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## Hydrogen and Shell in NL

KIVI, 25/1/23

**Alice Elliott**

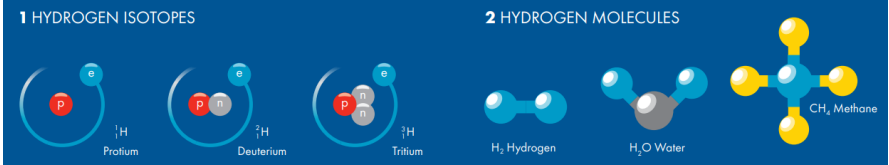
Shell Hydrogen Interface Lead

## Today ...

- What is H<sub>2</sub>, how can it be made, and is it sustainable?
- What is it used for now (in NW Europe), and how is this changing?
- What is Shell's vision for net zero and hydrogen?
- What are we doing here and now to make this happen – and why?

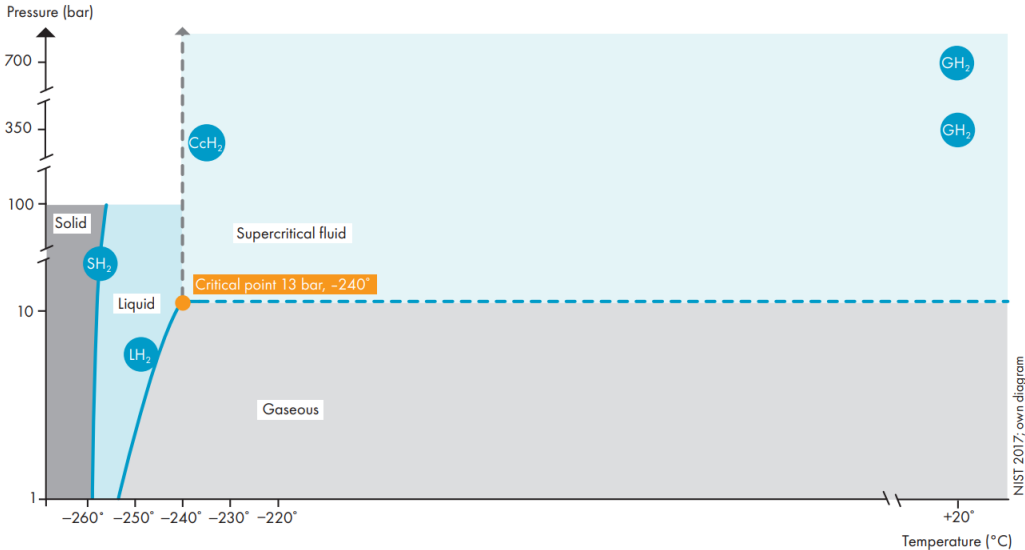
# Hydrogen

## The most abundant element in the universe

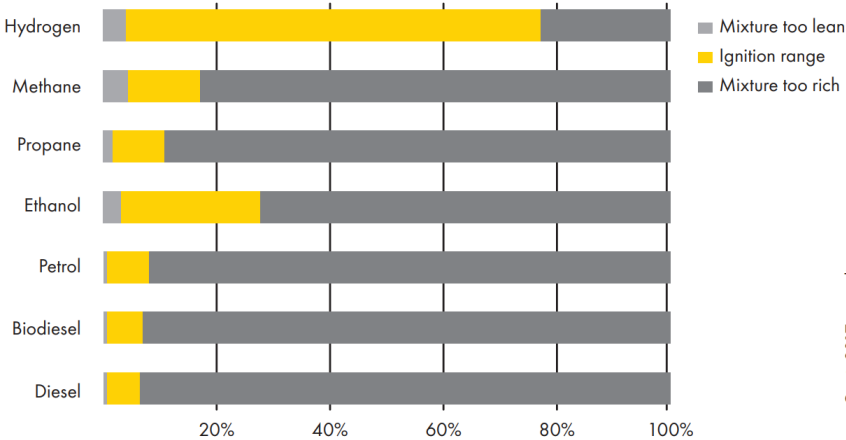


- About 75% of the universe mass is hydrogen
- Hydrogen combines with pretty much anything, so it's almost always found chemically bound
- Hydrogen really likes to remain gaseous... (liquid at -260 degC)
- Hydrogen has a very broad ignition range (and tends to explode rather than slowly burn)

