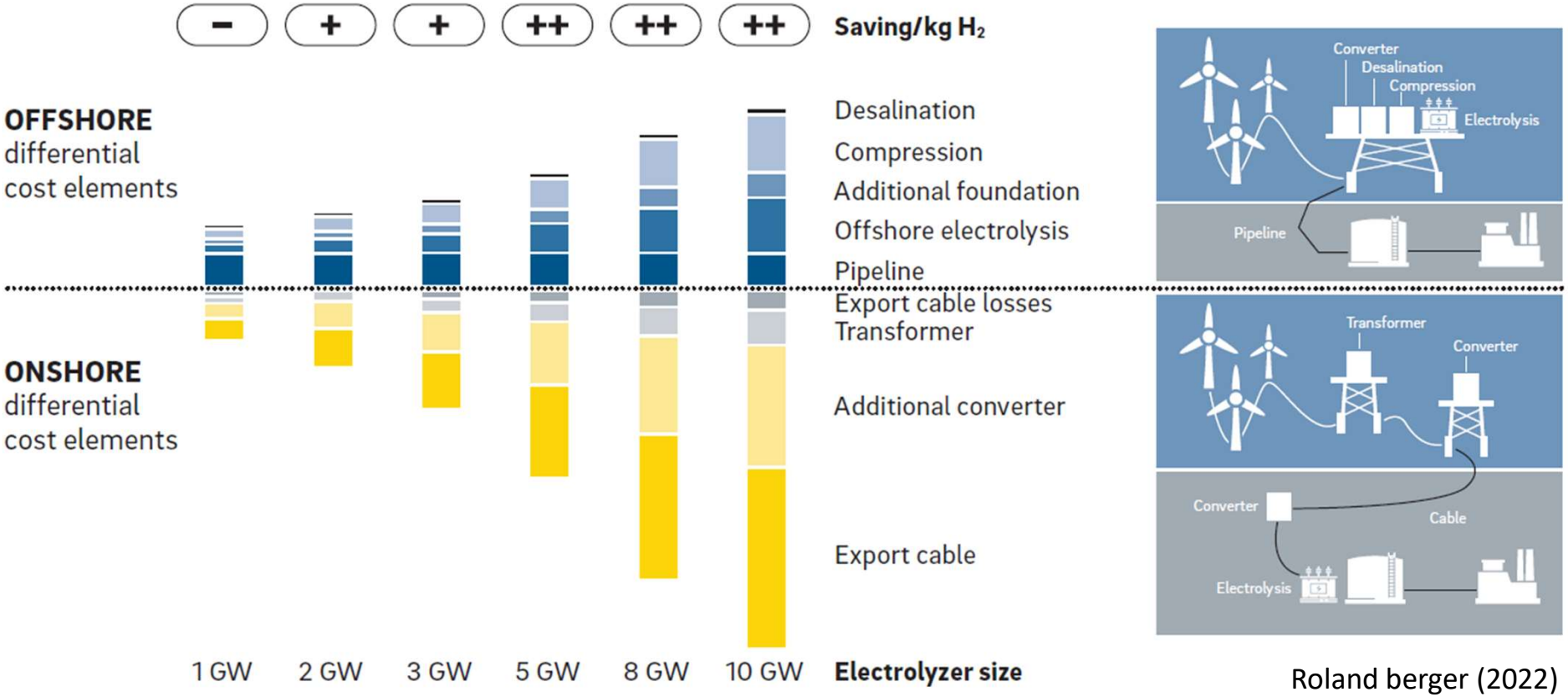


•Ref: www.north-sea-energy.eu, NSE(2020), Roland Berger (2021), AFRY (2022)

