



KIVI Jaarcongres 2020

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Hydrogen Production

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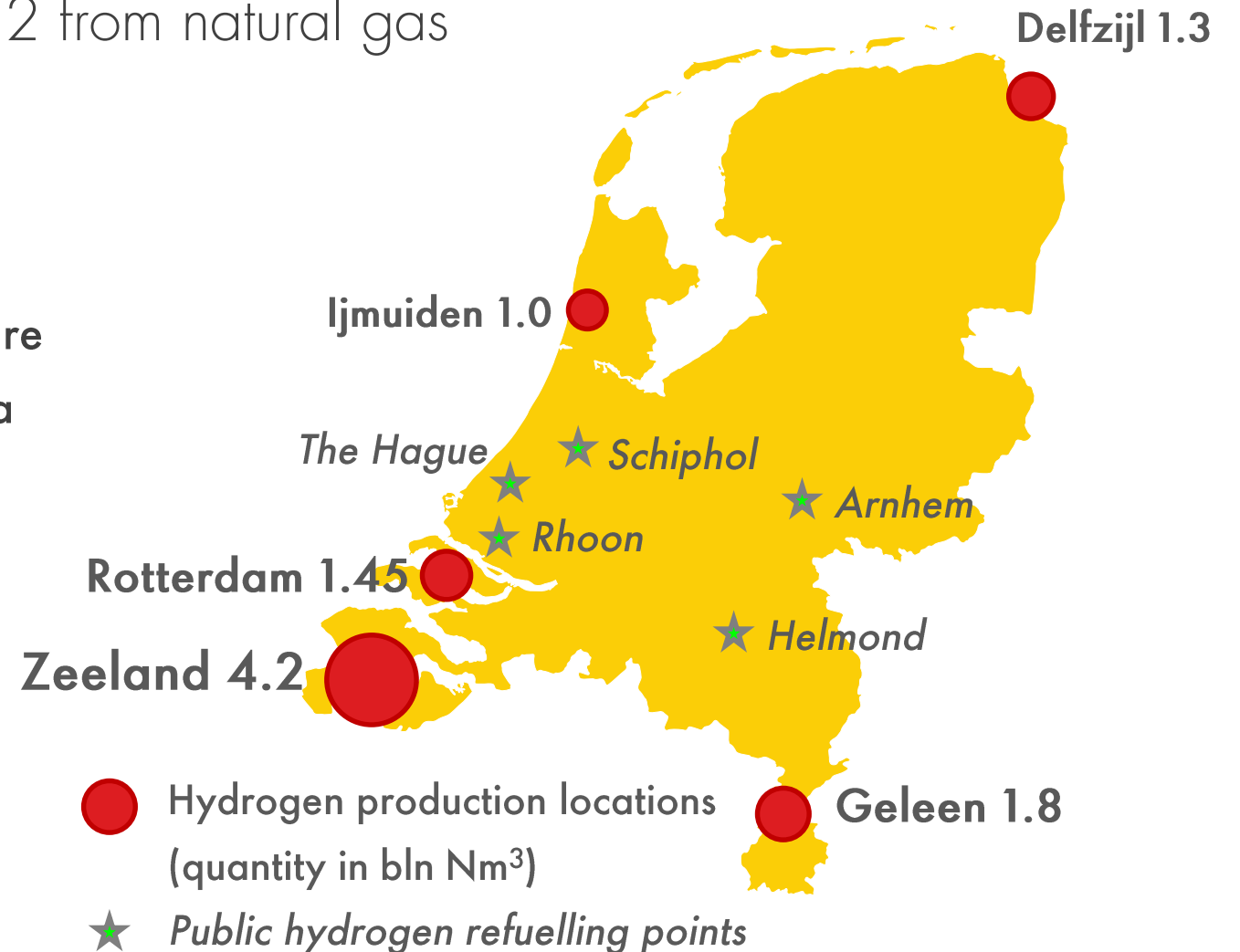
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Scene-setting: Hydrogen in the Netherlands today

Key industrial resource, mainly 'grey' H₂ from natural gas

- Annual production in NL over 10 billion m³ (~800kt/a)
 - Second largest in EU (total ~90 bln m³)
 - Captive / merchant / byproduct manufacture
- Primary uses: refinery feedstock and ammonia for fertiliser
- Pipeline networks (Air Liquide)
 - South NL, Belgium, northern France
 - Rotterdam / Maasvlakte area
- Use in mobility still very early stage



Source: report EZ OGNL.151886

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November 2020

How can hydrogen be made?

