

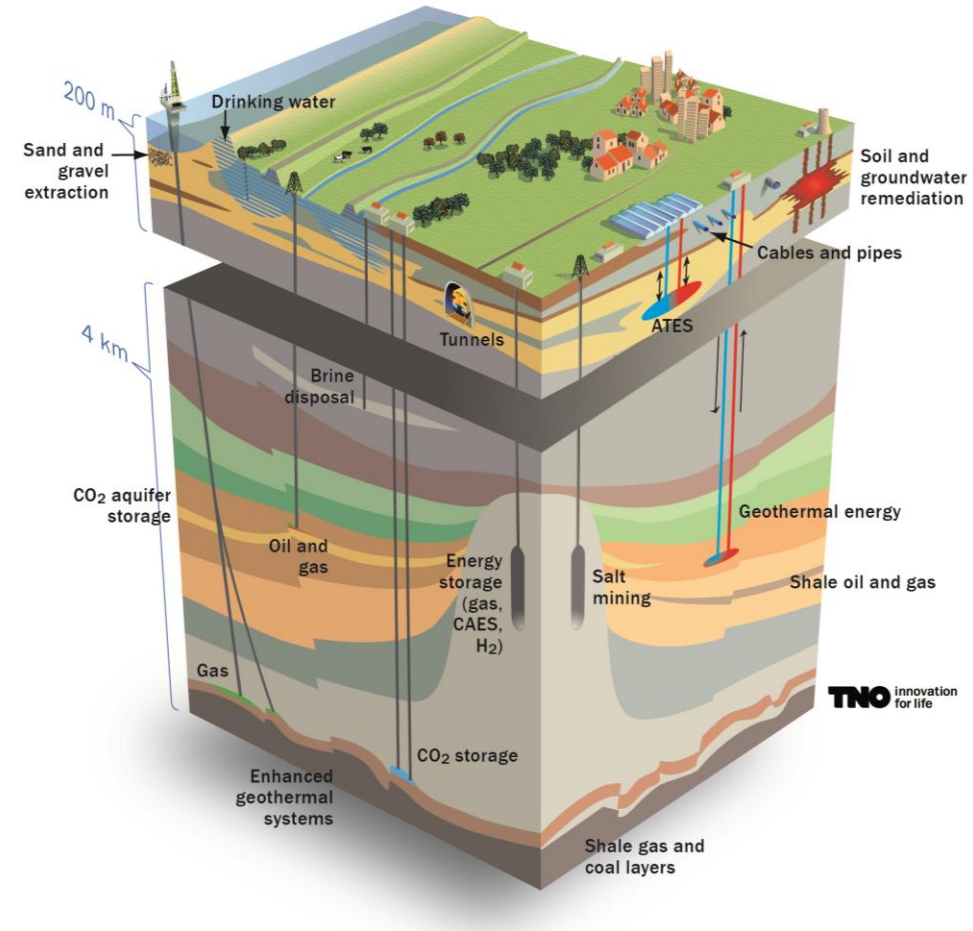


▶ **CCS R&D AT TNO**
SUZANNE HURTER AND FILIP NEELE
20 MARCH 2024, CATO

TNO GEOSCIENCE AND TECHNOLOGY (GST): OPTIMAL USE OF THE SUBSURFACE

TNO has been conducting R&D in CCS for over 30 years.
The Geoscience and Technology group (GST) is part of the Energy and Materials Transition Unit

- ❖ TNO track record in CCS
- ❖ Situation in Europe
- ❖ Challenge for The Netherlands
- ❖ Summary of current storage related projects
- ❖ Outlook into future R&D