Cost comparison on- and offshore hydrogen

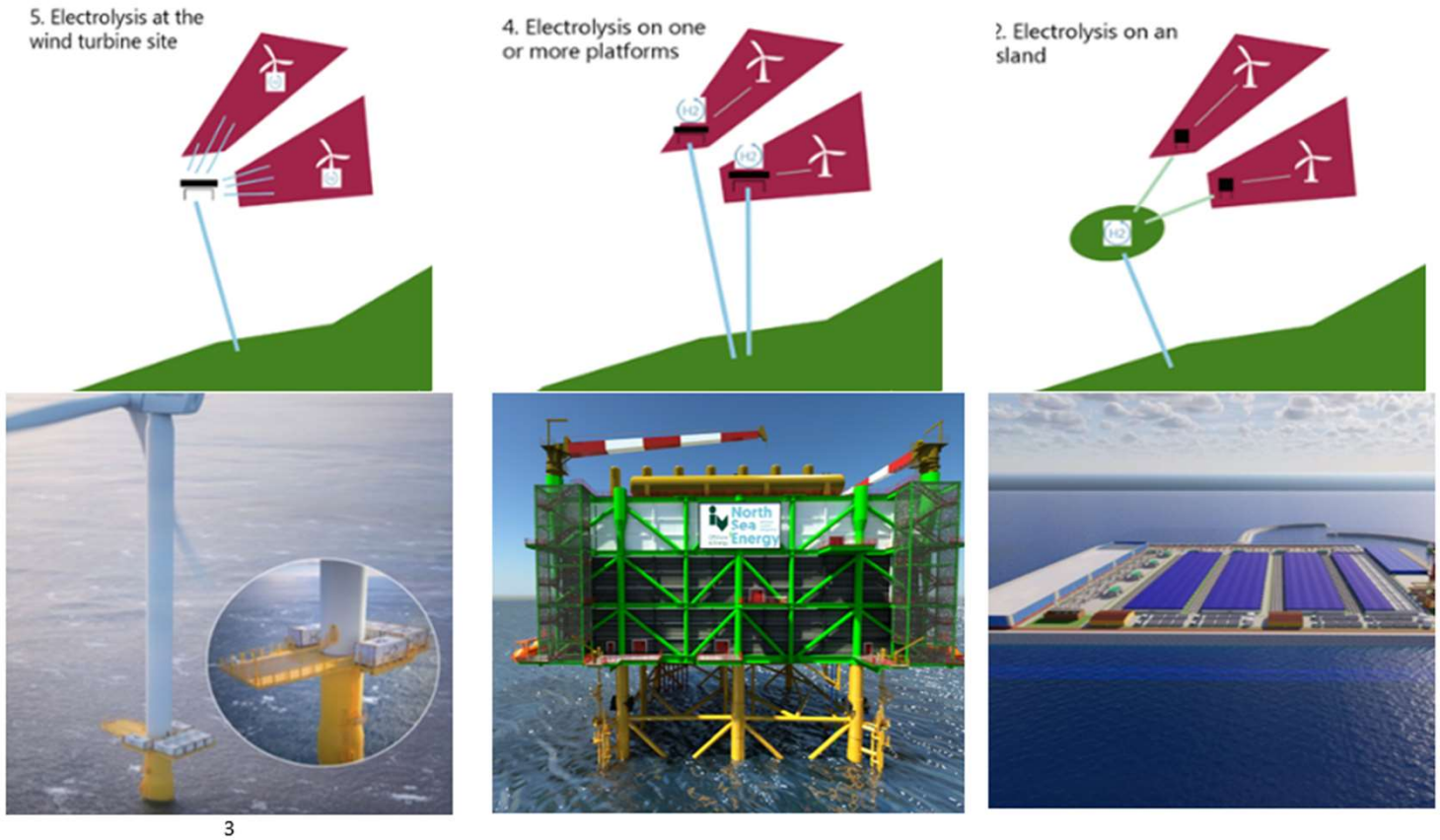
At larger scale, offshore hydrogen electrolysis is cheaper than onshore hydrogen electrolysis

INDICATIVE



Roland berger (2022)