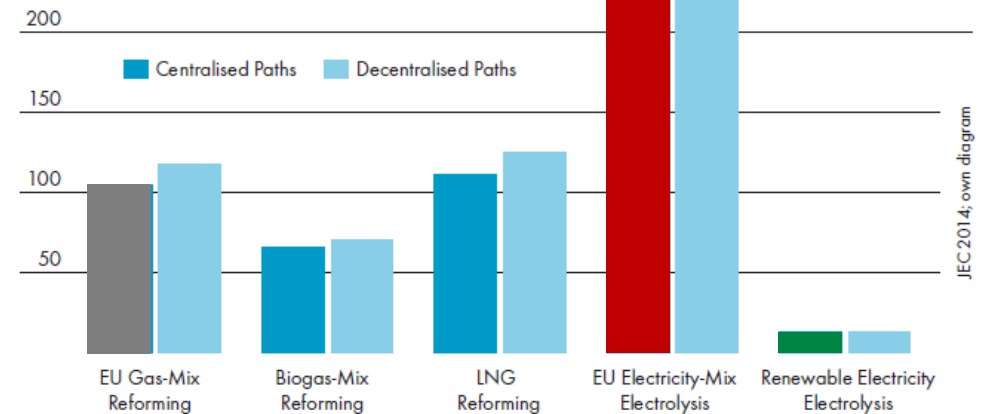
One single product: several different production routes

At industrial deployment stage

- **Grey H2:** reforming of natural gas
 - Steam methane reforming / Autothermal reforming / Partial oxidation ...
- **Blue H2:** natural gas reforming with carbon capture
- **Green H2:** water electrolysis using electricity from renewable sources

From reforming of natural gas 
From electrolysis (grid power EU-mix) 
From electrolysis (renewable power) 

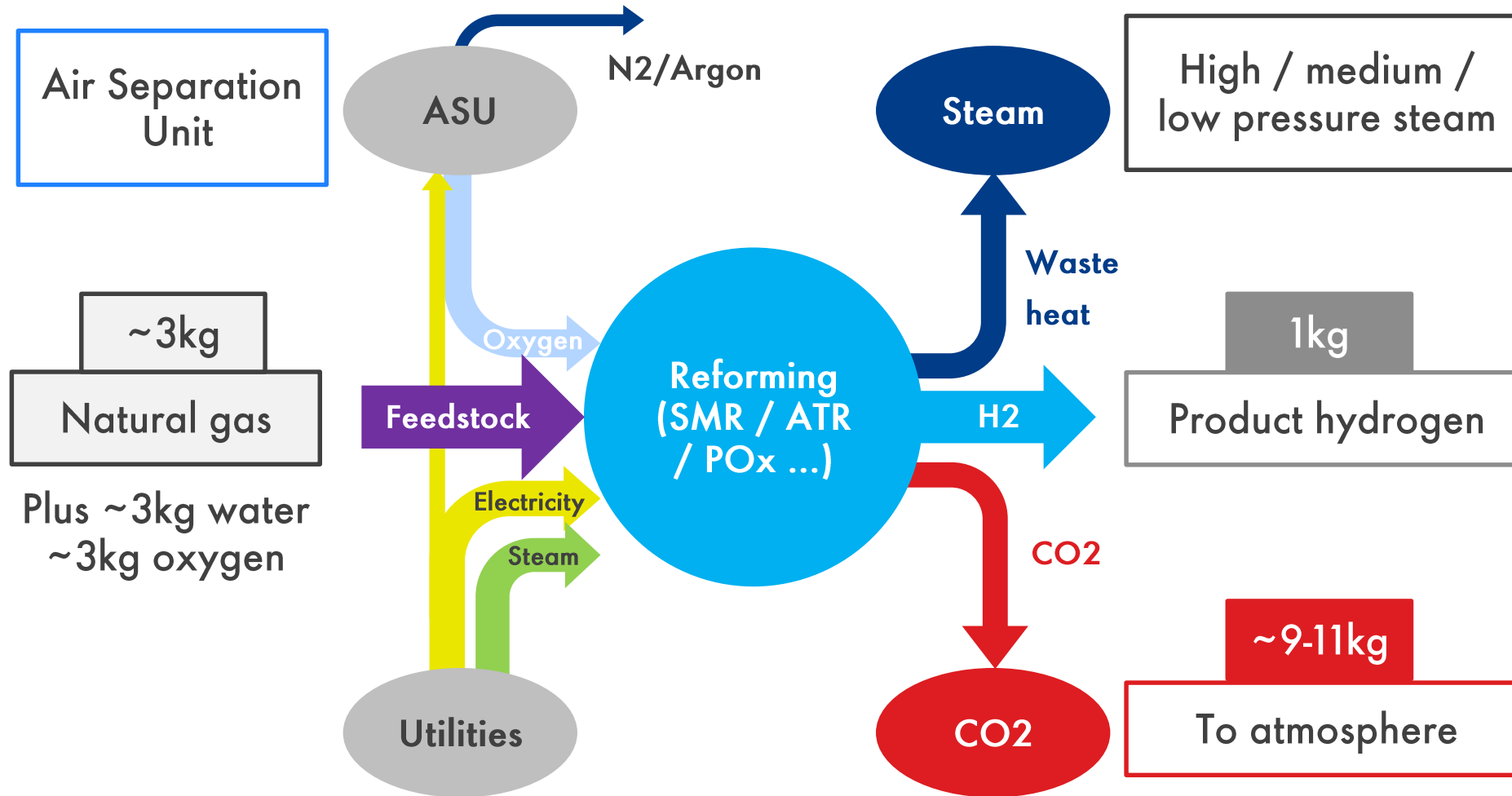
CO₂ emissions from hydrogen production (g CO₂/MJ H₂)



