CO_2 transport and storage: projects

March 4 2025

Filip Neele

filip.neele@tno.nl

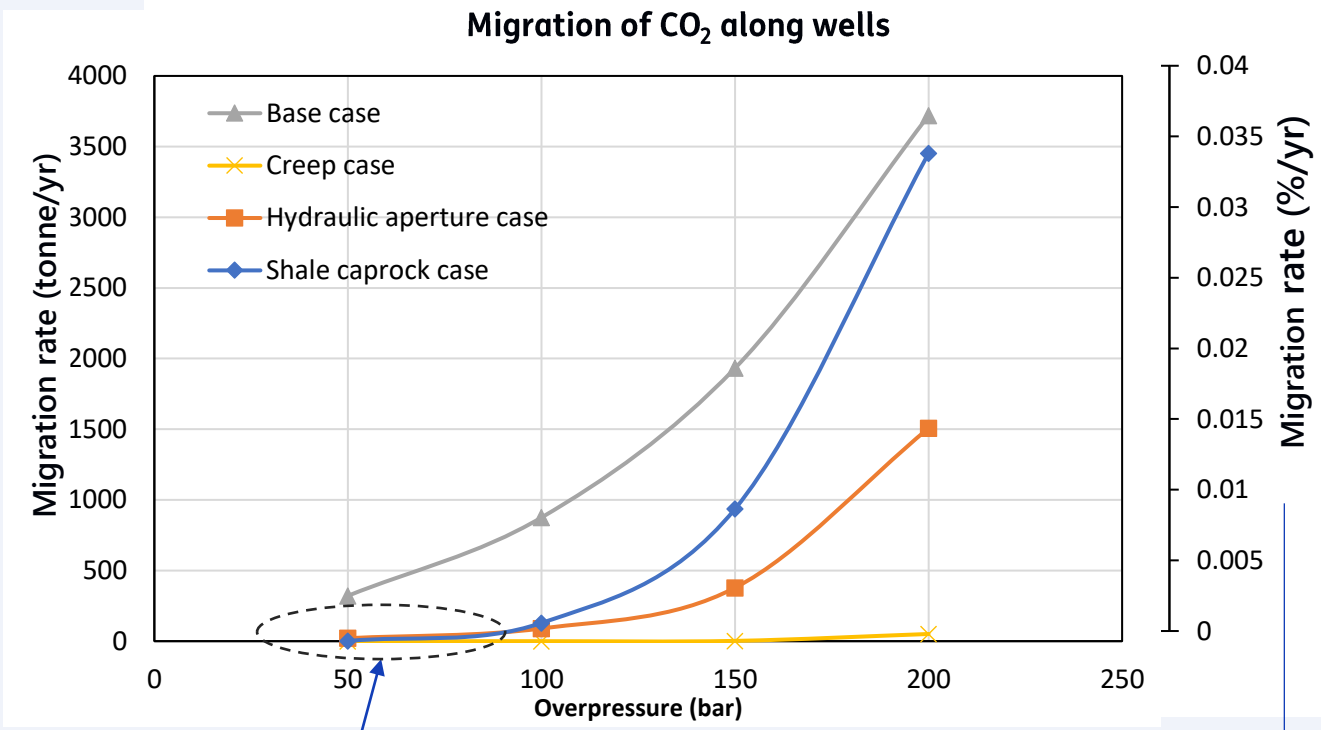
CO_2 transport and storage R&D @ TNO

- **Storage**
  - Near-well processes in reservoir (ERA-NET ACT Return) – calculator of migration along wells
  - Monitoring, conformance assessment (CETP Ramonco) – geological uncertainty, defining conformance
  - Aquifer storage (TKI New Gas) – providing the basis for aquifer storage NL offshore
  - Well integrity, leakage along wells (JIP Eloquence) – tool to estimate migration along wells
  - Well re-use (JIP Wiscos) – screening tool for well re-use
  - RCSG – ongoing testing of CCS facilities in Rijswijk lab
- **Transport**
  - Transport network simulation (ERA-NET ACT Action) – assessing transport & storage network performance
  - CO_2 flow loop (ENCASE, CO_2Time) – building and using the new CO_2 flow loop