3 PHASE DIAGRAM HYDROGEN

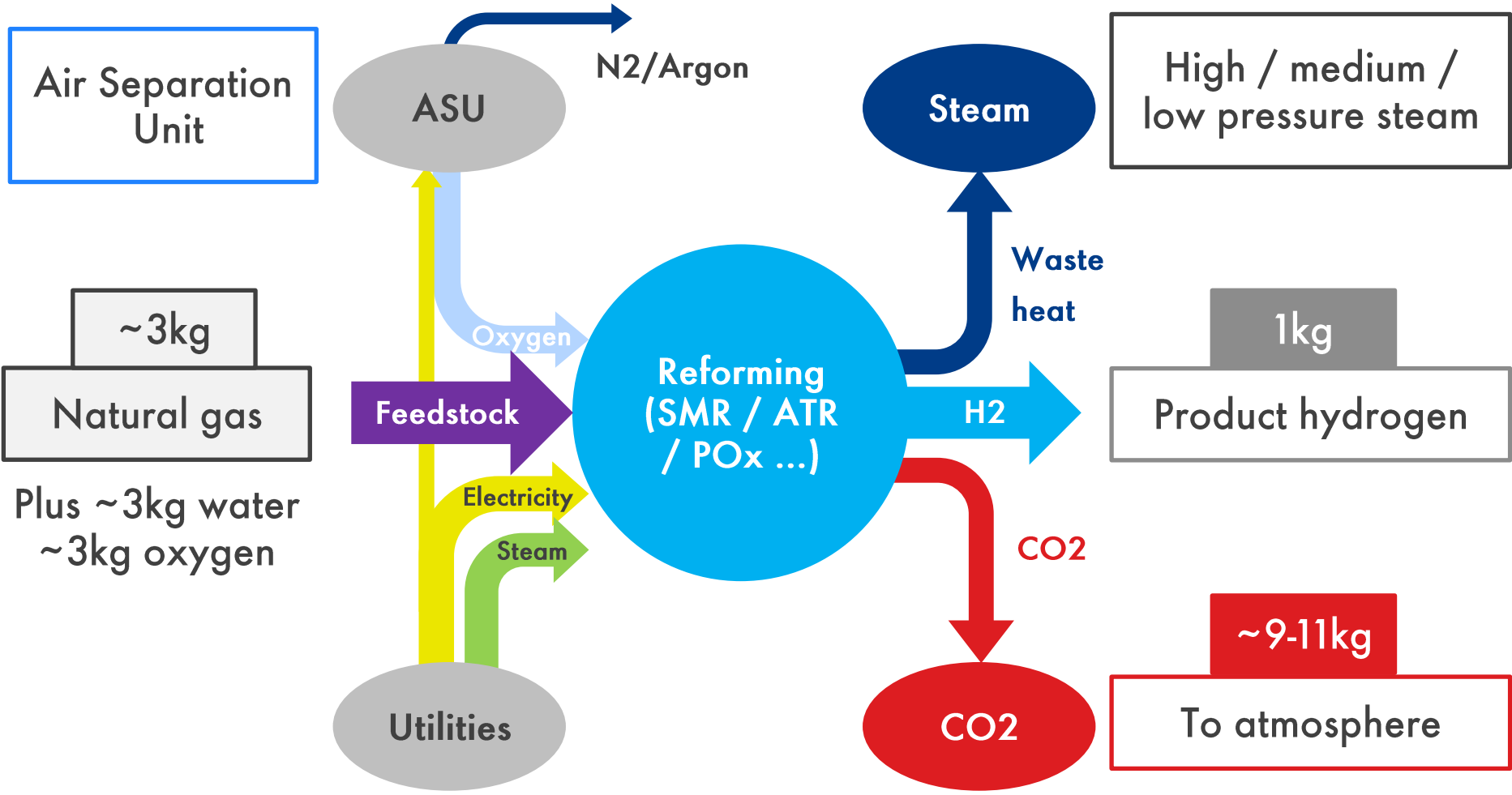


4 IGNITION RANGE OF FUELS



# Grey hydrogen – reforming of natural gas

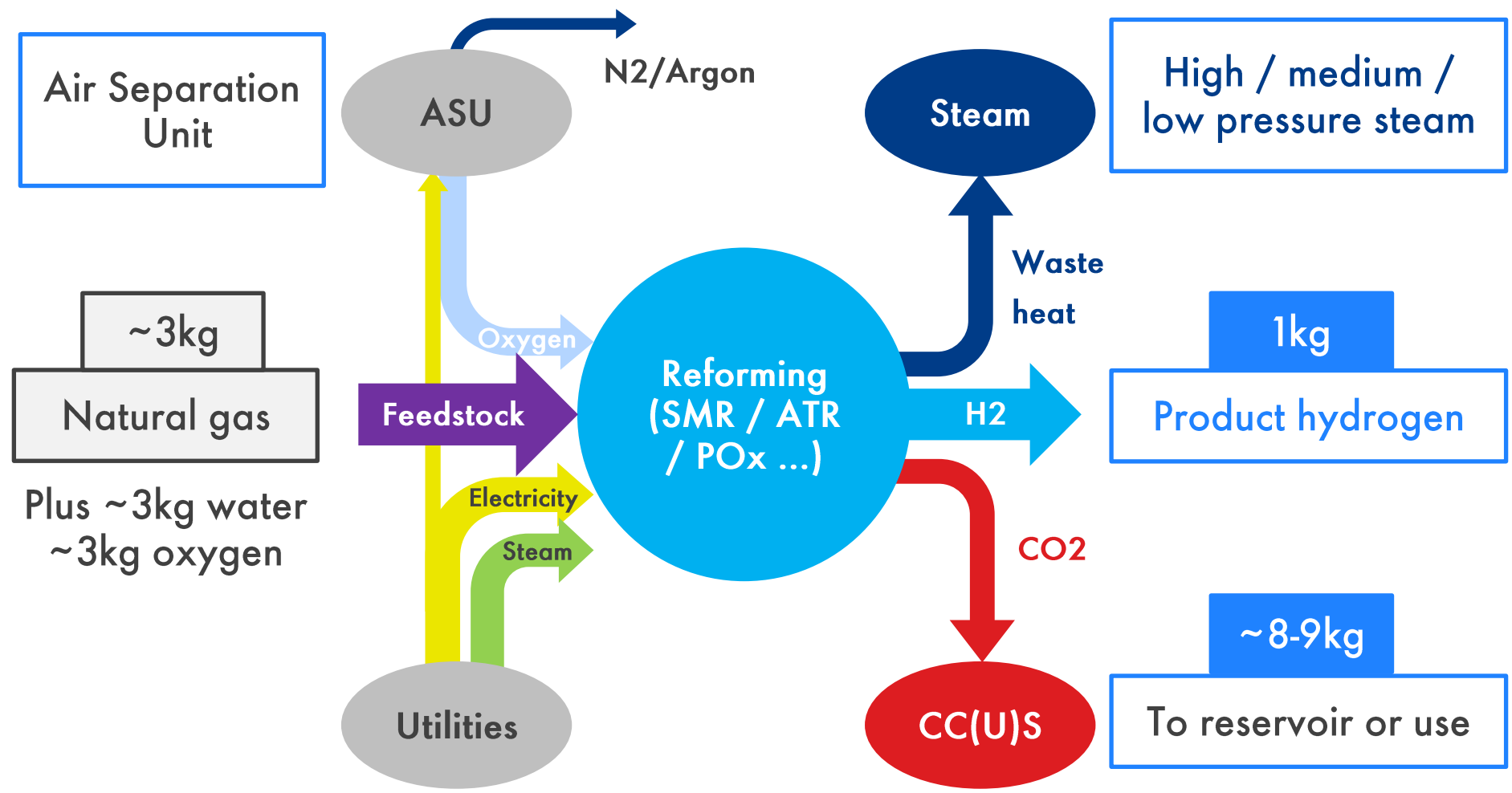
Well-established and widely used in industry, efficient but CO2-heavy



