November 21st, 2024

9th Dutch Exploration Day

Development of a Risk-based & Site-specific Monitoring Strategy for CCS

Gloria Thürschmid

Content

- Introduction to CCS
- Introduction to MMV
- Development of an MMV Strategy
- Summary & Conclusions

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Introduction to CC(U)S

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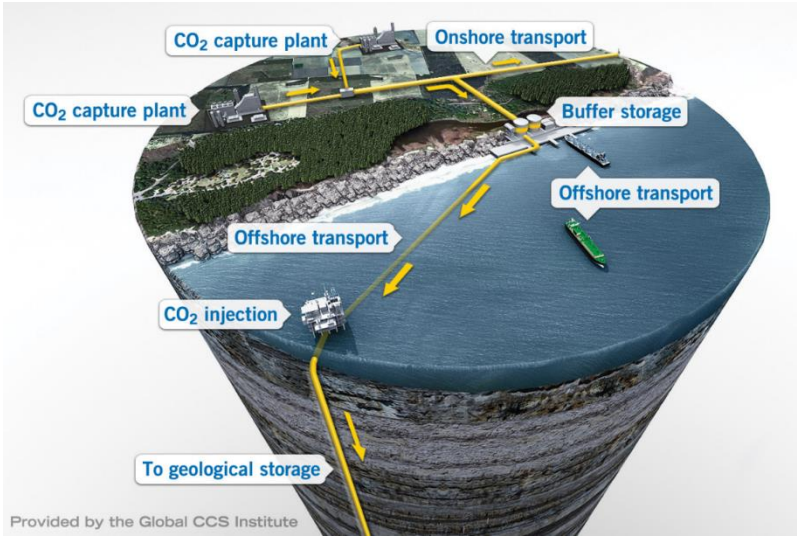
Carbon, Capture, Utilization & Storage is needed (faster)

- CCUS is recognized as an **essential technology** to reduce CO_2 emissions
  - ✓ **EU Green Deal**: Climate-neutral by 2050 (-55% by 2030*)
  - ✓ **Dutch Klimaatakkoord**: -49% by 2030, -95% by 2050

- **Acceleration & upscaling** is needed
  - ✓ **ICM**: Strategy to scale up the EU carbon management
  - ✓ **NZIA**: Regulatory framework to increase the competitiveness of the EU industry & technologies crucial for reducing CO_2 emissions
  - ✓ **CEN/TC474**: European standardization on CCUS



* compared to 1990 levels

CCS in The Netherlands

CCS in The Netherlands

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The Facts

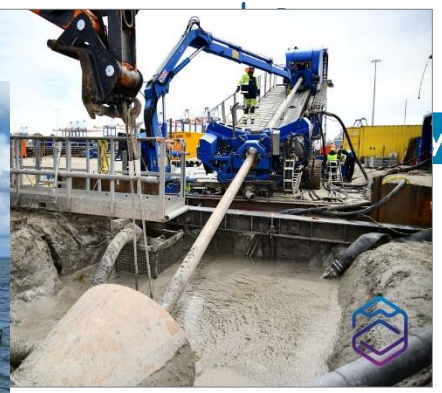
	Porthos	Aramis
Who?	Public-private partnership → Dutch state-owned parties in the lead: EBN, Gasunie, Port of Rotterdam	Public-private partnership → EBN, Gasunie, Shell, Total Energies
What?	Transportation and offshore storage project	Transportation project enabling offshore storage → Connected to Porthos onshore system & CO2next
Storage type?	Depleted gas fields	Depleted gas fields (from Shell, Total Energies, ENI)
Volumes and rates?	37 Mt (2,5 Mtpa)	ca. 400 Mt (7,5 to 22* Mtpa) *from 2030
FID?	taken in October 2023	expected 2025
Ready for Injection?	expected 2026	expected 2028/29

In the News

A selection from 2024

- **Porthos onshore construction started**
  - ➞ Drilling under seawall
  - ➞ Focus on onshore pipeline through harbor
  - ➞ Start construction of all onshore construction

- **Milestones achieved**
  - ➞ Members of the House of Representatives are visiting Porthos & Aramis
  - ➞ Celebration: Construction of the Porthos CO_2 network
  - ➞ Public consultation meetings of Aramis held



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What is MMV?