Source: Shell / Wuppertal Institute Hydrogen Study July 2017

Grey hydrogen – reforming of natural gas

Well-established and widely used in industry, efficient but CO₂-heavy

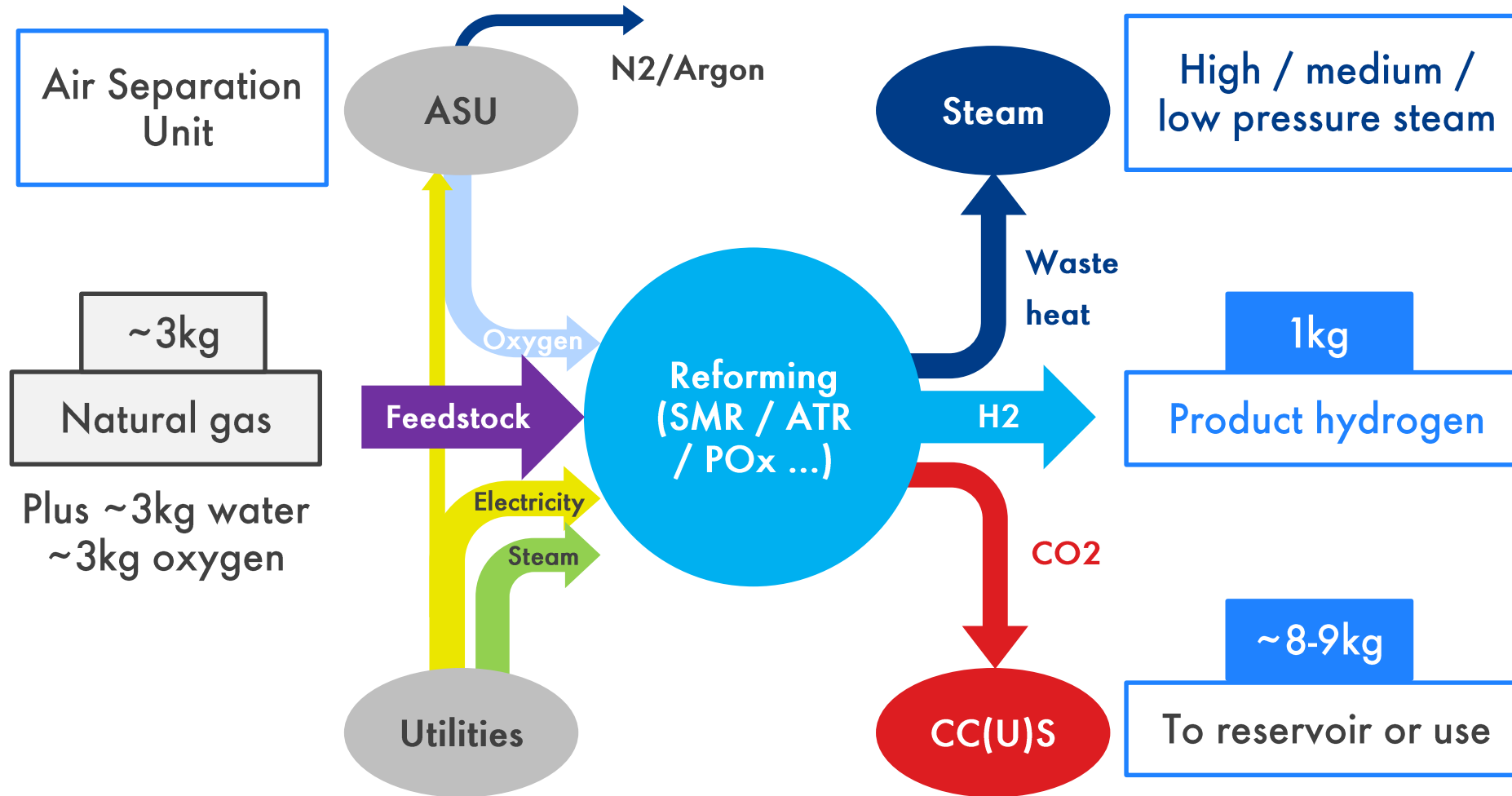


Options

- Steam integration
- Alternative oxygen sources
- Alternative hydrocarbon sources