- Options
- Steam integration
  - Alternative oxygen sources
  - Alternative hydrocarbon sources

# Blue hydrogen – also reforming of natural gas

CO2 is captured and either utilised or stored

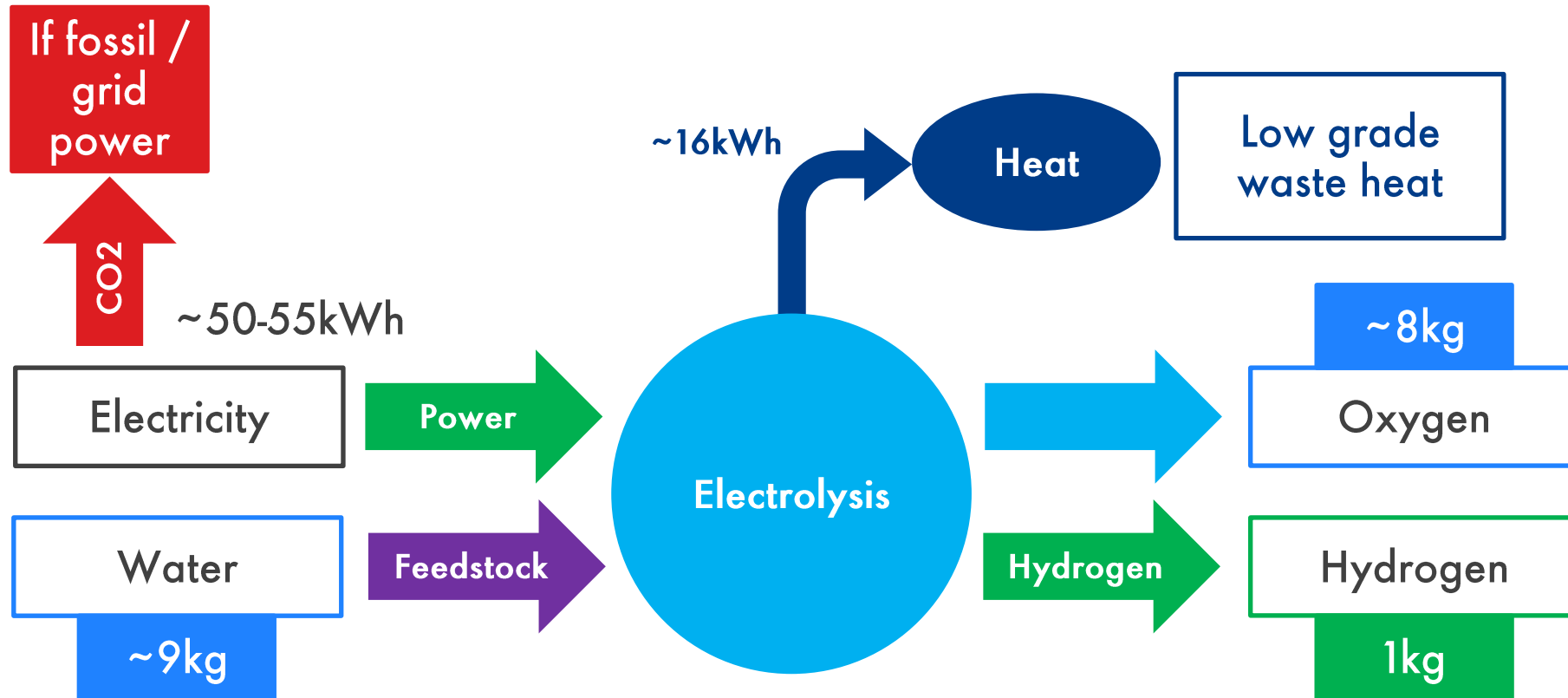


### Options

- 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 H<sub>2</sub>: direct production from sunlight
  - 15% conversion achieved in 2019 (KU Leuven)
  - Scale-up is pending
- Turquoise H<sub>2</sub>: methane pyrolysis
  - Solid carbon as by-product
  - Other hydrocarbons also possible sources
- Gasification of organics e.g. from waste
- Bio-H<sub>2</sub> 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>