Well-based and near-well processes in depleted fields

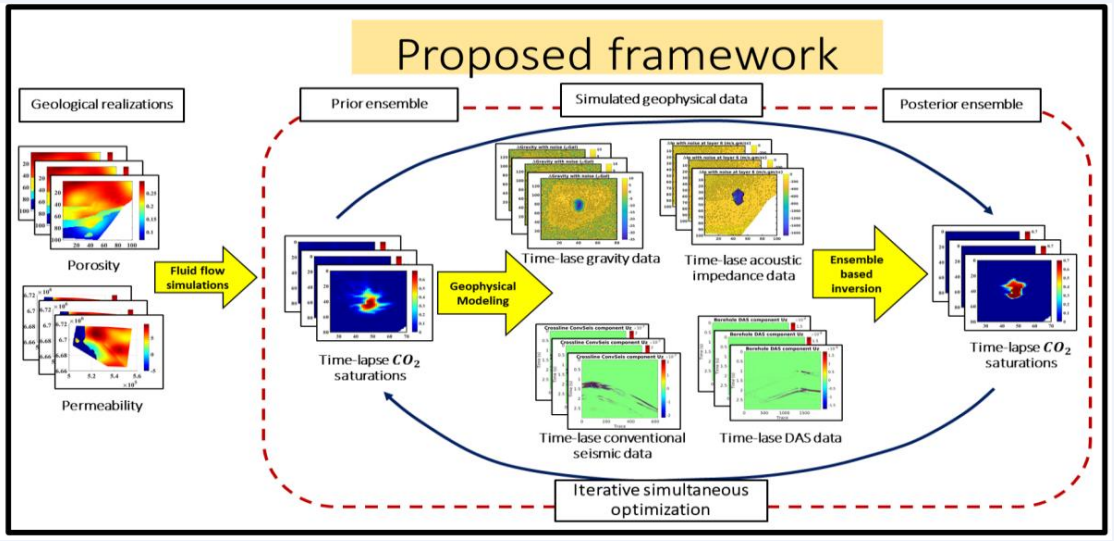
- **Project started Q2 2022, just finished**
- **Duration 3 years, lead: SINTEF (NO)**
- Goal: improve understanding and simulation capabilities of processes acting near injection wells in depleted fields
- Relevance: this knowledge and simulation capabilities will be needed when interpreting MMV data and assessing system conformance

See project website: return-act.eu

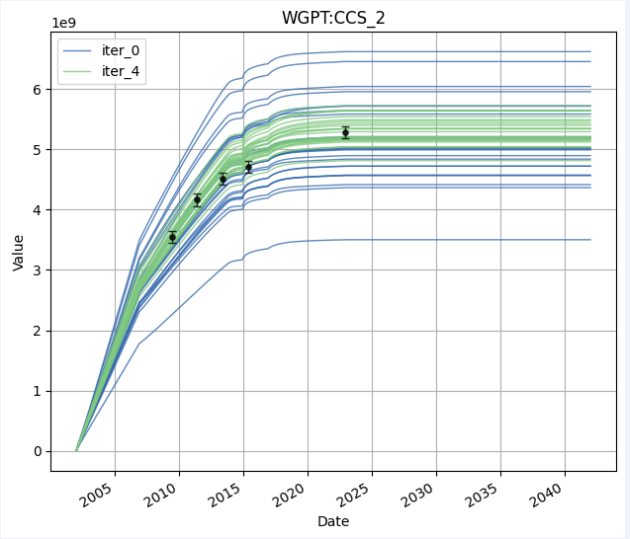


CETP Ramonco

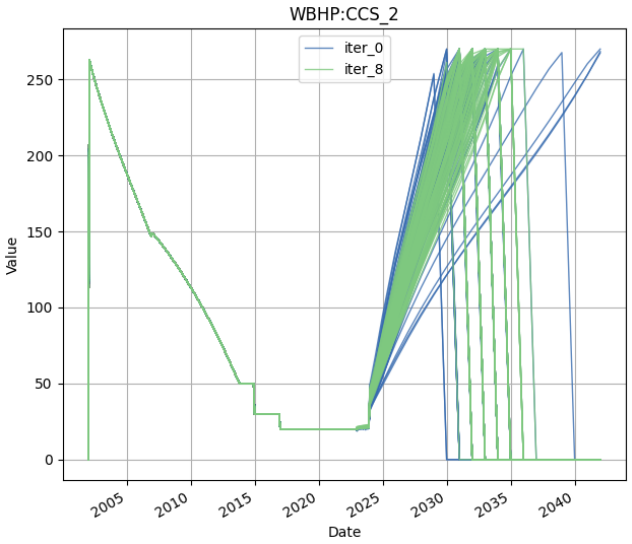
- **Conformance monitoring & assessment**
  - Ensemble based history matching
  - Quantitative conformance assessment
  - Monitoring system design
- **Joint inversion seismic and gravity data**
  - 3D images of CO_2 saturation in subsurface



2D workflow (from predecessor DIGIMON)



Curves: production and BHP from ensemble members
Blue: a priori production (top) and bhp curves
Green: HM with production data (black symbols)



Ramonco: understanding risks and risk perception along the CCS chain

Project objective:

- **Assessing risks to societal embeddedness that exist along the CCS technology chain (capture, transport, storage, monitoring)**
- **Addressing these risks with risk governance strategies**

