4-7 NOVEMBER 2024
ROTTERDAM, THE NETHERLANDS

GET2024

HYDROGEN & ENERGY STORAGE

CONFERENCE

UNDERGROUND HYDROGEN STORAGE IN THE NETHERLANDS – CHALLENGES & OPPORTUNITIES

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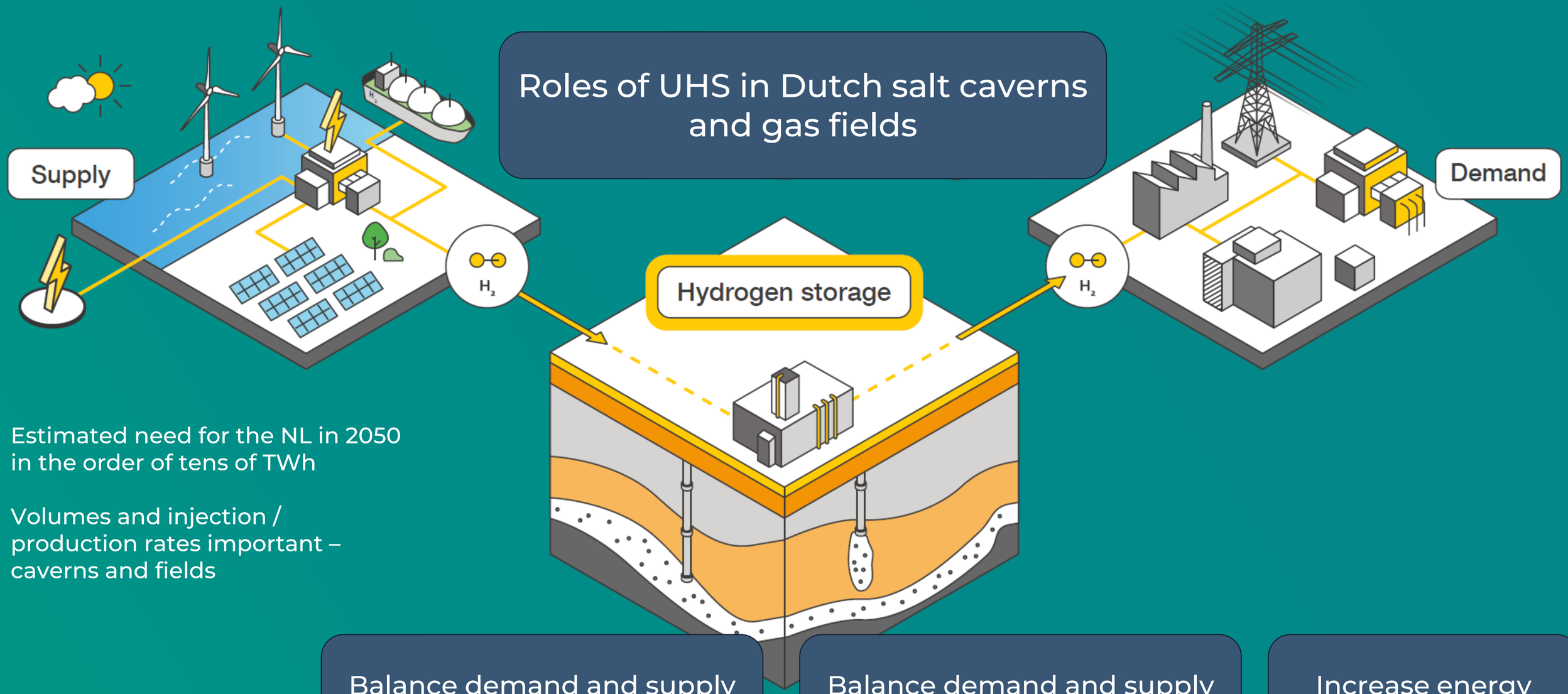
Michiel Damoiseaux, Marloes Kortekaas, Annemiek Asschert (all EBN)