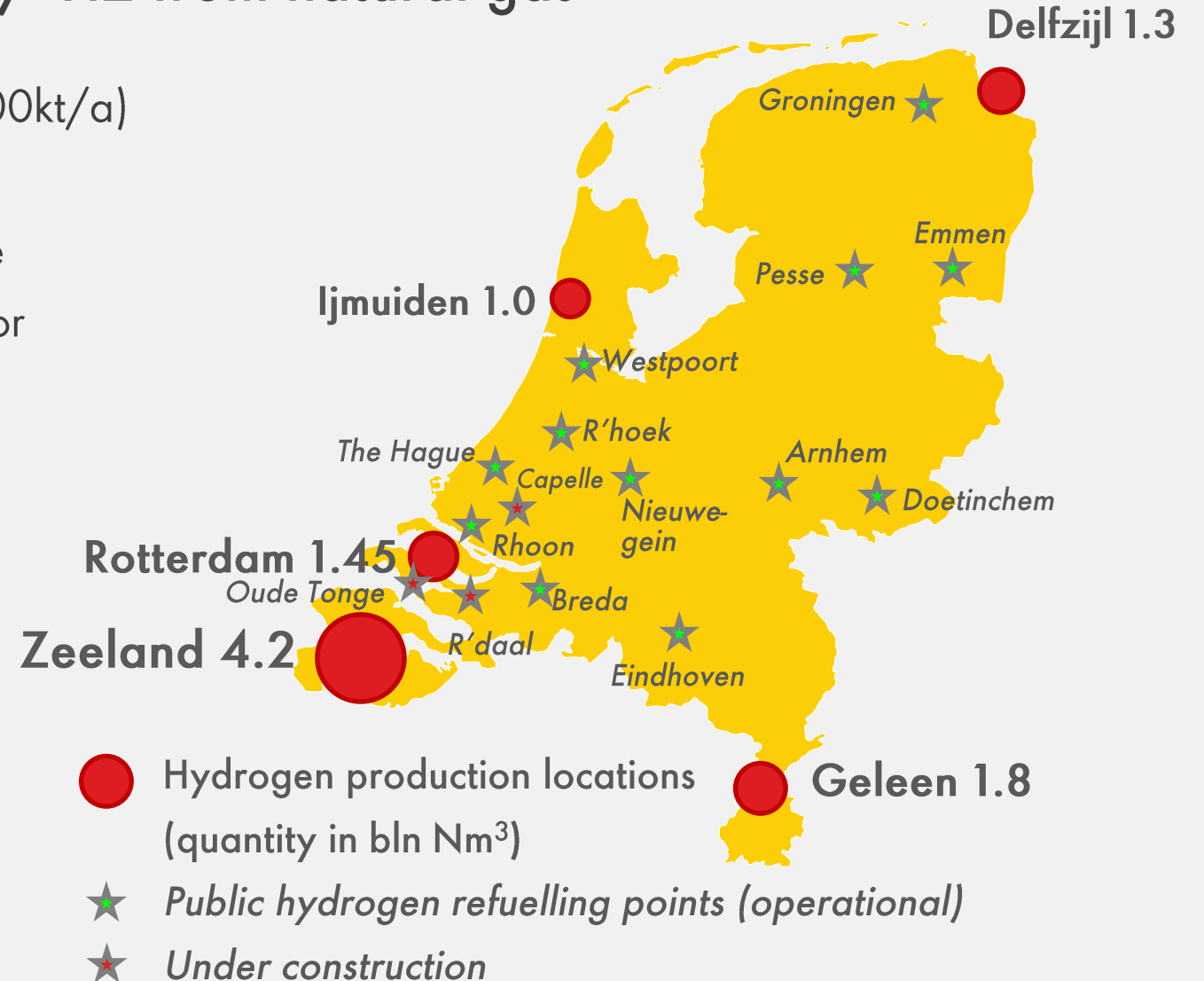


Source: BASF, [https://www.efzn.de/fileadmin/documents/Niedersaechsische\\_Energietage/Votr%C3%A4ge/2019/NET2019\\_FF1\\_04\\_Bode\\_Rev1.pdf](https://www.efzn.de/fileadmin/documents/Niedersaechsische_Energietage/Votr%C3%A4ge/2019/NET2019_FF1_04_Bode_Rev1.pdf)

# Scene-setting: Hydrogen in the Netherlands today

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

- Annual production in NL over 10 billion m<sup>3</sup> (~800kt/a)
  - Second largest in EU (total ~90 bln m<sup>3</sup>)
  - 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 early stage



Source: internal report

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# NL has potential for CO2 reduction using H2 in all sectors

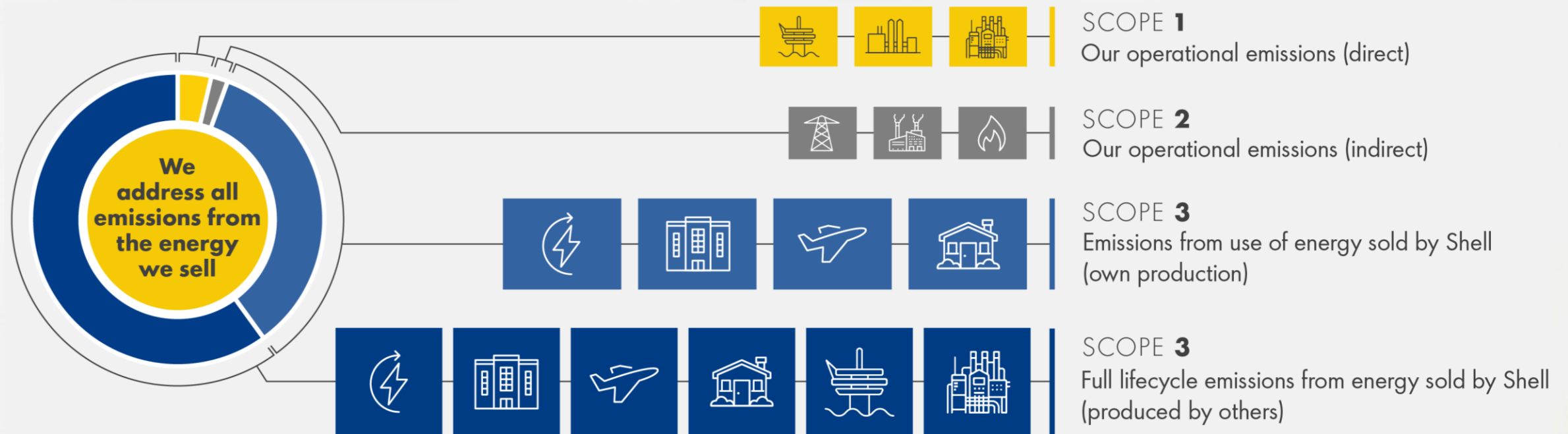
## How to enable rapid market growth and system integration?