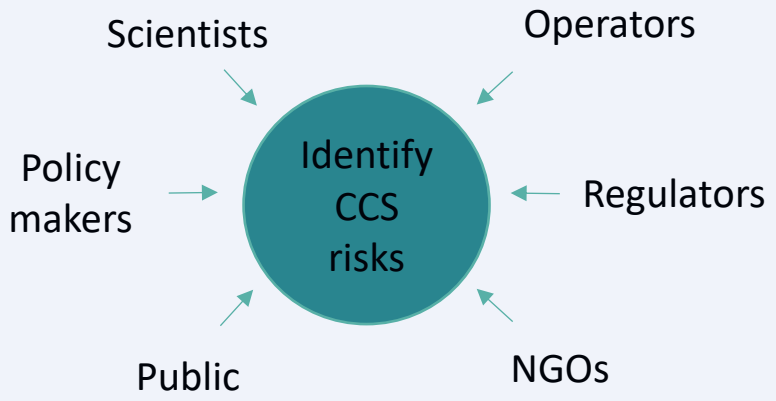
Why is it important?

- Efficient deployment of CCS requires a multidimensional assessment of risks (environmental, social, political, economic, technical)
- Advice for context sensitive risk governance strategies

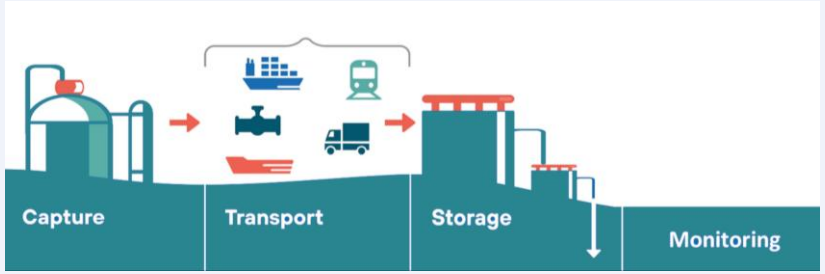
Research approach:

- Mixed methods approach combining **surveys**, **interviews**, **focus groups** and **expert/stakeholder workshops**
- Internationally comparative (Norway, The Netherlands, Germany, Romania, Greece)

360° risk assessment:

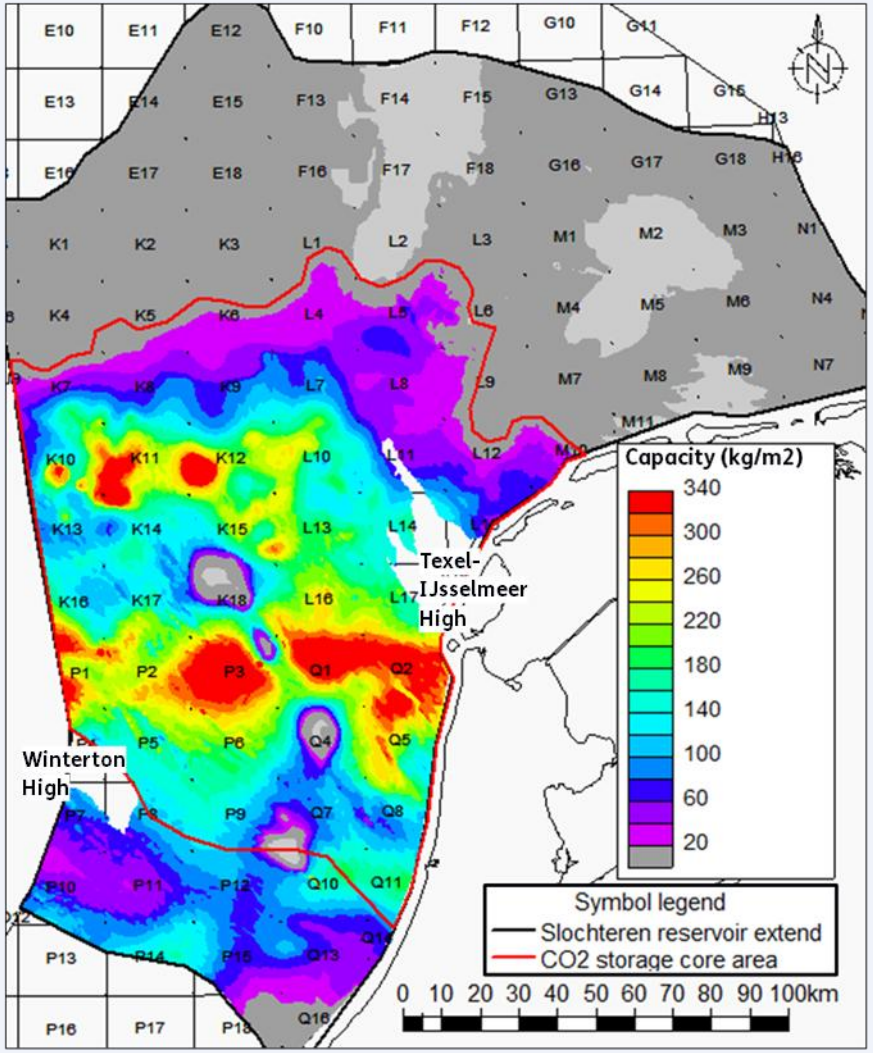


Please contact Marit.sprenkeling@tno.nl



TKI CO_2 storage in aquifers

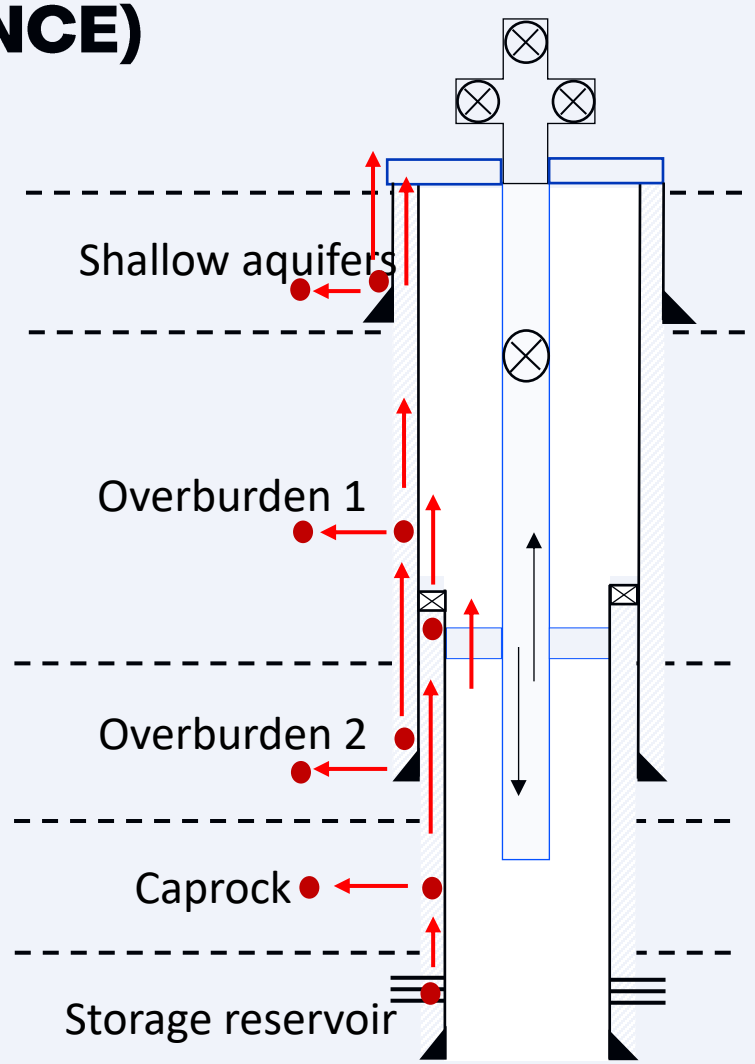
- Objective:
  - For relevant aquifer storage plays in Dutch offshore:
    - **explore the relation between pressure limit, storage capacity, and risk of loss of containment**
- Topic(s):
  - developing compartmentalised (i.e., relatively small) aquifer structures
  - using depleted fields with water leg
  - defining guidelines for maximum pressure definition
  - loss-of-containment-risk *vs* storage capacity *vs* maximum pressure
- Product / result
  - **Material for policy to enable aquifer storage on Dutch continental shelf**
- Partners: operators in Dutch offshore
  ENI, TotalEnergies, Shell, Petrogas, One-Dyas, EBN
- Timeline: start Q1 2025, duration 2 years



SCADSA study, TNO, 2024

Development of a tool for quantitative leakage assessment of legacy wells for abandonment and reuse (ELOQUENCE)

- Holistic leakage assessment tool that considers the entire well path and aims to predict the most likely leakage pathway as well as the leakage rate.
- The tool provides as assessment of the expected quality of the cement sheath (microannuli size) based on operational and in-situ conditions
- Such a tool facilitates quantitative leakage assessment of legacy wells for abandonment and reuse purposes
- The tool will incorporate results from lab experiments and will be verified by field cases (based in Norway, Netherlands or other regions of interest).