Roles of UHS in Dutch salt caverns and gas fields



Estimated need for the NL in 2050 in the order of tens of TWh

Volumes and injection / production rates important – caverns and fields

Balance demand and supply of hydrogen

Balance demand and supply of sustainable energy

Increase energy independence

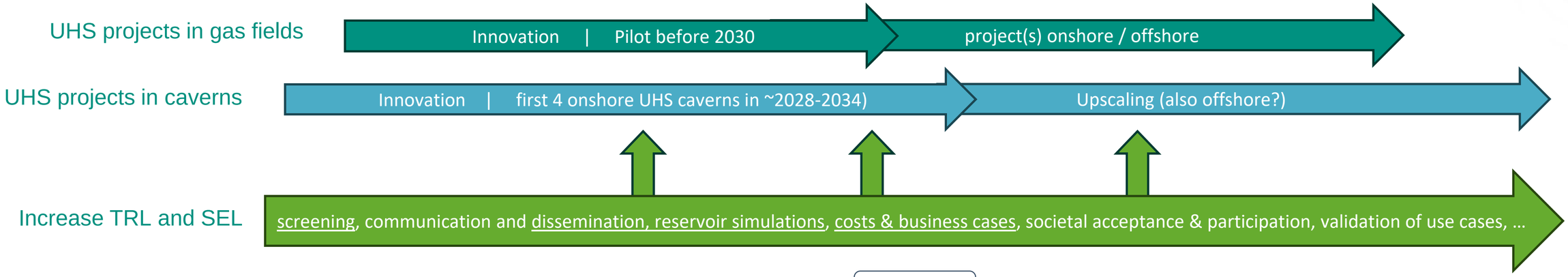
CHALLENGES AND OPPORTUNITIES

For UHS in Dutch salt caverns and gas fields

- Immature H2 market, high costs and long lead times - insufficient incentives to invest
- Uncertainties in UHS needs – volumes and capacities (through time)
- Low to medium TRL and SEL (pilot needed)
- Planning in space and time challenging
- Public acceptance not a given

- Dutch subsurface, infrastructure and seaports offer potential for national and international storage of H2
- Governmental support (NL, EU)
- Strong R&D, workforce and international network
- Tradition of corporation between public and private companies

pros and cons of the UHS options must be clear for timely development of (pilot) projects