Blue hydrogen – also reforming of natural gas

CO₂ is captured and either utilised or stored

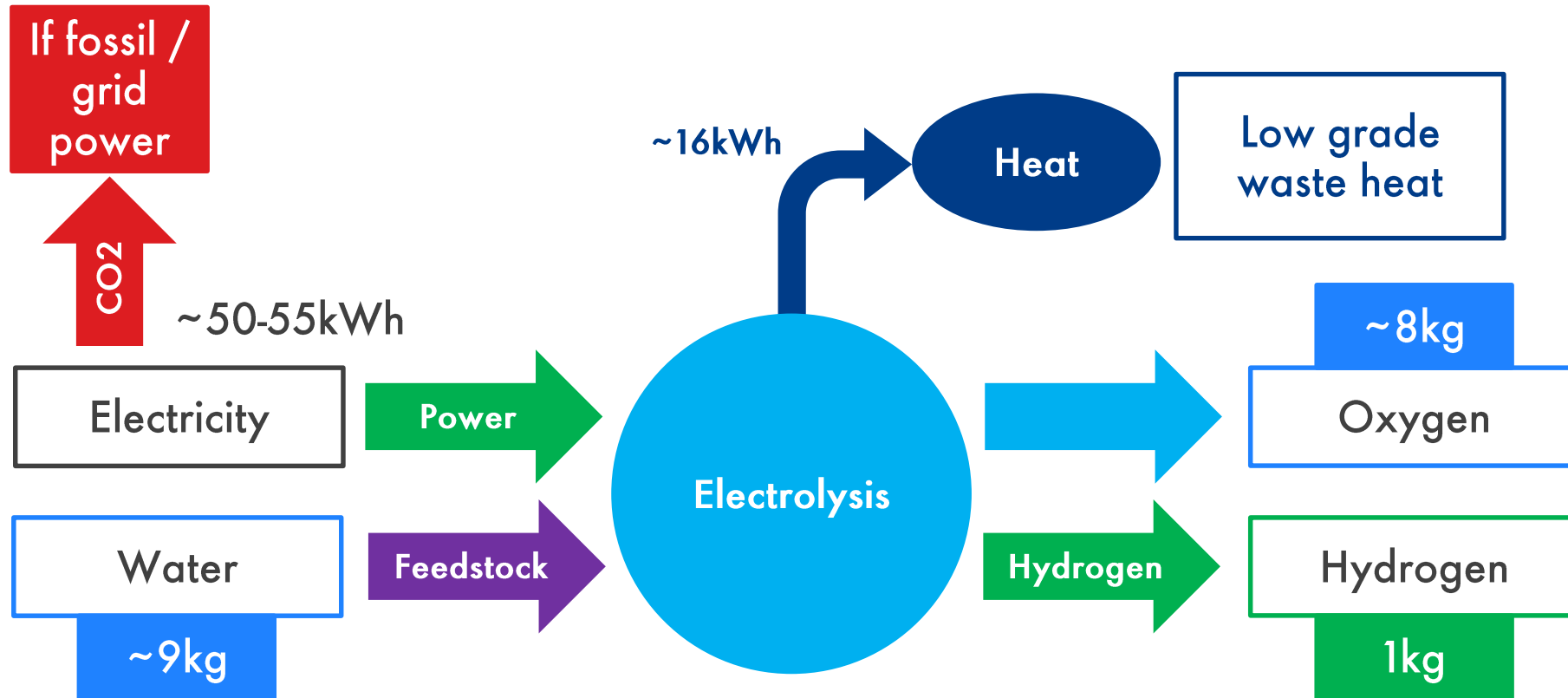


Options

- Steam integration
- Alternative oxygen sources
- Alternative hydrocarbon sources
 - e.g. refinery offgases
- Captured CO₂:
 - Utilisation
 - Sequestration
- ~0.5-1.2kg residual emissions (Scope 2/3)

Green hydrogen – Water electrolysis

Zero direct emissions – but power source is crucial



Options

- Oxygen utilisation if market available
- Waste heat integration

Alternative production technologies

Other options exist at (much) earlier technology readiness level