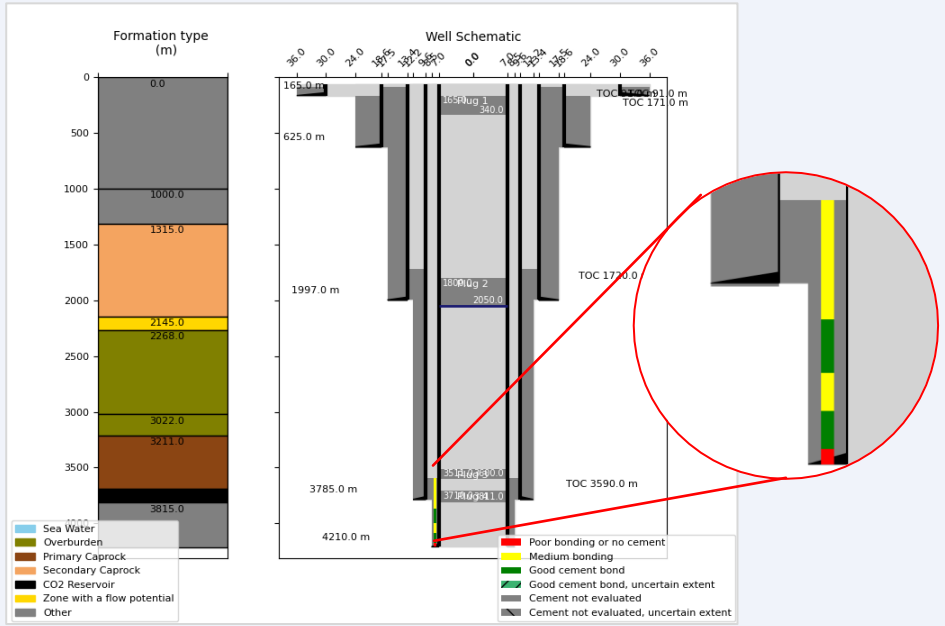


Well Integrity Storage Complex Screening (WISCoS)

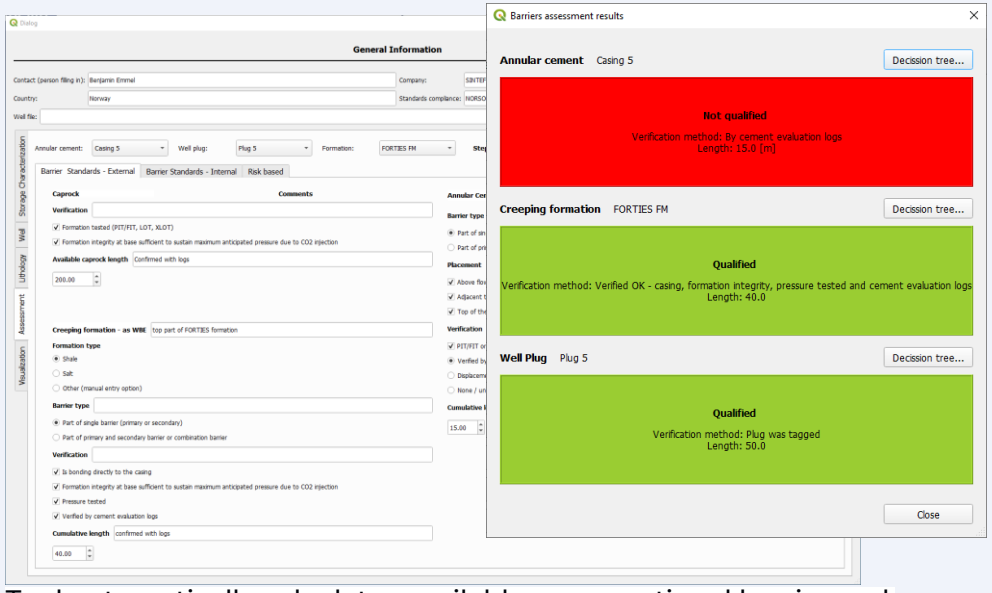
- **JIP** between TNO, SINTEF and North Sea operators active in CCS
  - North Sea regulators indirectly involved
- **Objective:**
  - Develop a standardized **well integrity risk assessment tool to assess all well types and support CCS Storage License & Permit Application** process

- Main features:

1. **Centralized data handling system**
2. **Generation of detailed well schematics**
3. **Well integrity assessment**
   - Automated cross sectional barrier assessment based on cement quality
   - Manual barrier assessment based on mitigation requirements