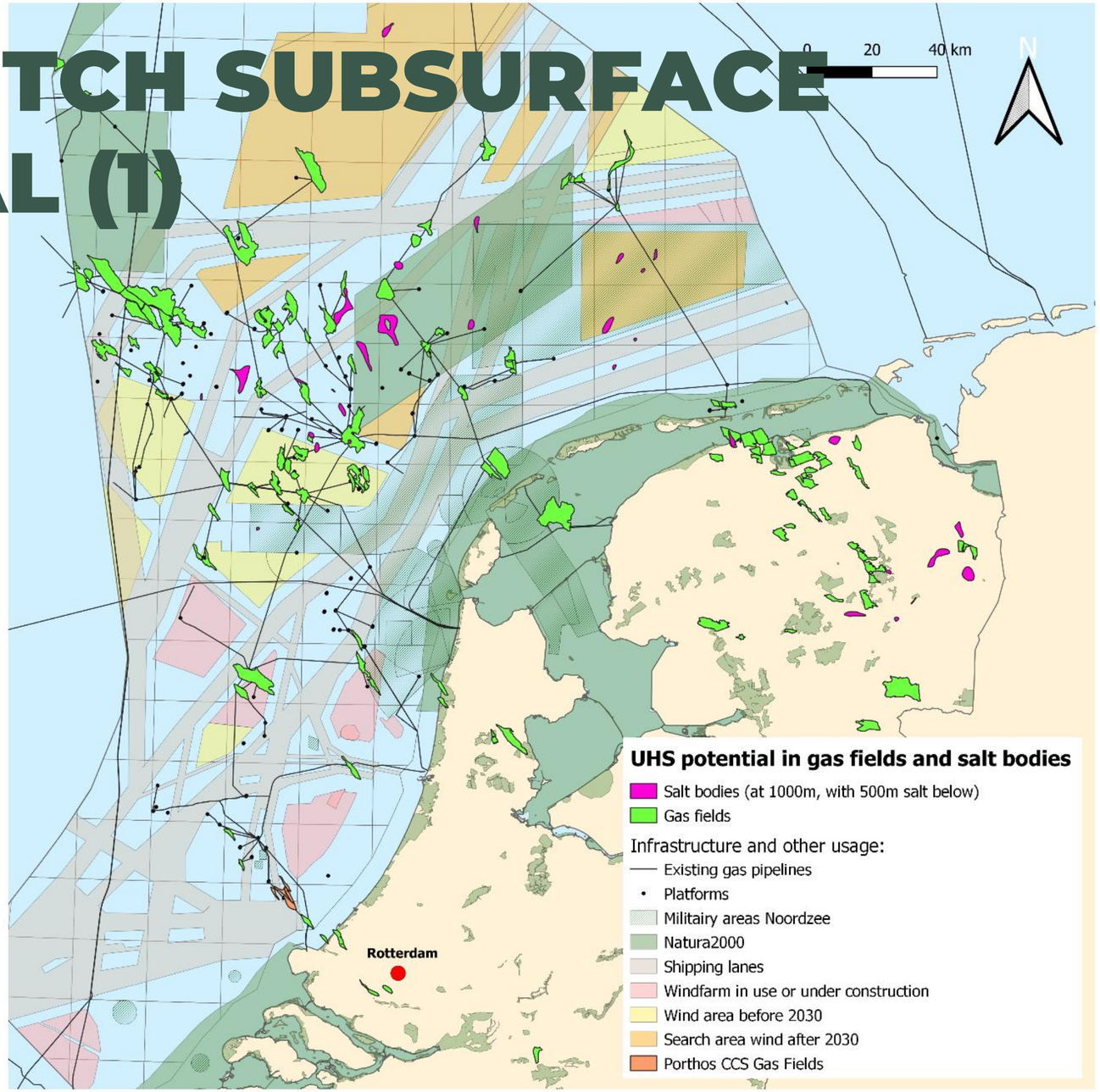


groen vermogen nl | Innovation engine for the green hydrogen economy

EU STARS H2

SCREENING THE DUTCH SUBSURFACE FOR UHS POTENTIAL (1)

- Dutch subsurface offers large potential for storing energy in new salt caverns and in existing gas fields and UGS, onshore and offshore – 750 TWh*
- Two-phase screening approach on multiple criteria:
  - High-level screening portfolio
  - Case-by-case analysis linked to future hydrogen valleys / use cases onshore and offshore and linked with advising of government



Salt body contours are based on TNO DGMv5. Gas fields based on selection in TNO-EBN (2022)

* TNO/EBN (2019, 2021,2022)

SCREENING THE DUTCH SUBSURFACE FOR UHS POTENTIAL (2)

- High-level screening Dutch gas field portfolio
- 300/567 fields do not pass criteria below
- Many opportunities, pilot needed soon

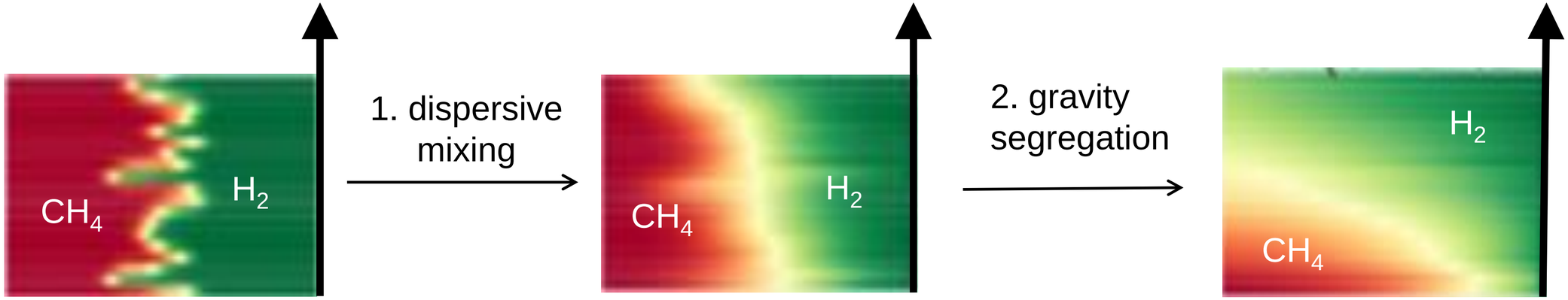
5 – Very suitable, no identified risks/unknowns
4 – Probably suitable, few identified risks/unknowns
3 – Possibly suitable, but identified risks/unknowns
2 – Probably not suitable, many identified risks/unknowns
1 – Not suitable, too many identified risks/unknowns