- Photocatalytic H₂: direct production from sunlight
 - 15% conversion achieved in 2019 (KU Leuven)
 - Scale-up is pending
- Turquoise H₂: methane pyrolysis
 - Solid carbon as by-product
 - Other hydrocarbons also possible sources
- Bio-H₂ e.g. from anaerobic digestion
- Others ...?



Source: <https://nieuws.kuleuven.be/en/content/2019/belgian-scientists-crack-the-code-for-affordable-eco-friendly-hydrogen-gas>

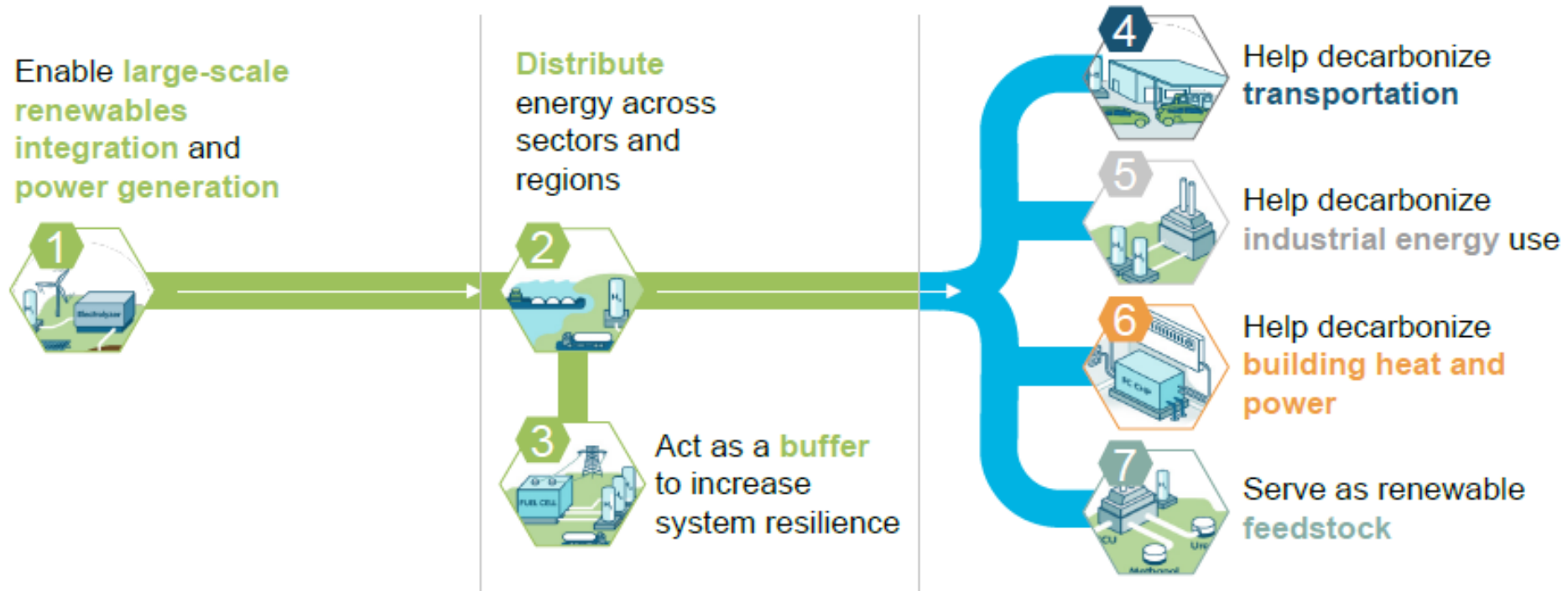


Source: BASF, https://www.efzn.de/fileadmin/documents/Niedersaechsische_Energietage/Vortr%C3%A4ge/2019/NET2019_FF1_04_Bode_Rev1.pdf