- 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
- Pace of change stepping up in neighbouring countries (BE/FR/DE)



# Shell's climate target

Shell aims to become a net-zero emissions energy business by 2050.



We believe Shell's **total carbon emissions** from energy sold **peaked in 2018** at around **1.7 Gtpa**

# The role of Hydrogen in reaching Net Zero



# Hydrogen in the future energy system

## Decarbonise hard-to-abate end-uses



Decarbonising transportation leveraging higher energy density uses



Decarbonising industry energy use replacing coal and other fossil fuels



Decarbonising building heat and power leveraging existing gas infrastructure



Decarbonising grey H<sub>2</sub> use in fertiliser, refineries and chemical industries

## Enable deep renewables penetration, distribution & system resilience



Enabling large-scale renewables penetration and power generation



Enabling large-scale renewables penetration and power generation



Act as a buffer or storage to increase system resilience

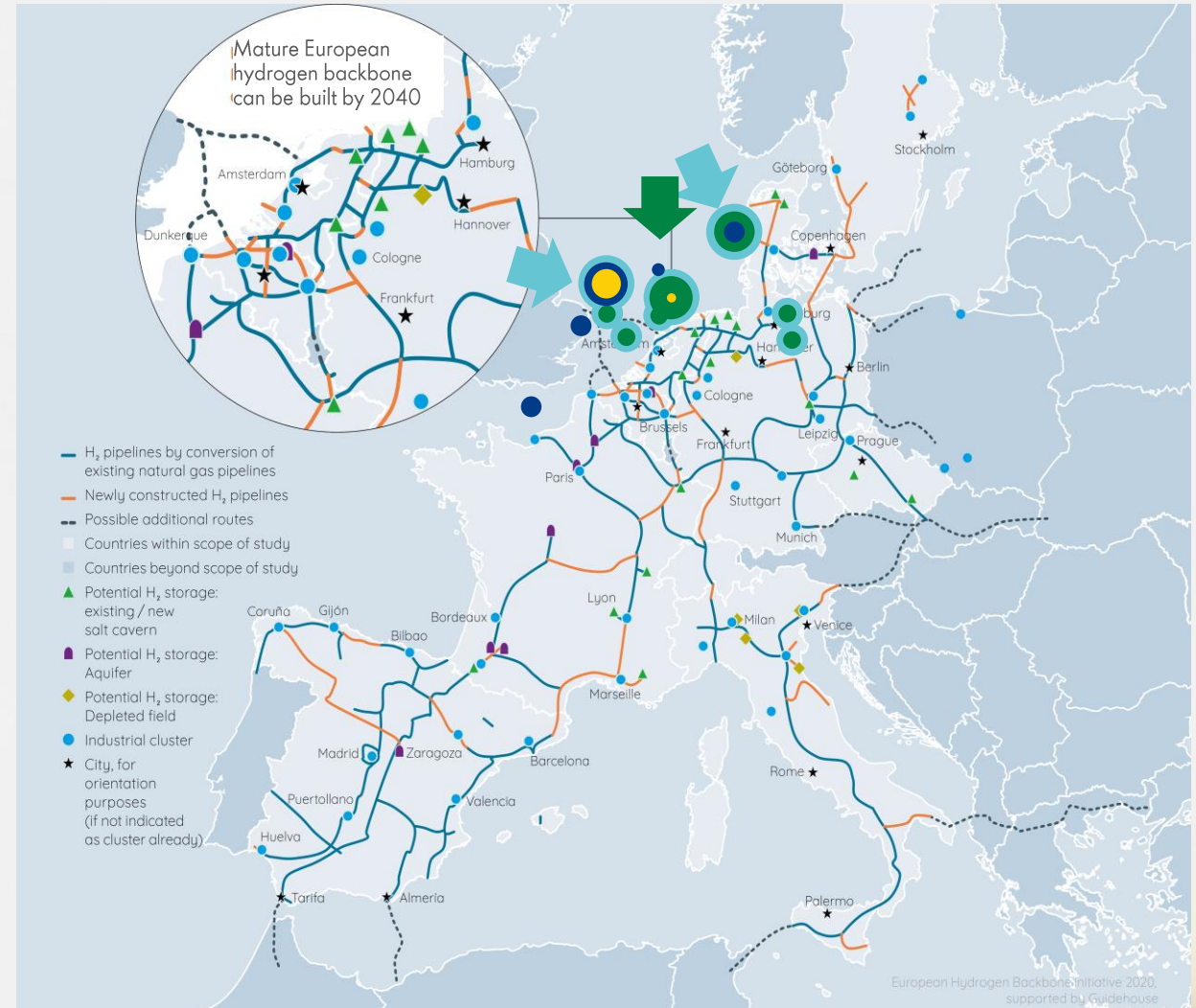


Electrolysers as real-time sinks for an oversupplied renewable system

# Focus on Hydrogen for Industry

Decarbonising industry starts at hubs, expanding to industry clusters as the infrastructure develops