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Measurement – **M**onitoring – **V**erification



"The monitoring, measurement, and verification (MMV)
of injected CO_2 into the subsurface is essential
for **assuring conformance** to its expected behaviour
or **detecting irregularities** over **time**
so that leakage and environmental **impacts are avoided**"

DNV, 2024

“MMV Principles”

Complying with **regulations**

Risk-based

Site-specific & **Fit-for-purpose**

Flexible & adaptable

Based on **best practices**

→ CCS Directive & National Law

→ TECOP analysis

→ Monitoring goals & domains

→ Contingency & modifications

→ Screening for new technologies

Spatial aspects of MMV

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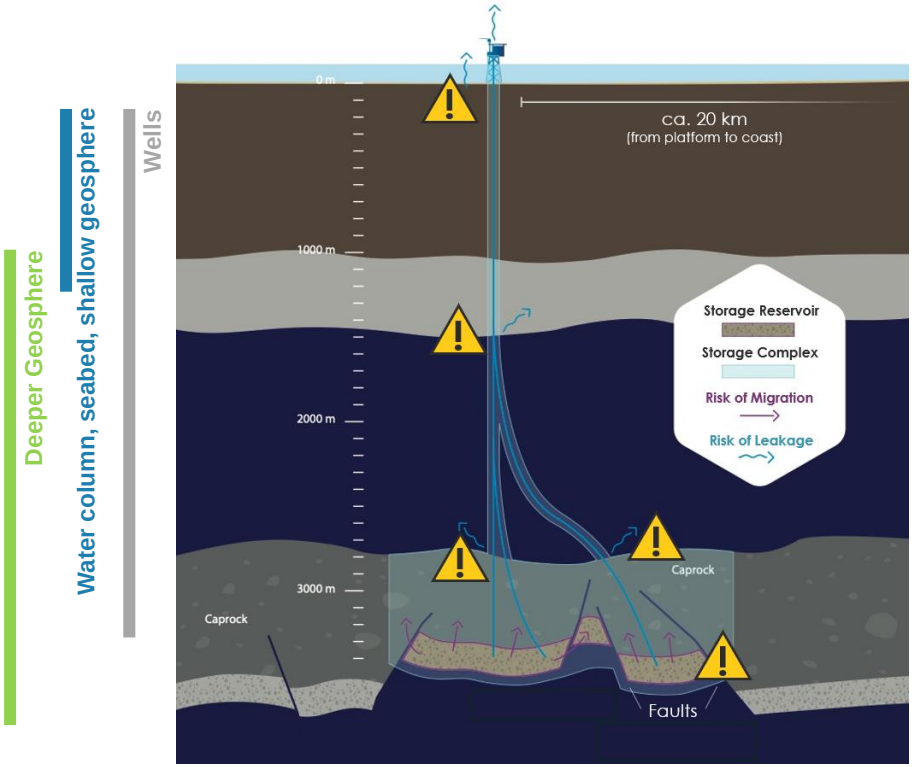
Monitoring domains

→ Identify weak spots!

Wells
- Legacy wells?
- Re-used injector wells?

Water column, seabed, shallow geosphere
- Gas bubbles?
- (Active) pockmarks?

Deeper geosphere
- Faults cross-cutting caprock?
- Reservoir-reservoir juxtaposition?
- Spill-points?
- Critically stressed faults?