Offshore Hydrogen production concepts

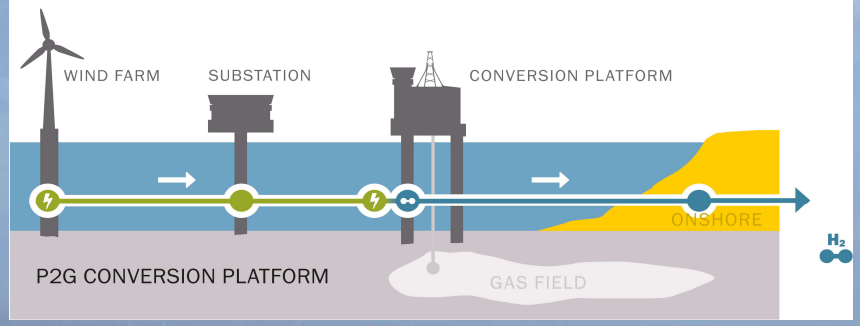


A) Electrolysis at the turbine, scale 15 – 20 MW

B) Electrolysis on wind farm level, scale 300 – 500 MW

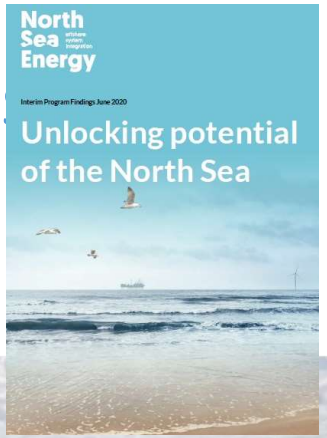
C) Electrolysis on energy island, scale Multi GW