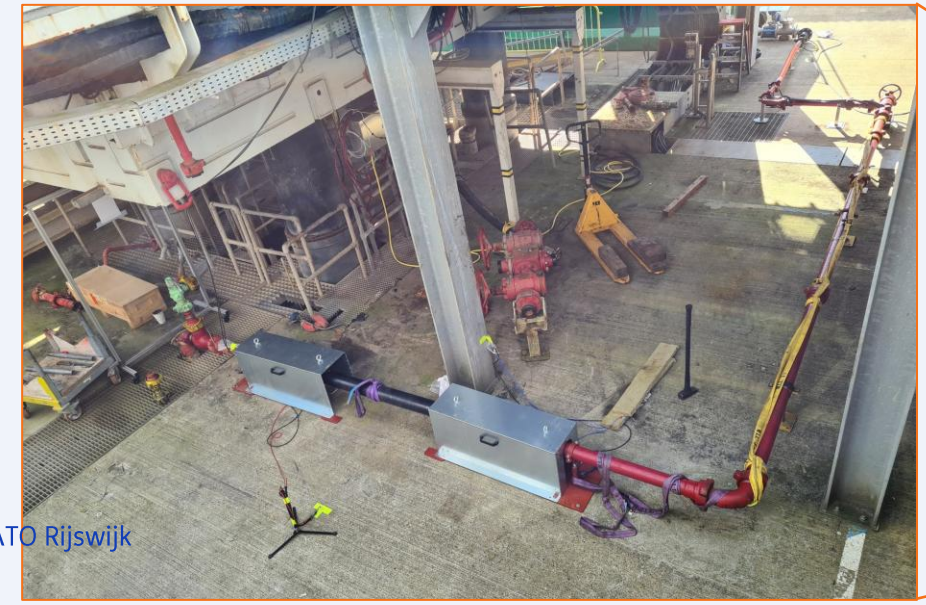
Tool generates well schematics based on data input about well design, formation, cement quality etc



Tool automatically calculates available cross sectional barrier and allows for manual assessment of individual WBEs

Testing CCS downhole tools at RCSG

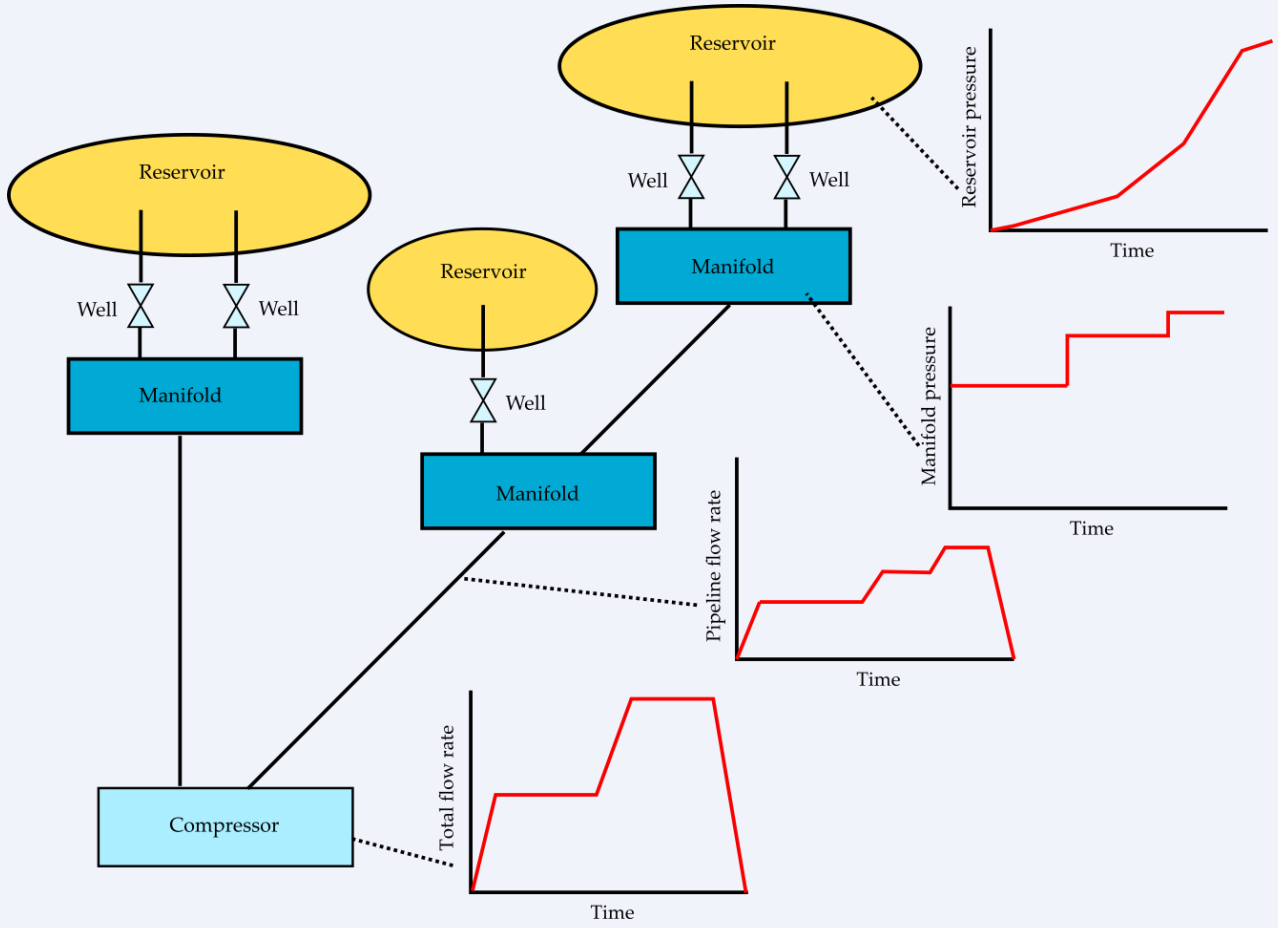
- Successful tests of a downhole tool to be applied in CO_2 injection wells to control the wellhead injection pressure and the phase change behaviour
- Testing performance using RCSG's rig and mud circulation system
- In the next phase the tool will be tested in the test well at ~300 m depth