	Proof points		
Increasing uncertainty & risk	<b>Step 1 – Own Use</b> Serve own-use as anchor demand in hubs – enables to build supply positions and gain experience and credibility	RefHyne - Rhineland Rotterdam Electrolyser	●
	<b>Step 2 – Serving the hubs</b> Serve local third party customers in hubs - create market and solutions, expand supply position	GZI - Emmen Rotterdam Electrolyser Hamburg	●
	<b>Step 3 – Starting the clusters</b> Serve inter-regional and international industrial demand through an expanding hydrogen backbone network	North <sub>2</sub> Ingoland	● ↓
	<b>Step 4 – Fully developed</b> Traded hydrogen commodity market – facilitated by a wide-spread hydrogen pipeline network, including import	Rotterdam import Hamburg Import	● ↓



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# Projects



# R&D: Developing and integrating technologies of the hydrogen value chain

## Production

- Assure hydrogen's quality and purity

## Storage

- Computational modelling to identify innovation
- Storage tank designs for H2 long distance transportation

## Transport

- Liquid H2 long range research

## Building hydrogen networks

- Feasibility studies to integrate electrolyser in energy system (local grid or industrial sites)

## Distribution

- Safe and easy-to-use dispensers



# Shell Hydrogen power dispenser

## Success story for collaborative development



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Greenpoint, Pesse (Drenthe)

- Both 700bar and 350bar refuelling
- Universal payment solution
- Touchscreen display
- Lightweight nozzle
- Designed for installation on existing forecourt
- Available globally under licence

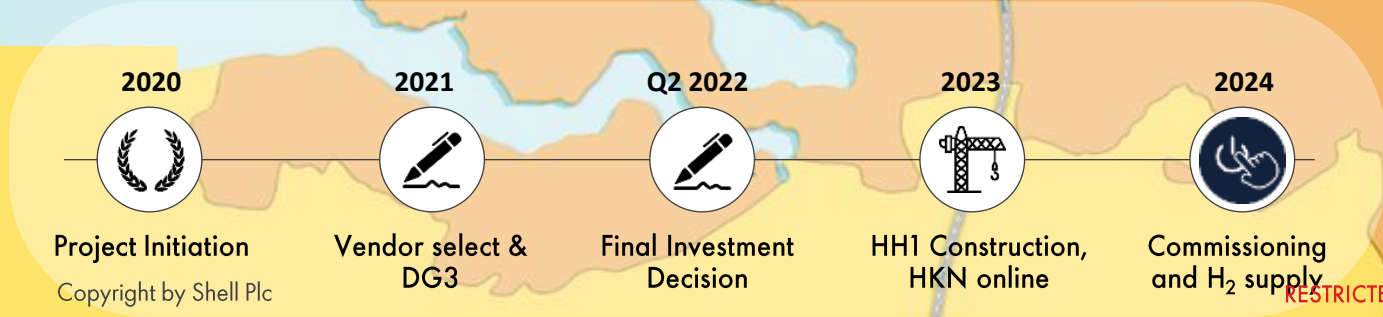
**Shell**  
**Hydrogen**  
Power Dispenser





# Holland Hydrogen I

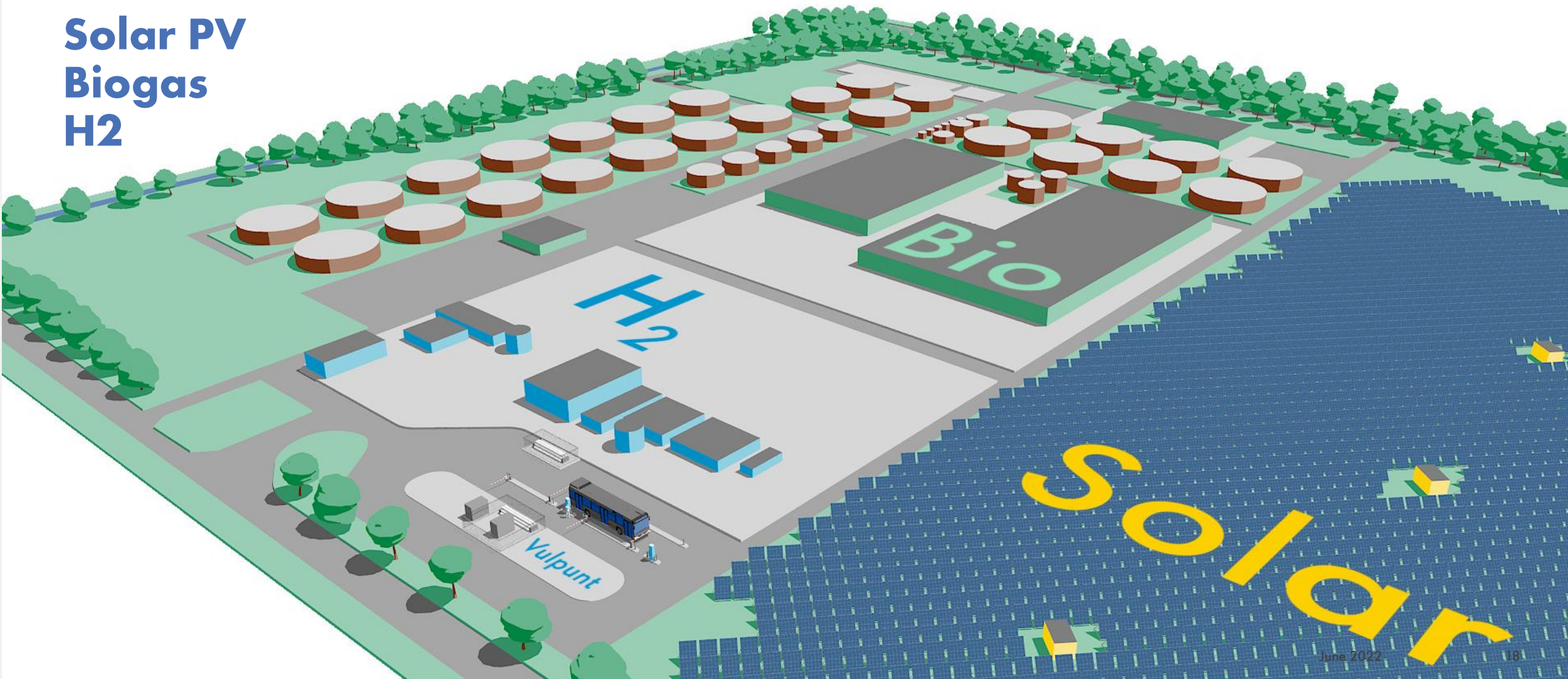
First scale-up of green hydrogen in an integrated value chain