Offshore hydrogen production pilot



Neptune Energy Q13A

Offshore hydrogen production from wind Platforms Energy Islands



www.poshydon.com

www.north-sea-energy.eu

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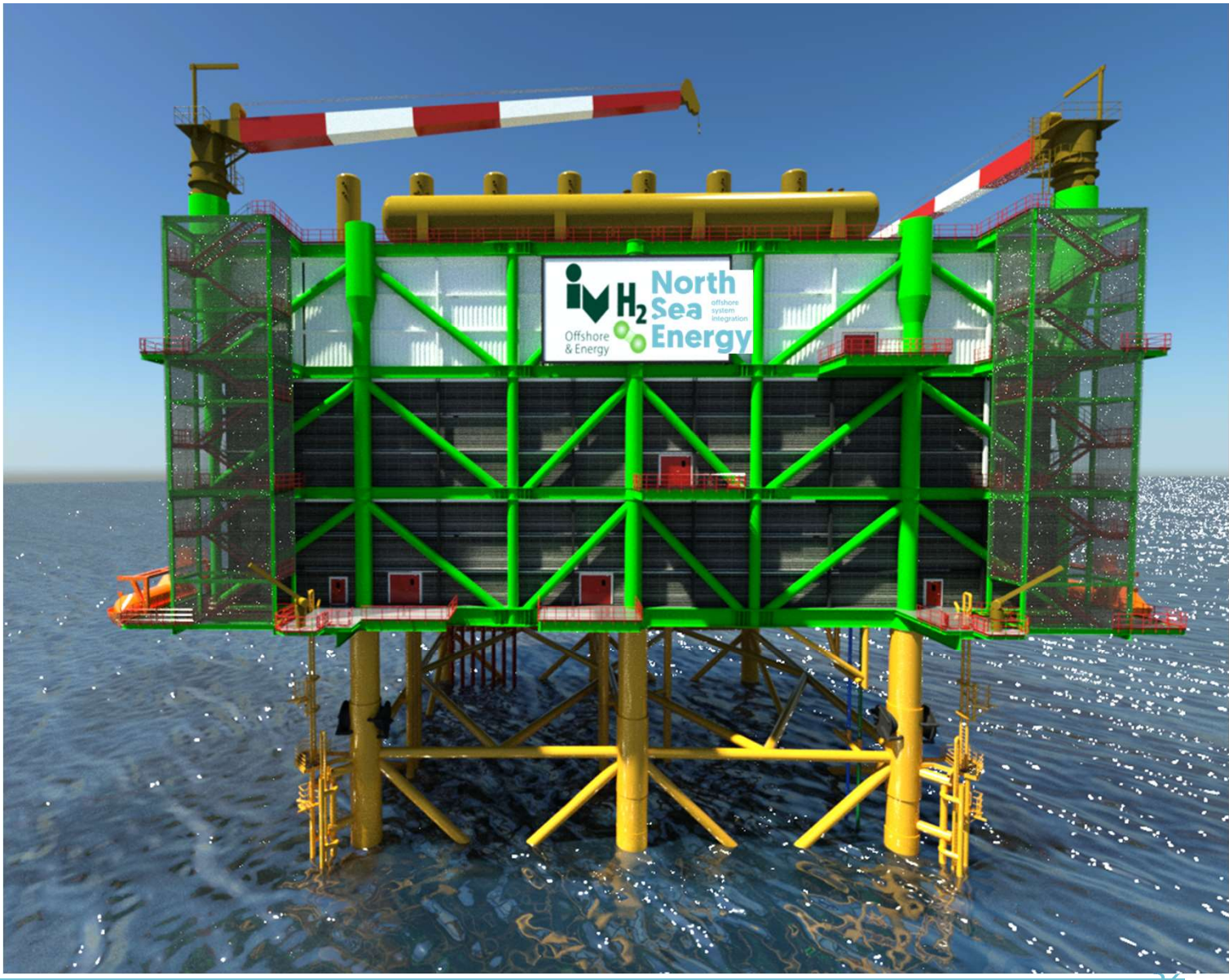
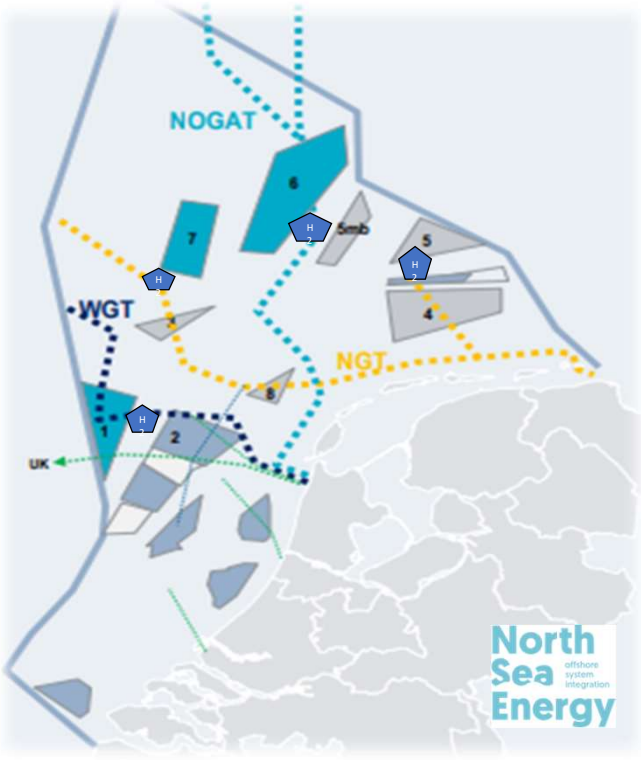
Full-scale offshore green hydrogen production capacity 500MW 85 KTA H2