Screening parameter	Unit	Why? Risk?	1	2	3	4	5
Fluid type		Leakage through seal		Oil			
Development phase		Leakage and accessibility through wells			Stranded, abandoned		
GIIP volume	bcm	Costs and functionality		>15	>7.5		
Temperature	°C	Microbial			<70		
Seismicity		Earthquakes		measured in field contour, 5km contour Groningen			
Stratigraphy		Leakage through seal/permeability risk		Chalk group, Upper North Sea group			
Age of wells	year	Leakage through legacy wells		Start production <1981			
High value of nature		High value of nature		Waddenzee			
More to come …							

SIMULATING RESERVOIR PERFORMANCE (1)

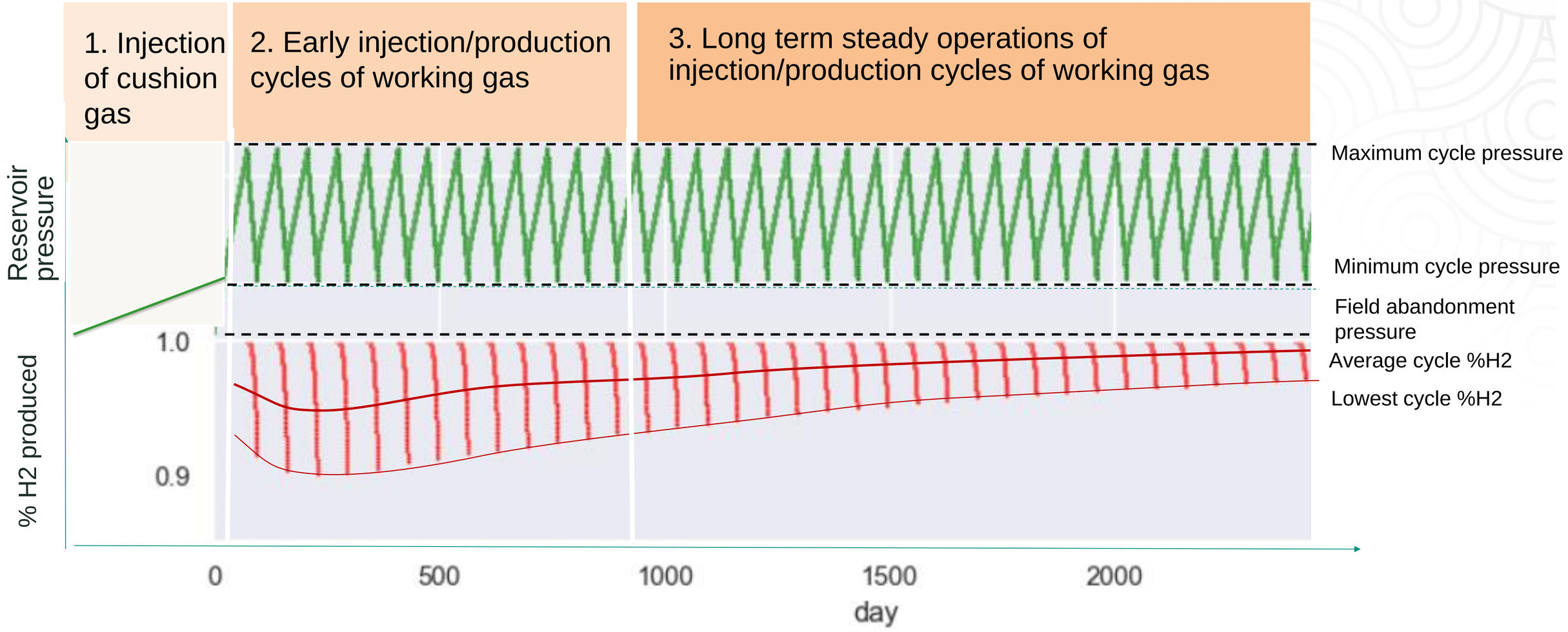
Field potential determined by reservoir performance (rates and purity)