Timely aspects of MMV

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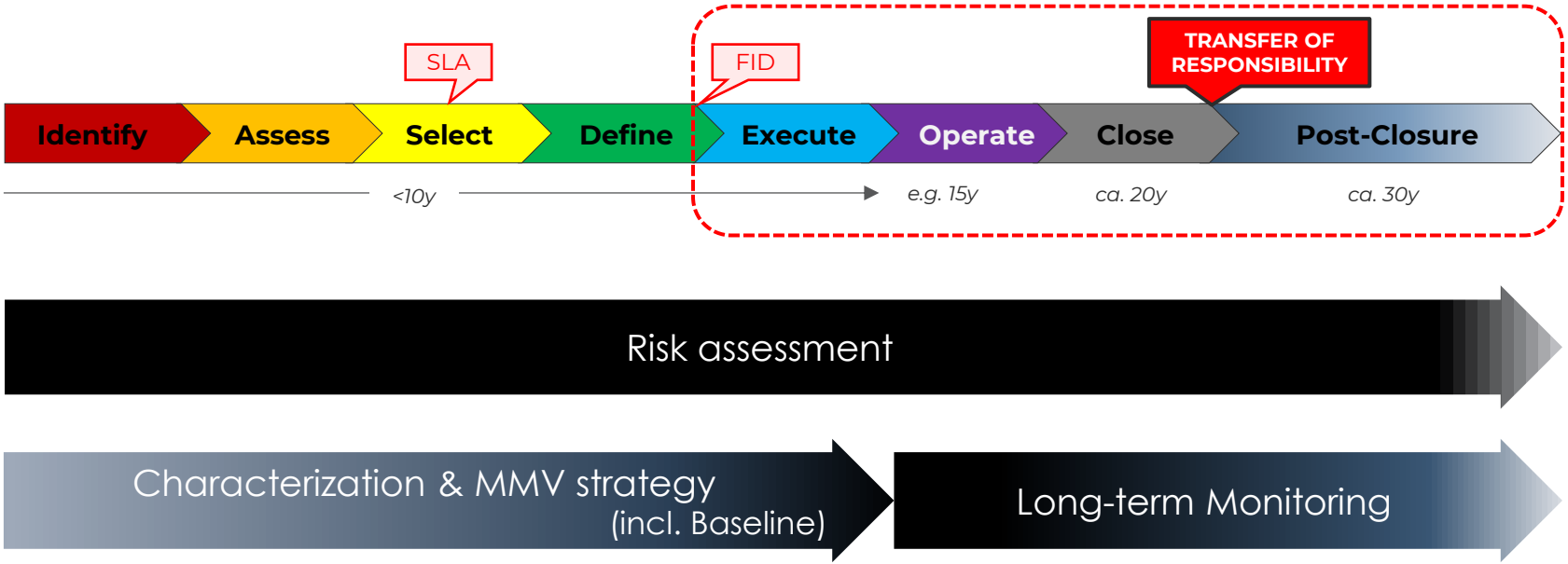
Long-term perspective & changing responsibilities



Timeline not to scale

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Approach to MMV plan development

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From DNV report for EZK (2024)

- Defining **objectives**, describing **context** & specifying monitoring **targets**
  → risk- and site-specific, fit-for-purpose, complying with regulatory requirements
  → measurable properties, variability, location & frequency of measurements, detection thresholds
- **Screening & selecting** monitoring techniques
  → in-depth assessments and final selections (feasibility, VOI, pre-warning?)
  → considerations: objectives, cost, quality/resolution, deployment/operability, maturity
- **Planning** monitoring activities (and corrective measures)
  → different requirements per project phase, but continuous risk management
  → spatial and temporal variability to be considered
- **Evaluating** completeness
  → review to ensure compliance and effectiveness
- **Updating** the plan
  → every 5 years at least