Energy Transition: The changing role of hydrogen

Helping decarbonise an evolving and electrifying energy system

Enable the renewable energy system → Decarbonize end uses

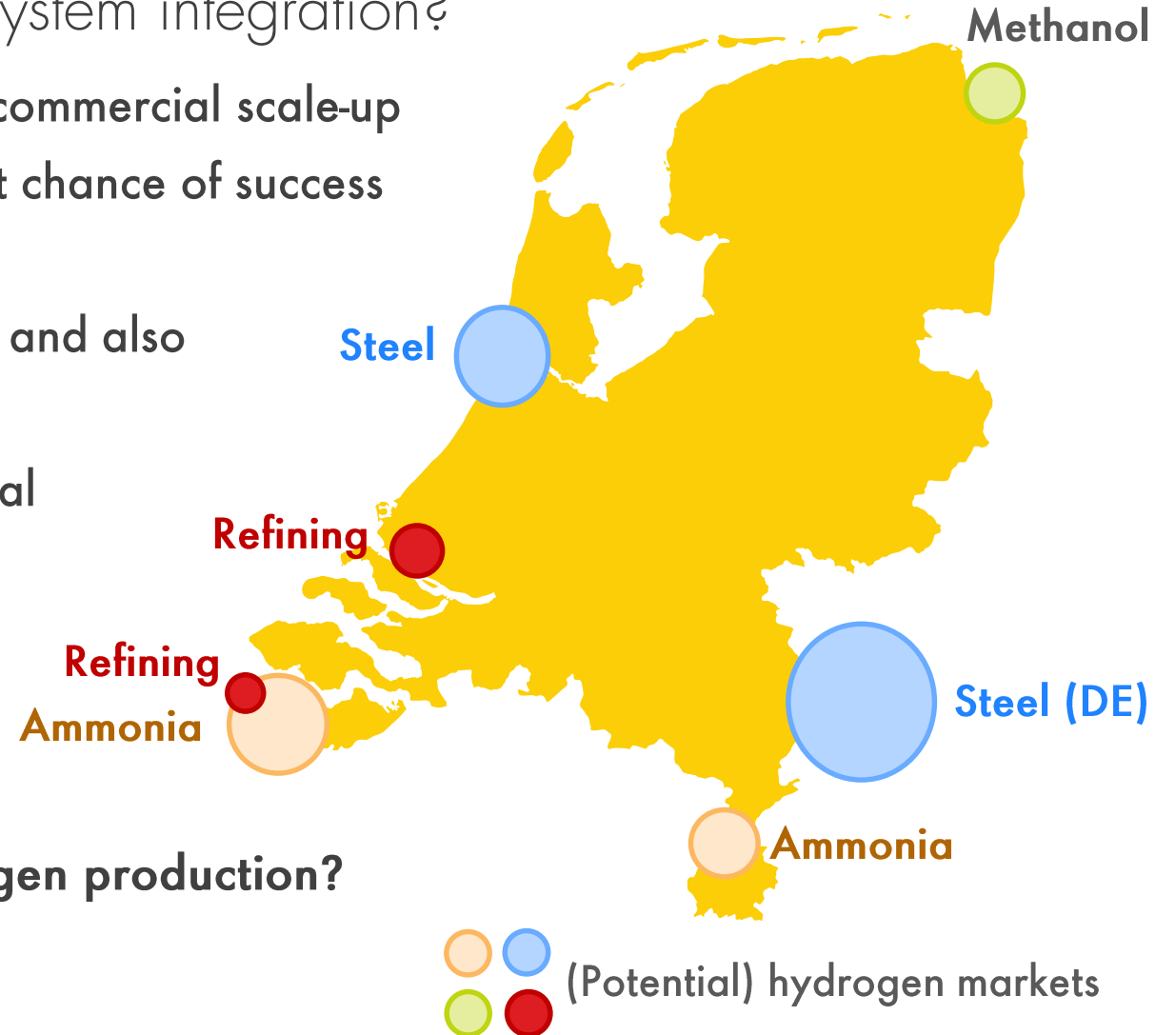


Source: hydrogencouncil.com – currently over 90 members worldwide

NL has potential for CO2 reduction using H2 in all sectors

How to enable rapid market growth and system integration?