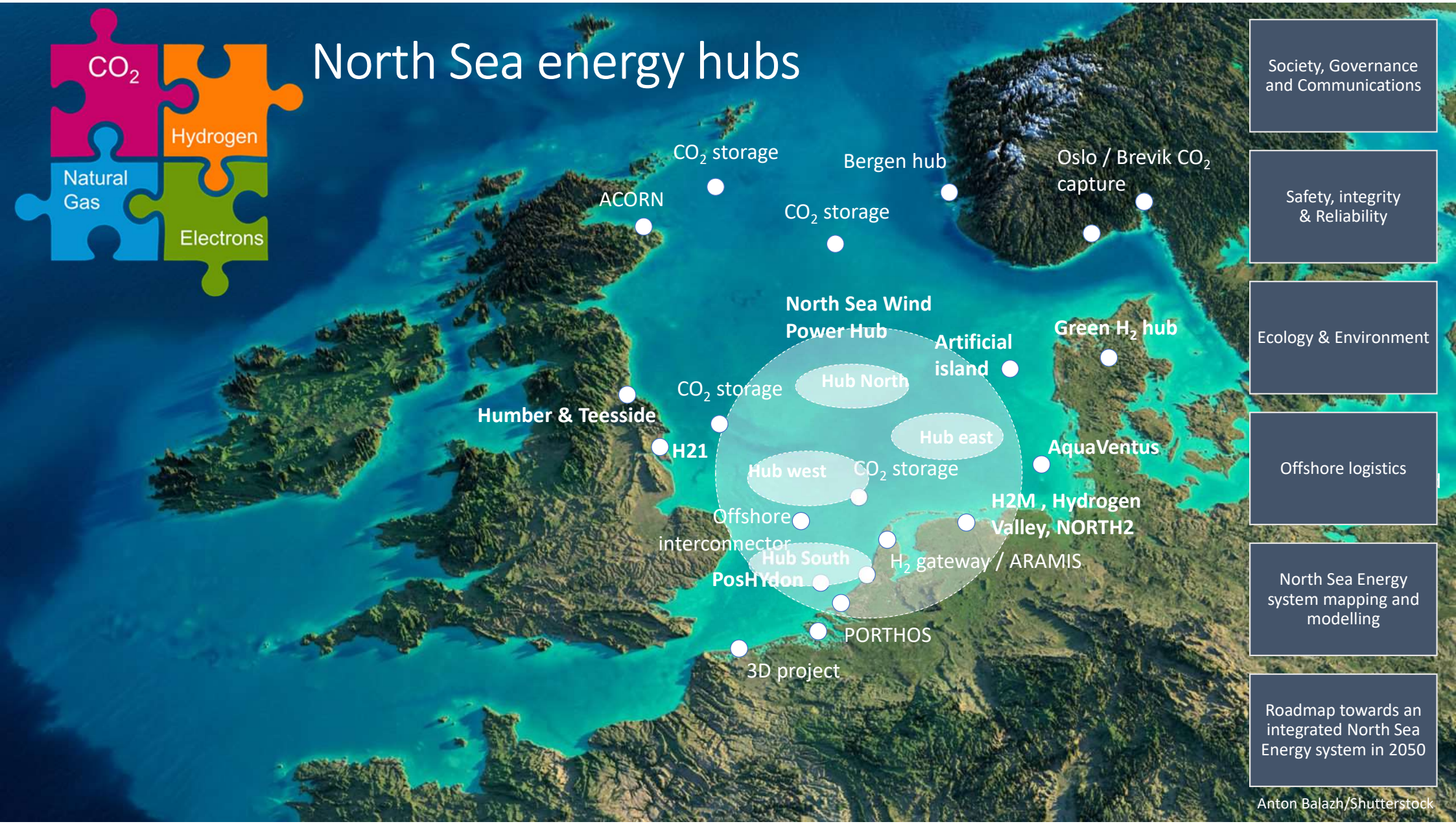
- Concept design ready
- Target realisation 2031
- Location: TNvdW