- Dynamic box modelling of a UHS with mixing, for representative reservoirs and operational setups
- Behavior of methane – hydrogen interface impacted by reservoir parameters (permeability, heterogeneity, reservoir dip, well position and completion)
  - more heterogeneity & faster cycling means faster mixing of methane and hydrogen
  - on longer timescales gravity segregation provides an opportunity to keep methane and hydrogen separate (horizontal wells?)



Reijnen-Mooij et al. 2024, SPE-220013

SIMULATING RESERVOIR PERFORMANCE (2)



UHS COST ESTIMATES & BUSINESS CASES

- Generic parametric cost model for UHS systems (caverns and gas fields)
- Facilitate analyses and decision making on (pilot) projects, yield insights on cost drivers and impact of design choice

Design Requirements

- ☐ Injection rate
- ☐ Production rate
- ☐ H2 purity (input/output)
- ☐ Reservoir specifications
- ☐ H2 color
- ☐ Etc…

→

Technical Plant Design

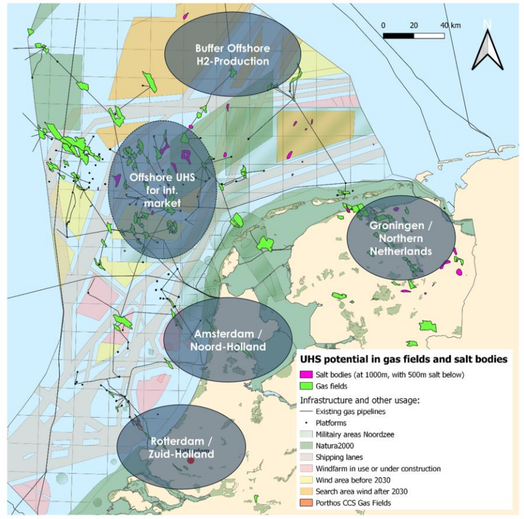
- ☐ # of wells
- ☐ Compressor specs
- ☐ PSA specs
- ☐ Etc…

→

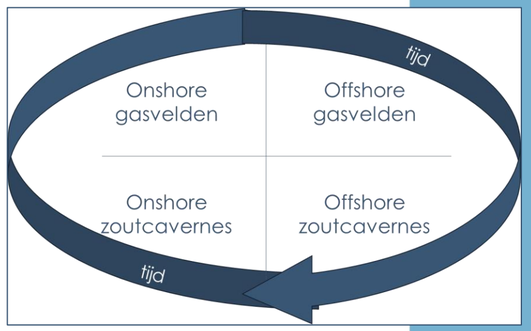
Cost Estimation

- ☐ Cost of individual scope items
- ☐ Total cost
- ☐ Upper/lower bound
- ☐ Etc…

- Next:
  - Business case model for use cases with raw (uncertain) inputs.
  - Get insights in feasibility and comparison between use cases, LCOHS, parameters for commercial projects, sensitivities.