→ Search for **synergies** to increase cost-efficiency

Porthos CCS

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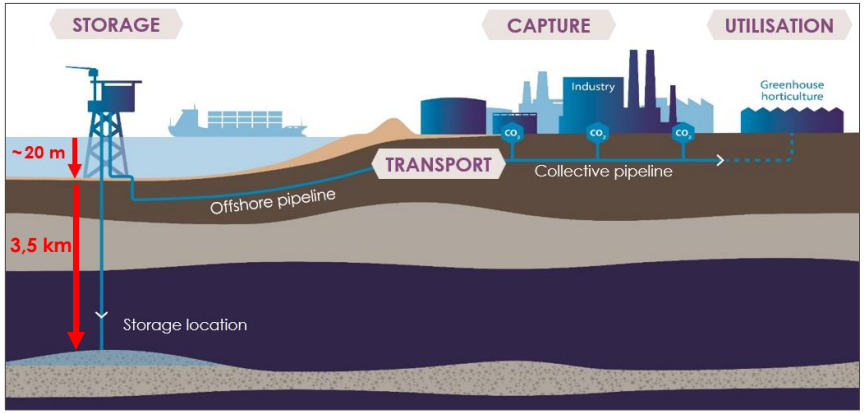
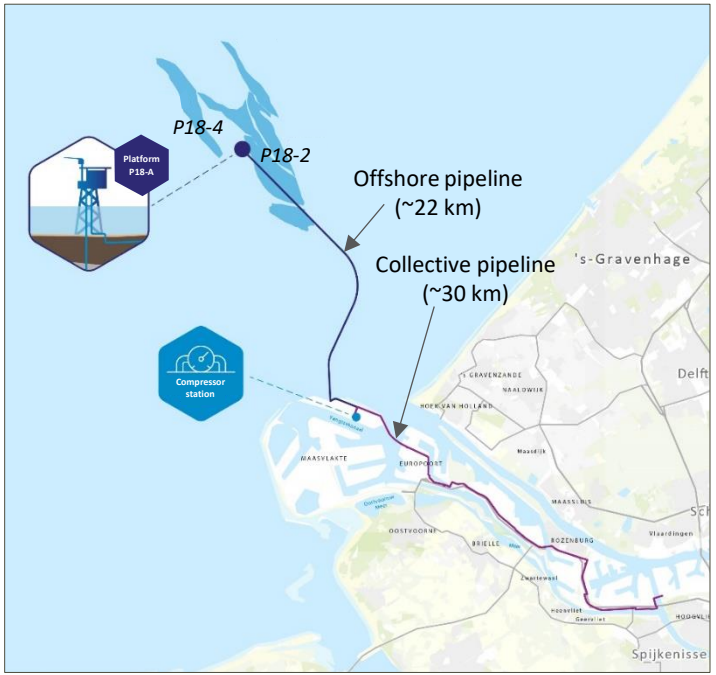
Port of Rotterdam CO_2 Transport Hub and Offshore Storage





Porthos CCS

Subsurface details

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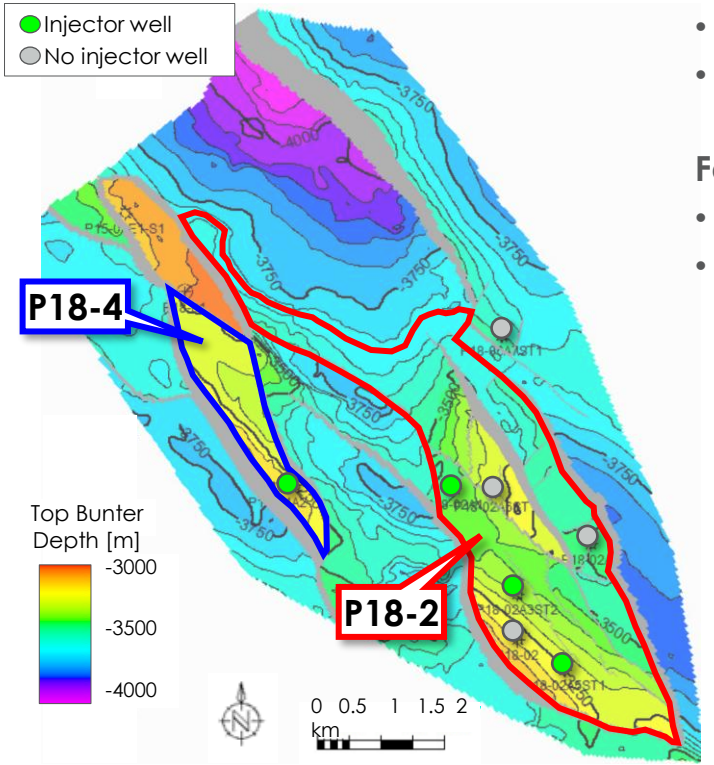