- Growing (industrial) hydrogen demand is key to commercial scale-up
 - Integrated and collaborative projects have best chance of success
 - Industrial clusters leading the way
- (Offshore) renewables expansion offers potential and also constraints for green H2
- Energy imports and (European) connectivity crucial
 - Policy frameworks also highly influential



How to accelerate scale-up of commercial hydrogen production?

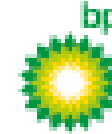
H-Vision: Blue H2 for rapid decarbonisation of heavy industry

Achieving 2030 CO2 targets and paving the way for a green H2 future

Objectives

- Support industry to reduce CO2 emissions
 - Decarbonising CO2-heavy refinery fuels
- Support Rotterdam to realise its 2030 climate ambitions (Rotterdam Climate Agreement)
 - Highly collaborative project
 - Substantial reduction in CO2 from Rotterdam refineries by 2030
- Blue H2 from refinery fuel gases at large scale
 - Infrastructure relevant for Rotterdam's future role as a (green) hydrogen hub

Core partners



Support partners



Port of Rotterdam



Power Plant Rotterdam

H2Gateway – Accelerating H2 decarbonisation from Den Helder

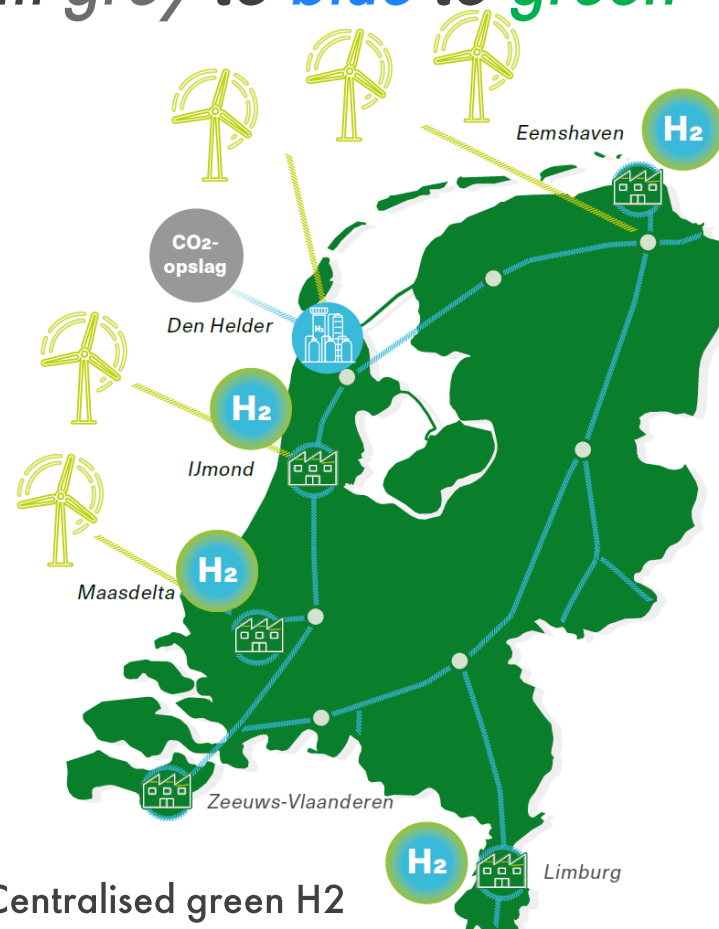
Integrating H2 production and transport: *“From grey to blue to green”*



Local H2 production from gas with high CO2 emissions



Centralised H2 production from gas with effective CCS; CO2-free H2 transported via national backbone



Centralised green H2 production using offshore wind, green H2 transported in NL and beyond via (inter)national backbone

NorthH₂

Kickstarting the green hydrogen economy

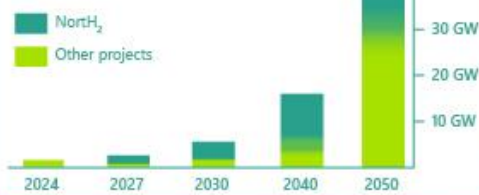
One single integrated chain in which renewable power generated by offshore wind farms is used for large-scale green hydrogen production, transmission, storage and supply. With this ambitious initiative, Equinor, Gasunie, Groningen Seaports, RWE and Shell Nederland, supported by the Province of Groningen, will help achieve the targets from the Dutch Climate Agreement.