Universiteit Utrecht



CO₂ TRANSPORT AND STORAGE

CURRENT PROJECTS: PCI/PMI CANDIDATES

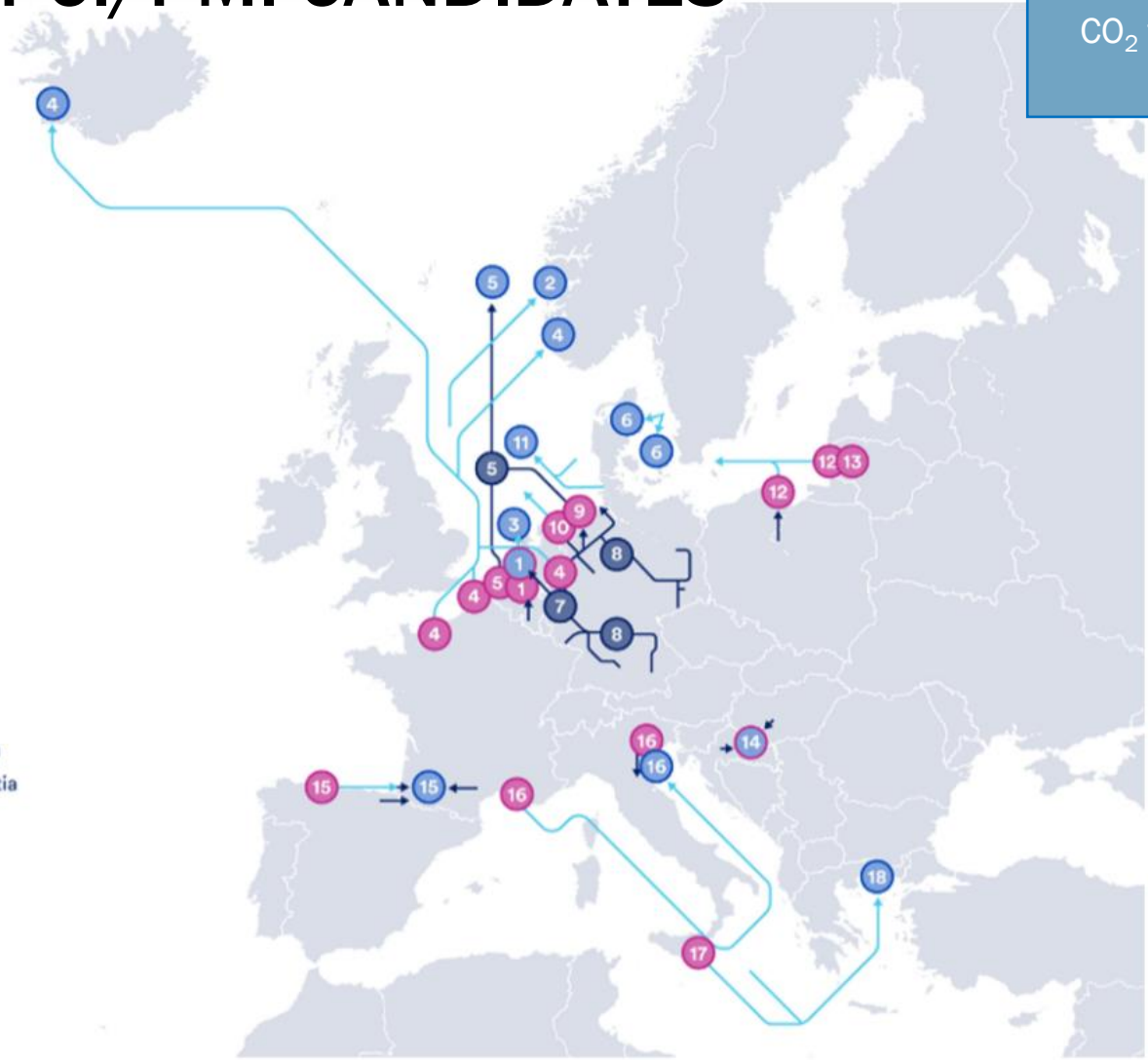
PCI: Project of Common Interest
 PMI: Project of Mutual Interest

Projects with PCI and PMI status can access EU funding to develop CO₂ transport and/or storage infrastructure

Carbon Capture, Removal, Transport and Storage in Europe

- Emitter Hub and/or CO₂ Export Terminal
- Pipeline Project
- Geological CO₂ Storage and/or Import Terminal
- Co-Located Emitters and Storage
- Ship Transport of CO₂
- Pipeline Transport of CO₂