ACT ACTION

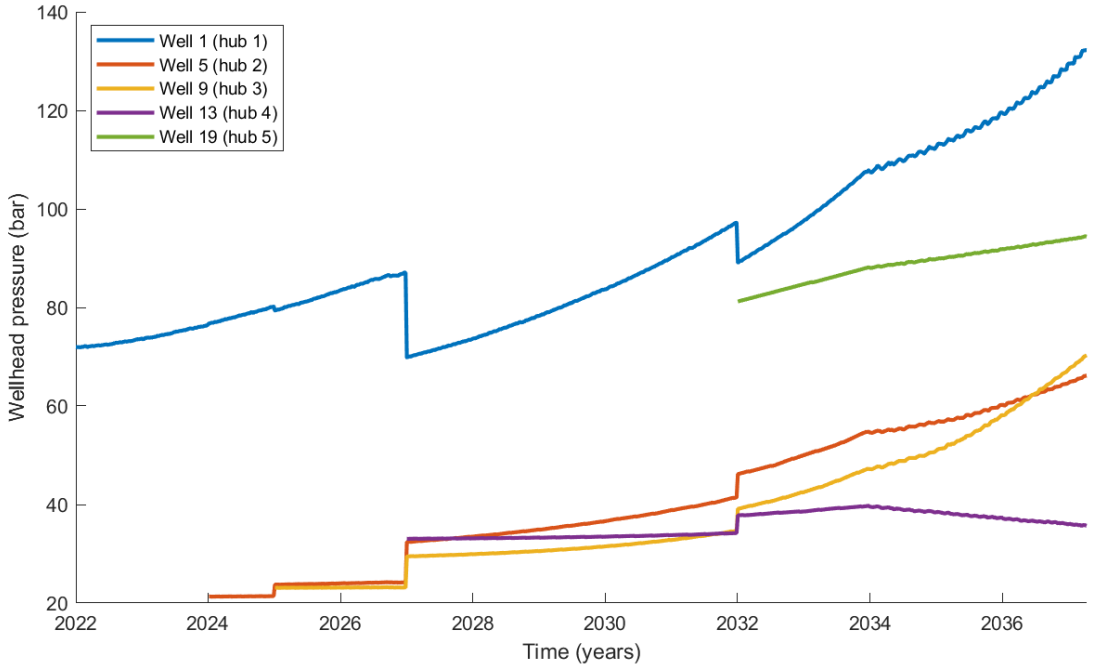
- **CO_2 transport and storage network evolution**
- Almost closed
- Goal: create physics-of-CO_2-flow-based simulator of a CCS transport & storage network, study a network's behaviour, management and evolution
- Relevance: the behaviour depleted fields is likely to affect the development and operation of a network of storage locations – should be clarified as early as possible