H2 Infrastructure developments

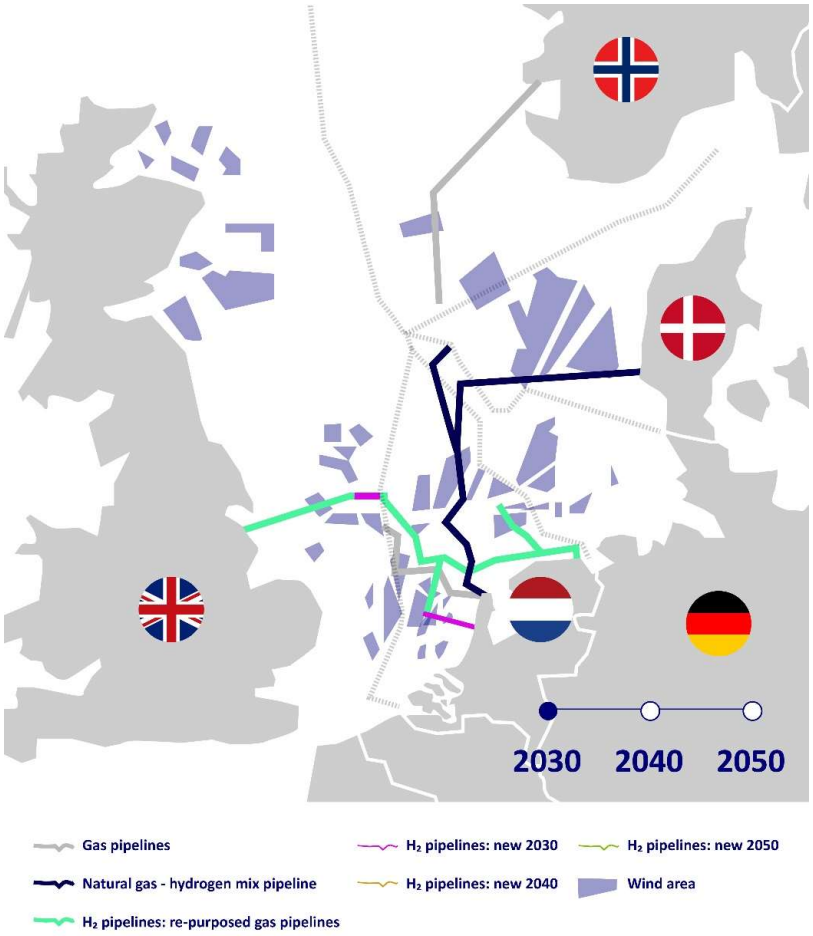
ONSHORE AND OFFSHORE H2 TRANSPORT

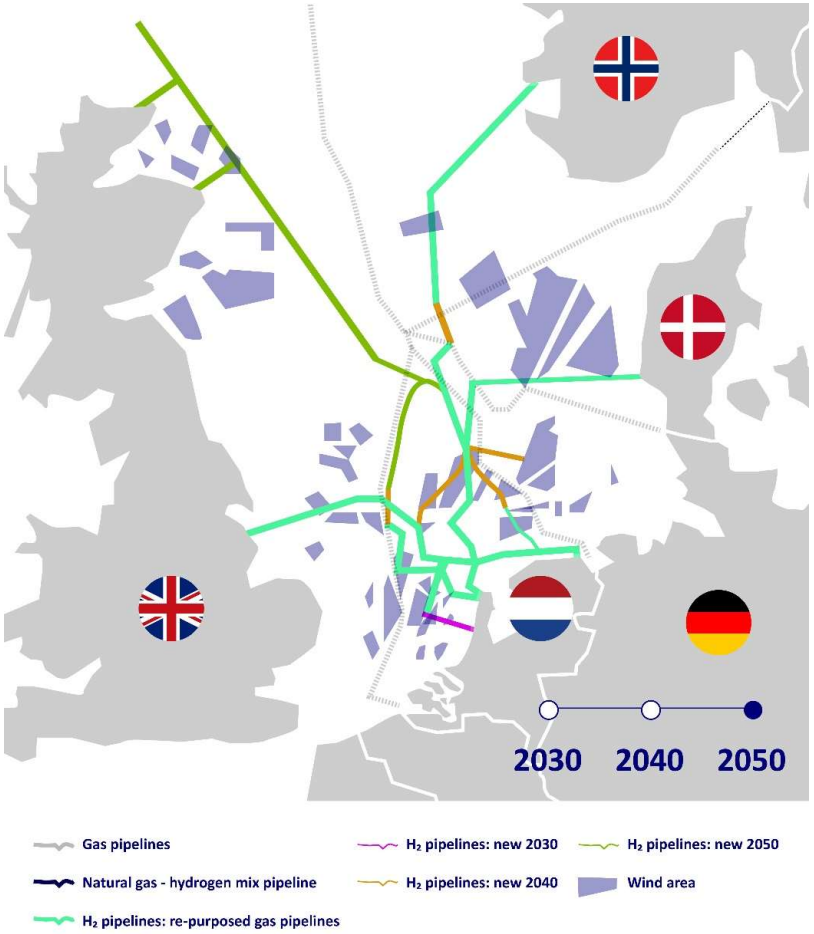


- National Hydrogen Backbone development of Gasunie (2020). Construction ongoing
- Offshore Hydrogen production and transport North Sea Energy (2022) – Retrofit and new


CO_2
Hydrogen
Natural Gas
Electrons
North Sea energy hubs
CO_2 storage
ACORN
Bergen hub
CO_2 storage
Oslo / Brevik CO_2 capture
North Sea Wind Power Hub
Artificial island
Green H_2 hub
Hub North
CO_2 storage
Humber & Teesside
H21
Hub east
AquaVentus
Hub west
CO_2 storage
H2M , Hydrogen Valley, NORTH2
Offshore interconnector
Hub South
PosHYdon
H_2 gateway / ARAMIS
PORTHOS
3D project
Society, Governance and Communications
Safety, integrity & Reliability
Ecology & Environment
Offshore logistics
North Sea Energy system mapping and modelling
Roadmap towards an integrated North Sea Energy system in 2050