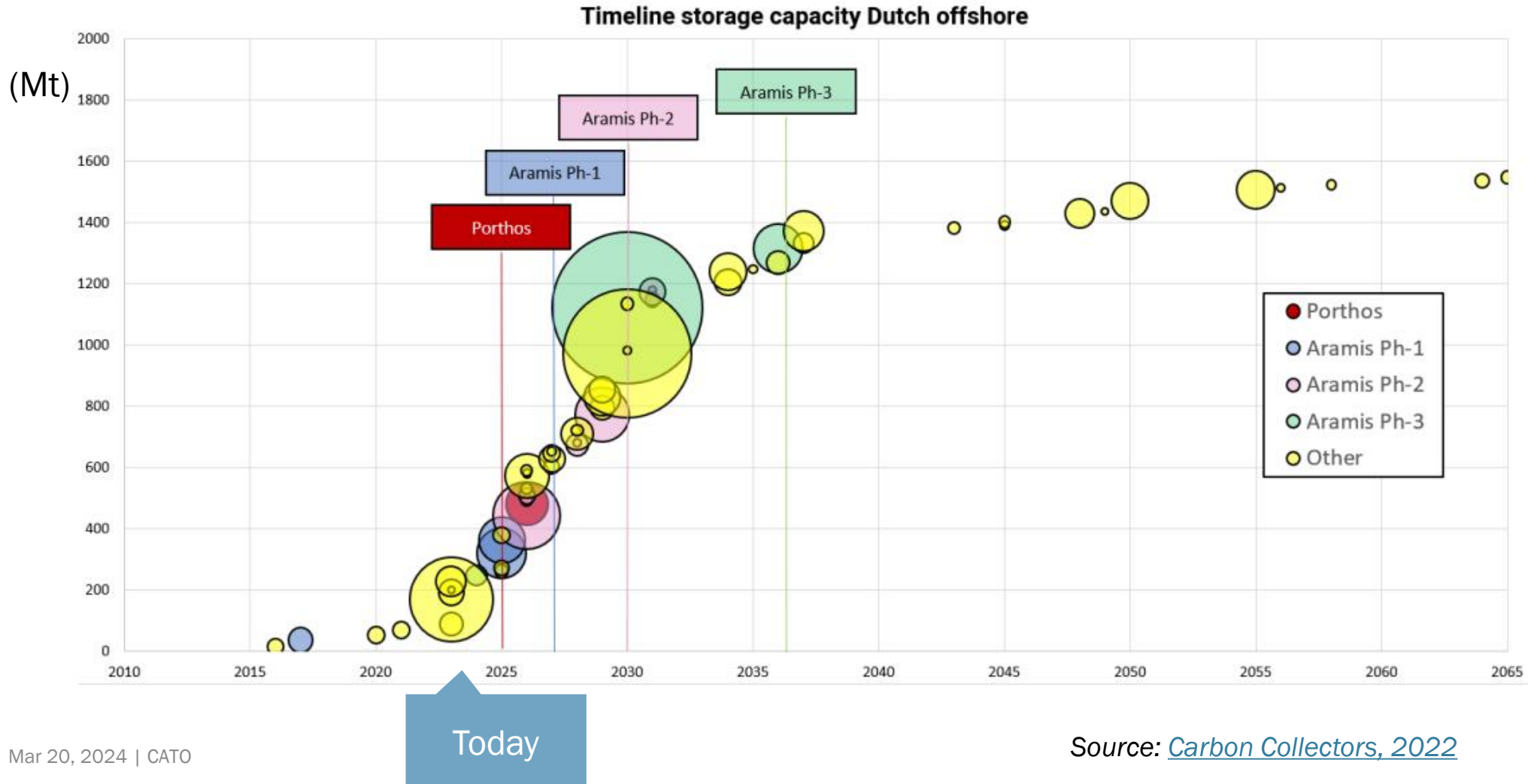
- | | |
|---------------------------------|------------------------------------|
| 1. CO ₂ TransPorts | 10. Noordkaap |
| 2. N-LITES | 11. Bifrost |
| 3. Aramis | 12. ECO ₂ CEE |
| 4. Nautilus | 13. CCS Baltic Consortium |
| 5. EU2NSEA | 14. Geothermal CCS Croatia |
| 6. Norne | 15. Pycasso |
| 7. Delta Rhyne Corridor | 16. Callisto |
| 8. German Carbon Transport Grid | 17. Augusta C ₂ |
| 9. WH2V (eNG Hub phase 1) | 18. Prinos CO ₂ Storage |



- › Subsidy schemes in place to support policy; examples:
 - › National schemes: contract for difference
 - › EU: Connecting Europe Facility (CEF): provides (partial) funding for construction of transport and/or storage infrastructure
 - › EU: Innovation Fund (IF): funding for construction and operation of CCS projects