RESTRICTED



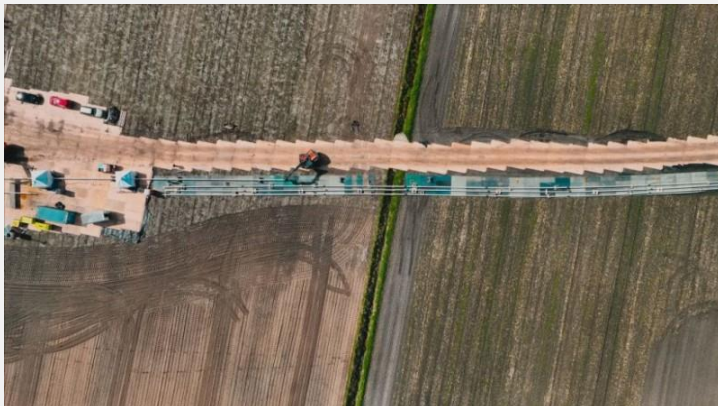
Solar PV  
Biogas  
H<sub>2</sub>



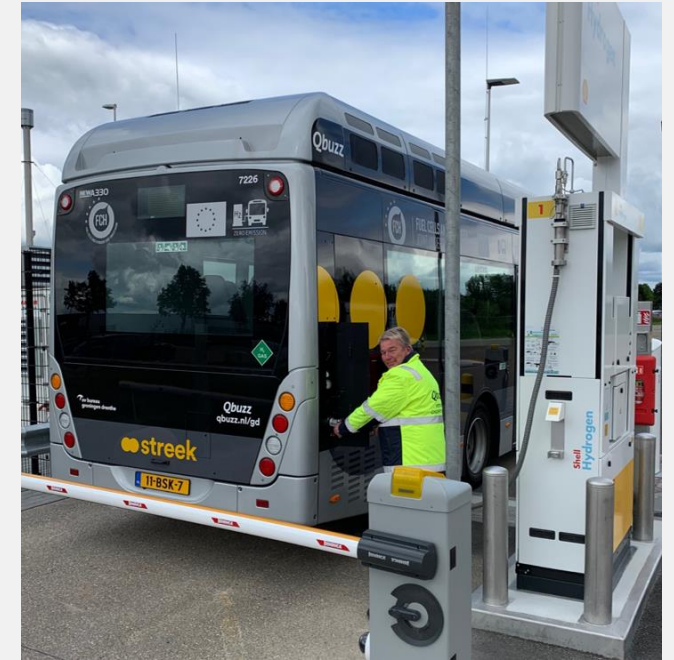


# H2 PROJECTS

- Emmen Hydrogen Refuelling Station: operational since 6/22
  - First public heavy-duty HRS for Shell in NL
- Hydrogen pipeline to industry
  - First part of planned nationwide hydrogen backbone in NL



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# RefHyne I

## Building a 10MW PEM electrolyser

- Shell has opened a 10-megawatt PEM (polymer electrolyte membrane) electrolyser, the largest of its kind, to produce hydrogen at the Rhineland refinery in Germany.
- Now investigating the possibility of scaling up to 100MW (working with ITM Power)
- This project is supported by the European Union.





# Hydrogen for transport in Germany – up and running

- Foundation of Joint Venture company in Jan 2015
- Network comprised ~100 hydrogen refuelling stations by the end of 2021
- Example of industry partnership sharing risks across the value chain, supported by Government