We will be supplying large quantities green hydrogen to industry in the Netherlands and North-western Europe, reducing CO₂ emissions by 8 to 10 megatons per year. This initiative will give the green hydrogen market a real boost!

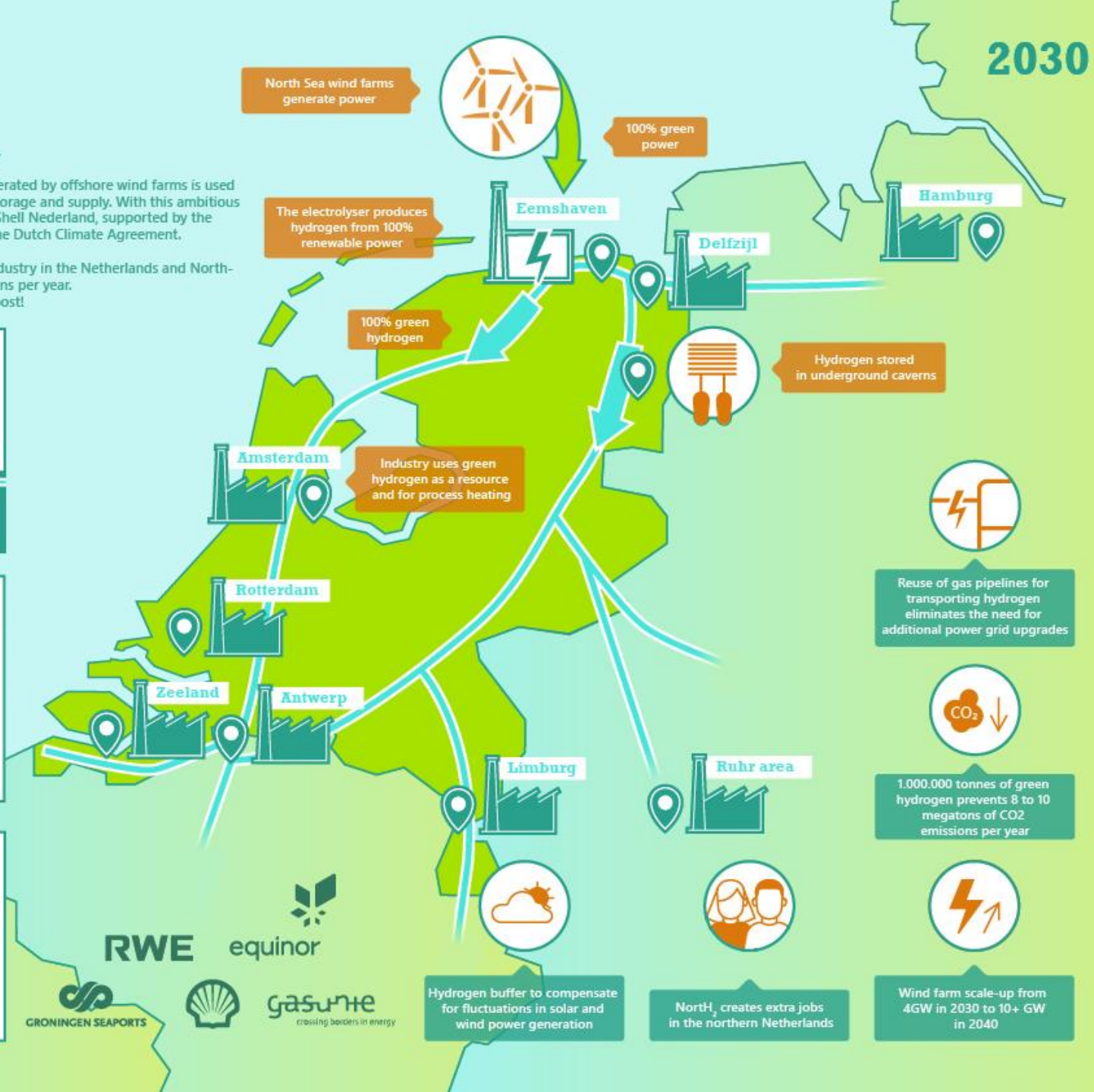
Scale-up in 2040:
More offshore wind farms and electrolysis



Scaling up green hydrogen production from 100% new wind power



Hydrogen supply to various sectors



Rotterdam Electrolyser

Kick-starting green hydrogen at scale in an integrated value chain