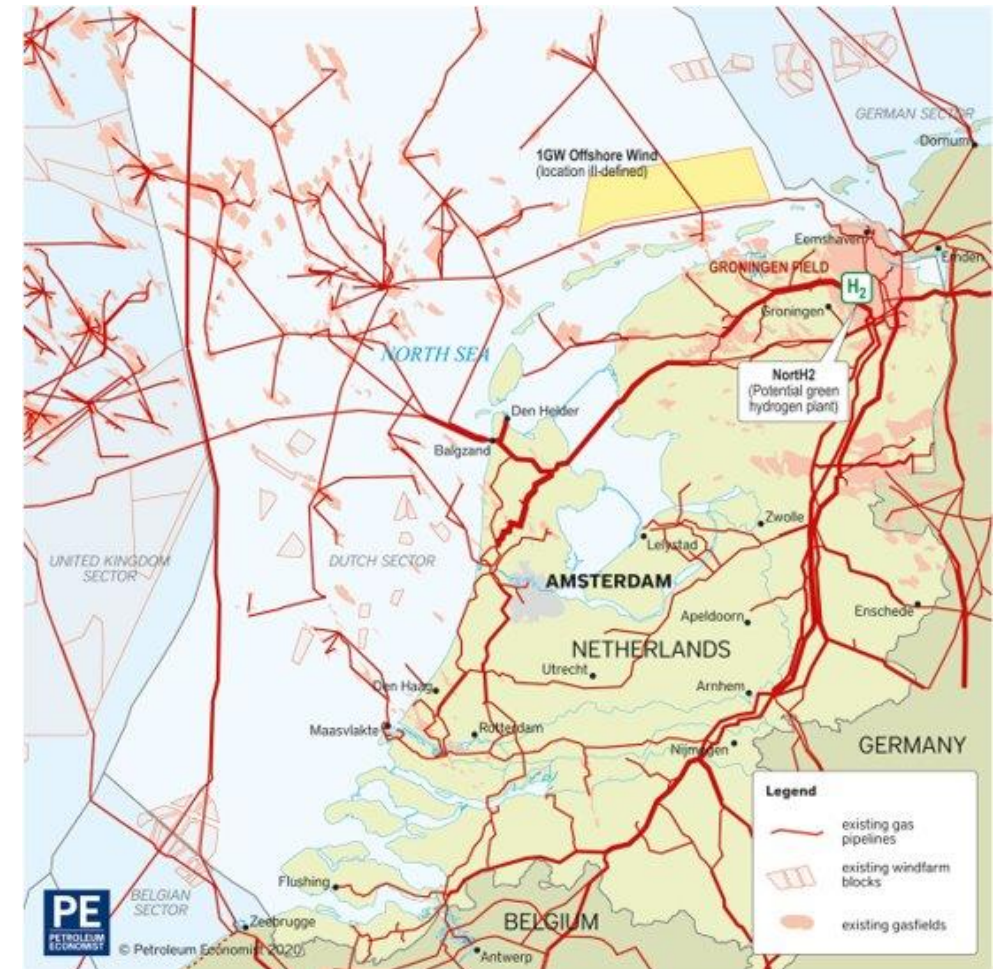
CO₂ STORAGE IN THE NETHERLANDS

STORAGE CAPACITY AVAILABLE IN DEPLETED FIELDS



› CO₂ STORAGE IN THE NETHERLANDS

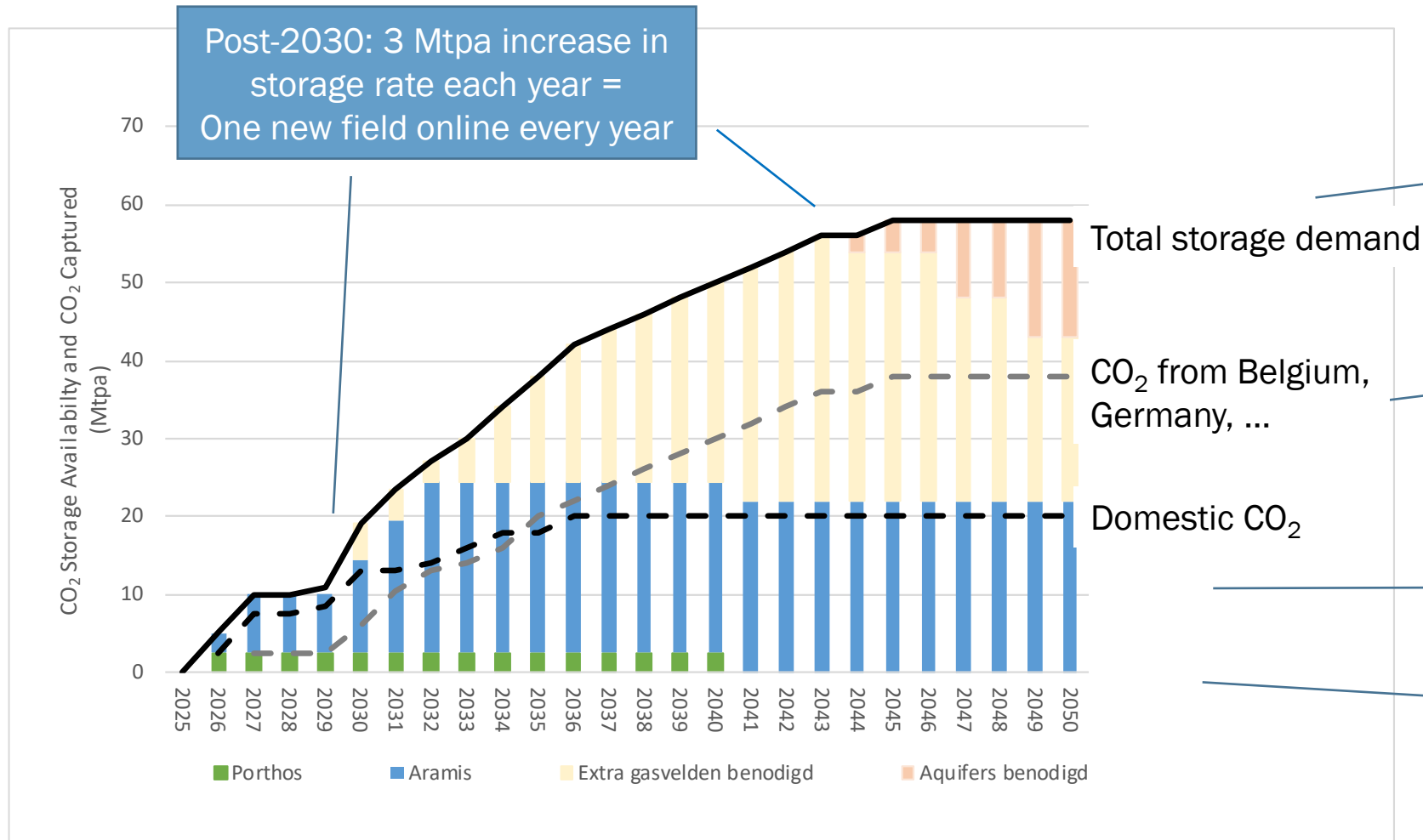
- › Several transport and storage projects in development
 - › First project now past FID and constructing – large scale, 2.5 Mtpa!
 - › Start first operations 2026
- › Several projects ongoing by 2030
 - › Storage rates close to 10 Mtpa
 - › Several suppliers, close to 10 wells
- › Significant task ahead, post 2030
 - › ~3 Mtpa increase in supply and storage rate, or
 - › 1 new depleted field online for storage each year
- › Industry and governments to develop best practices
 - › Speed up licensing
 - › Remove remaining issues and uncertainties



*Current gas network
Future CCS network complexity?*

CO₂ STORAGE IN THE NETHERLANDS

EXPECTED DEMAND FOR STORAGE CAPACITY



Orange: storage in aquifers (post 2040, need time to develop)

Yellow: 'additional' depleted fields developed for storage

Blue: Aramis (Shell, TotalEnergies, Neptune), 22 Mtpa

Green: Porthos (~40 Mt, 2026 - 2041, then full and closes)

Report on negative emissions (in Dutch)

› CURRENT CCS TOPICS AT TNO

Monitoring	<ul style="list-style-type: none"> - Design effective and efficient monitoring system - Define storage project performance - Define storage project conformance (i.e., agreement with expected behaviour) - Fibre optics, using telecom cables for monitoring - Low-cost seismic methods