Anton Balazh/Shutterstock

International perspective:
Grid development with new and repurposed pipelines



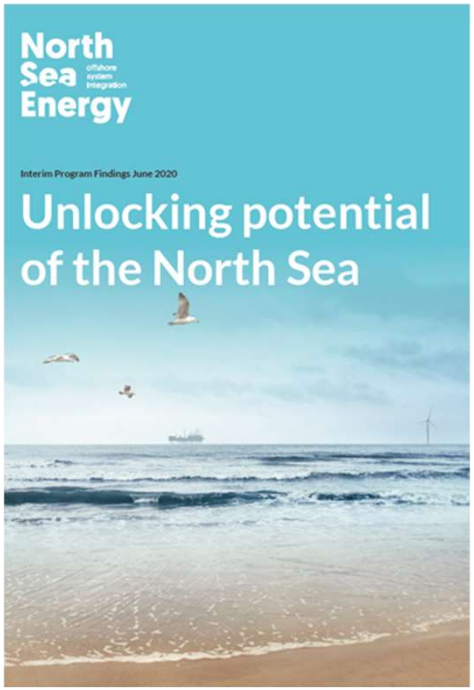


Conclusions

- Offshore wind acceleration beyond 2030 will require electrolysis onshore
- For wind parks beyond 100 km of the coast and more than 2 GW power offshore electrolysis is more economic
- Offshore electrolysis can be decentralised inturbine, on central platforms or islands
- Existing pipeline infrastructure can be (party) retrofitted for hydrogen transport, additional new infrastructure is needed to create interconnections
- Energy hubs at the North Sea can combine various functions for conversion stations HVDC, electrolysis, energy storage
- Energy hubs can be a number of platforms, artificial islands or gravity based structures

Questions?

RENE.PETERS@TNO.NL



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