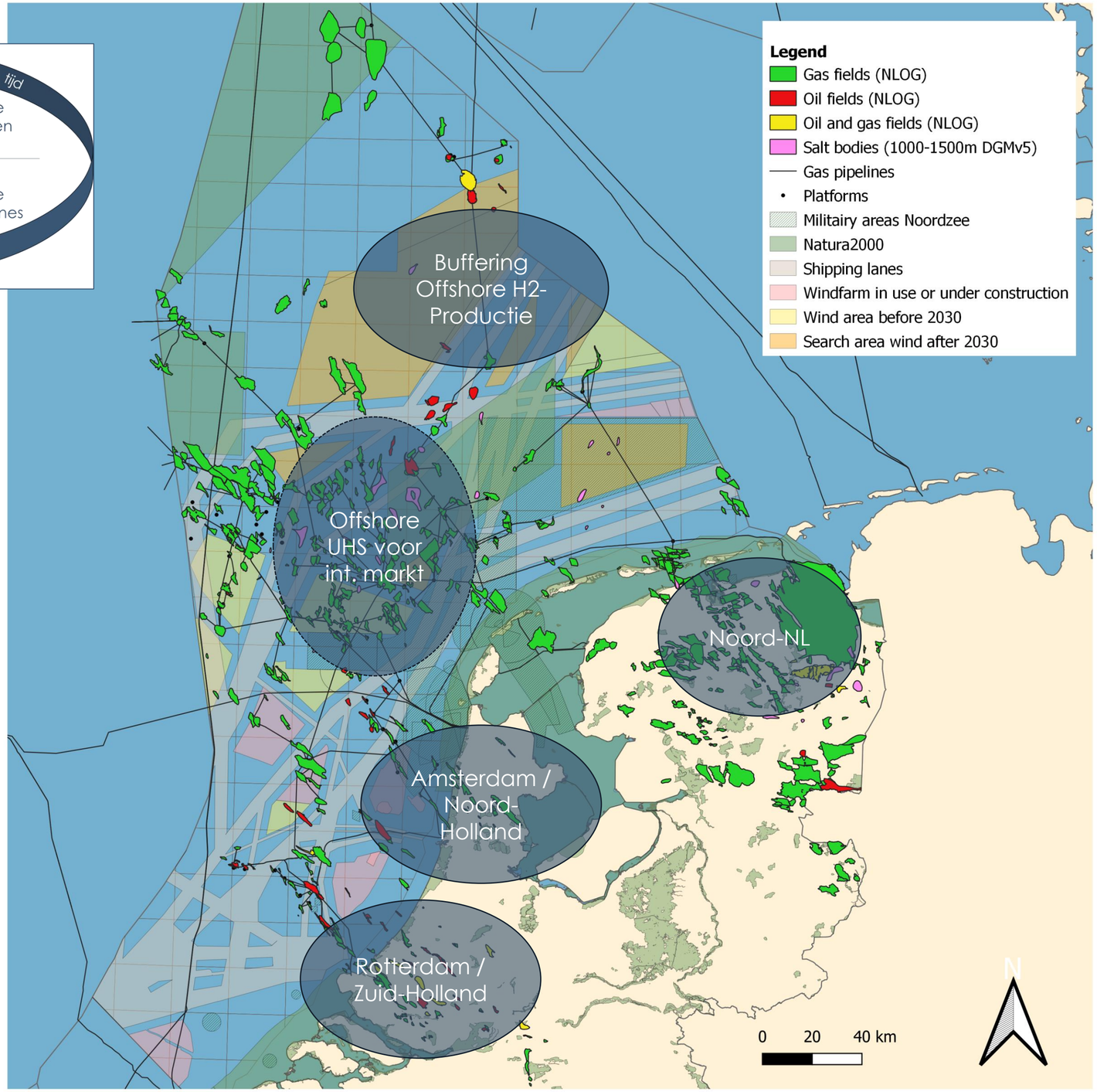


UHS Clusters (Use Cases)



1. bufferen van import/productie en doorvoer/gebruik van waterstof in regio Rotterdam
- bufferen van import/productie en doorvoer/gebruik van waterstof in regio Amsterdam (i.r.t huidige UGS).