Storage in aquifers Storage in depleted fields	<ul style="list-style-type: none"> - Find (offshore) aquifer structures for storage - Include aquifers in national roadmap for CCS - Develop effective and efficient injection scenarios - Find balance between risk and cost, compared to storage in depleted fields - Develop open-source reservoir simulators (OPM Flow) - CO₂ and H₂ storage
CCS network development	<ul style="list-style-type: none"> - Study how CCS networks evolve - Design and operation of (offshore) networks with depleted fields
Re-use of infrastructure	<ul style="list-style-type: none"> - Risks and cost of re-using wells - Well plugging methods
CO ₂ stream specifications	<ul style="list-style-type: none"> - Study impact CO₂ composition on cost of CCS
CO ₂ flow loop (under construction)	<ul style="list-style-type: none"> - Flexible and modular facility to investigate CO₂ behaviour for e.g. bends, valves, chokes, instruments , and porous media.

OUTLOOK INTO FUTURE R&D



Saline formation CO₂ storage

What is the storage capacity of NL offshore aquifers?
Maximum pressure estimation?
Will there be (and how to manage) interference?

Depleted hydrocarbon fields

How to evolve and manage networks and clusters?
How to integrate monitoring data in models (assimilation)?
How to evaluate conformance?
What are conditions for liability handover and after care?
How to decommission CCS projects?



› **THANK YOU FOR
YOUR TIME**

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TNO innovation
for life