Field details

- Discovery in 1989
- RF =98% (p_{res} approx. 20 bar)

Fault bounded compartments

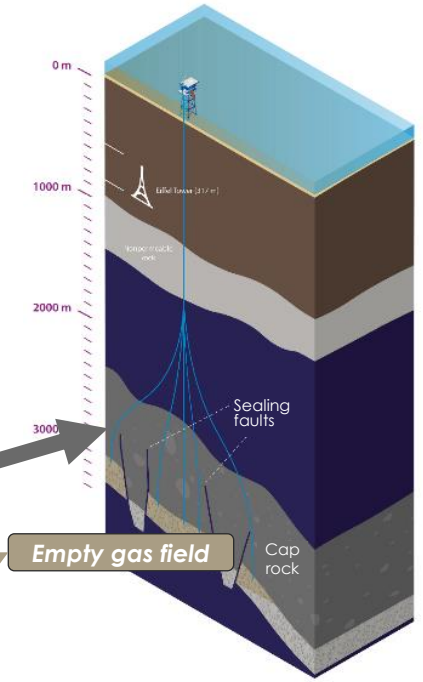
- P18-2 & P18-4
- hydraulically isolated

CAPROCK *[h~600m]*

→ ***Upper Germanic Trias Group***
→ ***Jurassic Altena Group***

RESERVOIR *[h~200m]*

→ ***Lower Germanic Trias Group (Main Buntsandstein Subgroup)***



Porthos CCS

From Concept to MMV Strategy

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- ✓ p/T sensors
- ✓ Fibre-optics (DAS/DTS)
- ✓ Integrity & Micro-annuli tests/logging

Wells

- ✓ Acoustic surveys (pockmark & bubble detection)
- ✓ Water benchmarking
- ✓ Sediment benchmarking
- • Shallow overburden survey*

Water column, seabed, shallow geosphere

- • Active seismic survey*
- • Passive seismic survey**

Deeper geosphere

**not included in MMV version 1.0*
***partly included in MMV version 1.0*

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Summary & Conclusions

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- ✓ **Large-scale CCS projects** are under development in NL (focus on **depleted fields**) with operations starting in 2026
- ✓ Monitoring should provide **confidence** in the **containment** and **conformance** of a CO_2 storage project
- ✓ The **Porthos** project is currently preparing the **final MMV plan**, reviewing new opportunities and feasibility
- ✓ Outcomes of the **research project DICTUM** could be suitable for **passive seismic monitoring** offshore (under development)

- ❖ **Proof of concept** & rapid **upscaling** will be key, including options for storage of CO_2 in deep saline aquifers
- ❖ MMV shall be **fit-for-purpose**, **risk-based**, and **cost-effective**, while ensuring the **long-term safety and security** of CO_2 storage
- ❖ **Continuous screening** of new developments and best practices contributes to increased flexibility and redundancy in MMV
- ❖ Enabling the **development of low(er) TRL** methods is essential to the whole sector and should be supported

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"There is an expectation that **first-of-a-kind (FOAK)** monitoring approaches **may be over-engineered** as the industry tests and certifies different MMV methods. This is crucial to maintaining public confidence, and each project will require a **robust set of baseline data**."

"There are **no one-size-fits-all solutions**. Monitoring activities must be tailored to the risk and uncertainties of specific storage sites."

From: NSTA (UK regulator)

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Any questions?