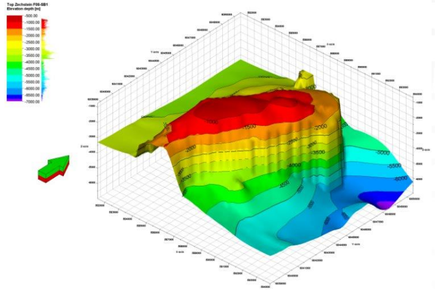
1. balanceren offshore waterstofproductie en –transport met cavernes en velden.
2. bufferen van import/productie en doorvoer/gebruik van waterstof in regio Noord-Nederland ook (i.r.t huidige UGS)
3. UHS in offshore gasvelden en/of cavernes voor internationale waterstofmarkt

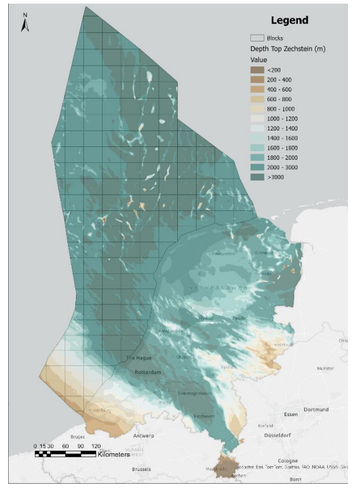


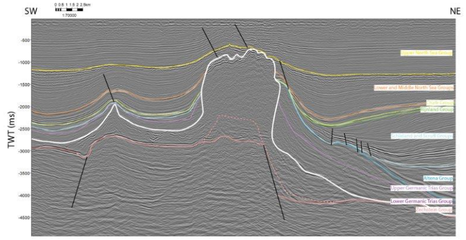
GEODE ATLAS

Atlas of subsurface resources in the Netherlands

- Joint project of EBN B.V. and TNO to create an atlas of subsurface resources in the Netherlands.
- Easily accessible, free, web-based GIS environment where play-based exploration data is presented for the main hydrocarbon plays in the Netherlands and for saline aquifer CCS in the Dutch offshore.
- Online since November 2021, yearly updates and additions.
- **Zechstein salt maps and factsheets for UHS will be added in November***







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www.geodeatlas.nl

SUMMARY & CONCLUSIONS

- UHS will play key role in the Netherlands with multiple functions
- There are challenges for timely development of UHS
- There are opportunities for UHS in the Netherlands
- Pros and cons of the options for UHS must be clear for timely development of (pilot) projects, requiring
  - *Focused studies and pilot(s)*
  - *Government support*