## Founding Partners

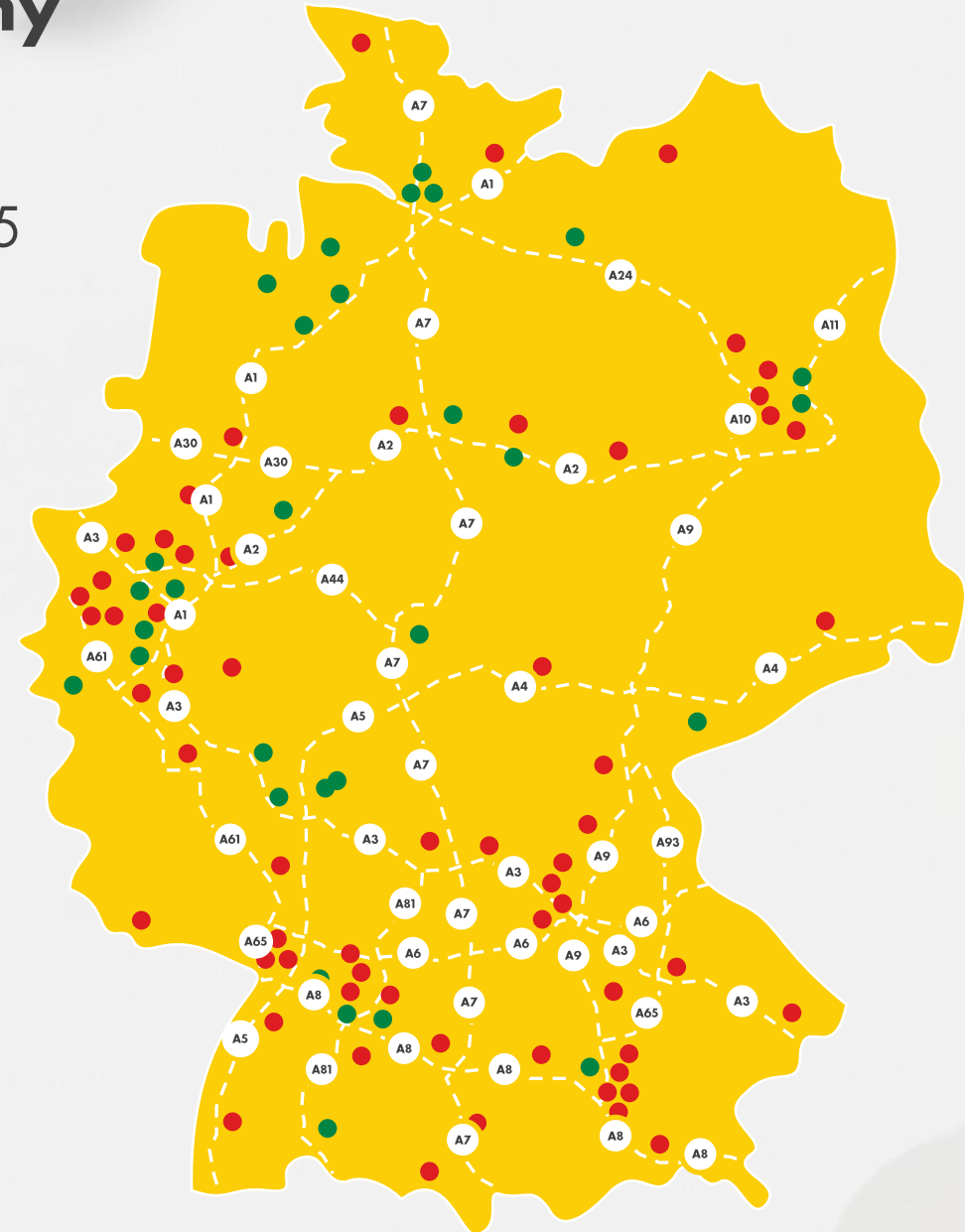


DAIMLER



### Key

- Shell Hydrogen filling stations
- Other Hydrogen filling stations



# Shell Hydrogen fuelling stations in the Netherlands

## ■ Groningen Bus refueller



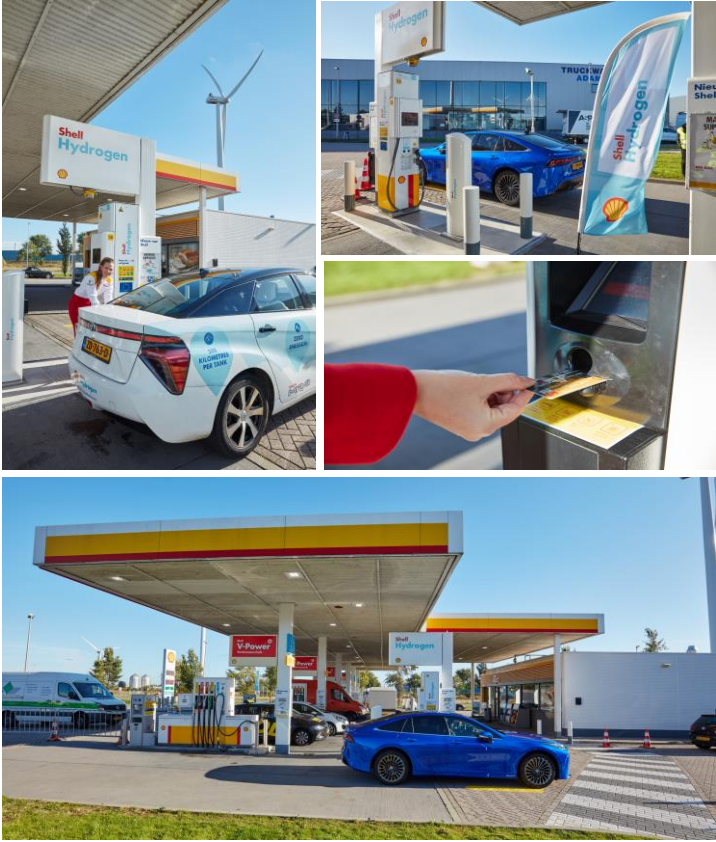
## ■ Ruygenhoek



## ■ Emmen



## ■ Westpoort Amsterdam





# Shell Hydrogen has come a long way ...



### Heavy Duty Transport - **H<sub>2</sub>Accelerate** - 2020

- Collaboration of truck manufacturers and energy companies working to advance funding and policy landscape for hydrogen trucking
- Phase 1: Proof of concept: > 20 stations, 100s of trucks
- Phase 2: European roll out: wide network coverage, 1,000's of trucks

### Founding Partners



# Hydrogen as an energy vector

## Proposed Gasunie H2 Backbone: distribution network linking key industrial clusters