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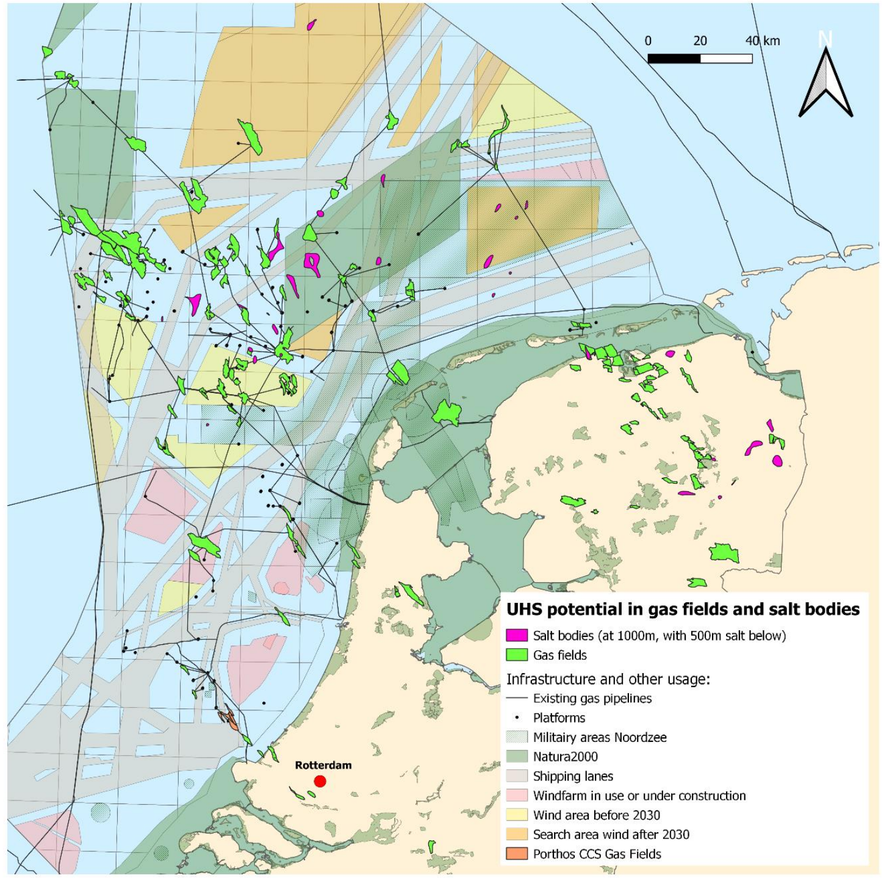
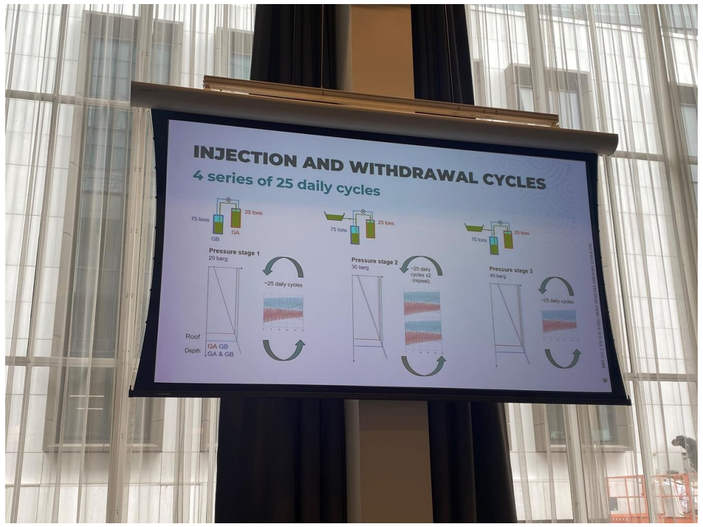


Salt body contours are based on TNO DGMv5.
Gas fields based on selection in TNO-EBN (2022).

Feedback GET conference Rotterdam 5-7 Nov ‘24

Many talks and conversations on UHS (pilot) projects in caverns and gasfields

- Use cases for UHS very similar or the same across the world
  - Storing hydrogen from excess electricity, produce back and use to generate electricity when demand peaks (Australia, Germany, Spain, UK (Austria and Hungary not presented))
- Most projects involve public companies and/or public money
- Many similarities in approach for UHS in gas fields
  - National scale screening of fields
  - (Lab) research and simulations of reservoir performance, microbial and chemical effects, containment, etc..
  - Pilot to de-risk and optimize large scale project(s)
- Societal acceptance key factor
- Government pull & push key
- Insights in the design of pilots



- Also very relevant: upcoming *TCP-42 UHS Confidence Level Report* (edited by TNO)

REFERENCES

All publicly available

- Damoiseaux et al, [2024] - *Screen for techno-economic and cost modelling of UHS. Presented at 3rd International Summer School on UHS, Edinburgh, 2024.*
- GEODE Atlas (EBN/TNO) – www.geodeatlas.nl
- Reijnen-Mooij et al. [2024] - *A Study of Underground Hydrogen Storage in 2D Box Models With Properties Comparable to Typical Depleted Gas Fields in the Netherlands (SPE-220013-MS)*
- TNO/EBN report [2019] - *Ondergrondse Opslag in NL: Technische Verkenning*
- TNO/EBN report [2021] - *Ondergrondse Energieopslag in NL 2030-2050; Technische evaluatie* vraag en aanbod
- TNO/EBN report [2022] - *Haalbaarheidsstudie Offshore Ondergrondse Waterstofopslag*
- Van Klaveren [2024] – internal EBN work