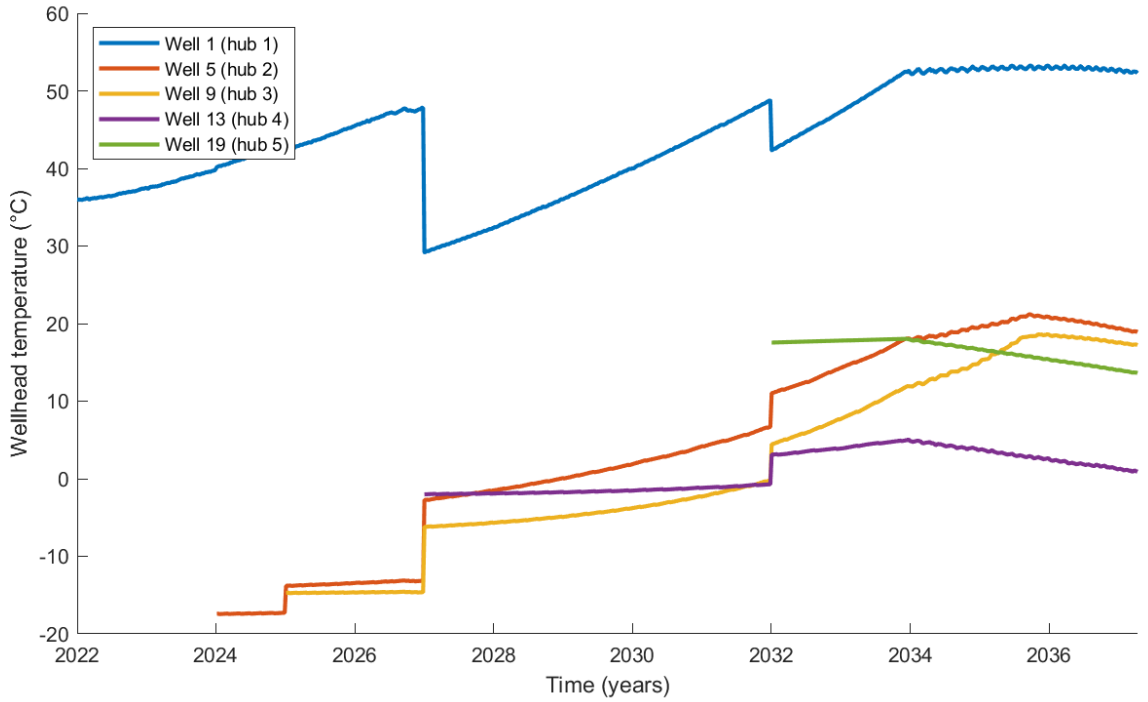
- Result
  - Steady-state model to study flow in complex networks, with proxy models for wells and reservoirs
  - Step-wise steady-state, accommodating flow and boundary conditions varying over time
  - Current work: optimise flow distribution over network



The ACTION model van represent reservoirs with different properties, slowly filling up over time

ACTION network tool: Example of simulation results





Pressures and temperatures can be evaluated over the years of injection (or other time scales)

Low temperatures are reached at low reservoir pressures

Higher pressures are required at high reservoir pressure

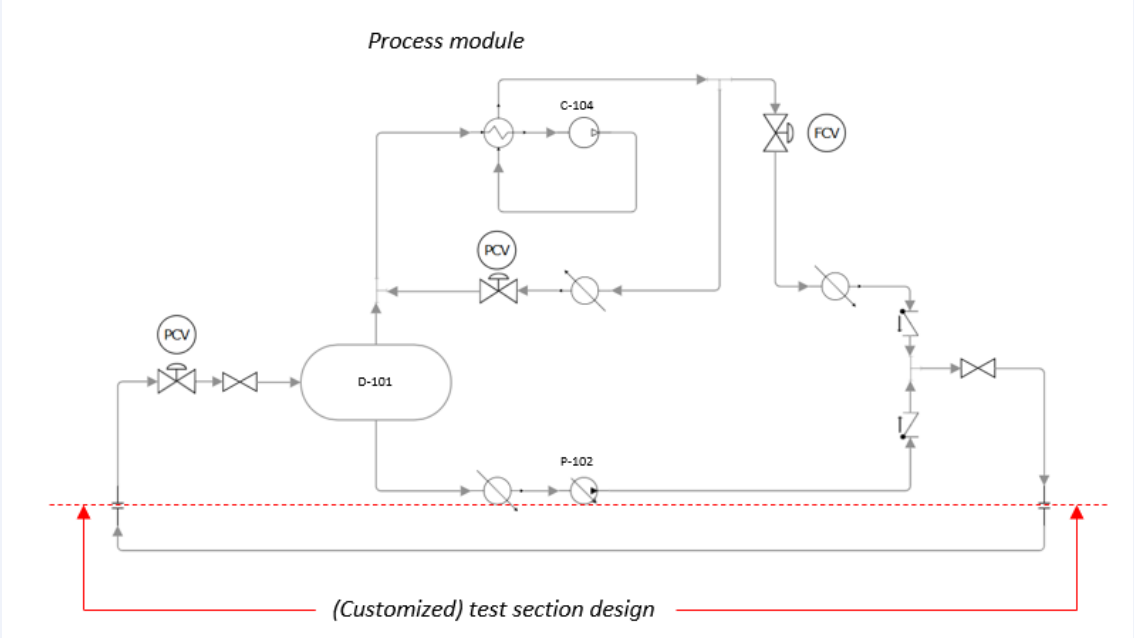
Flow redistribution can be used to improve temperatures and pressures

Colorado flow loop

- Test section ID of ½”-1”
- Flow conditions

	Min	Max
Flow rate gas		20 m/s (1/2” pipe), 5 m/s (1”)
Flow rate liquid		1-2 m/s
Pressure		100 bar
Pressure drop		75 bar
Temperature	-50 °C	+ 40 °C

- Pure CO_2 / CO_2 with impurities
- Default test section: horizontal section followed by a vertical downwards section (both > 100 diameters long for fully developed flow)
- Flexible and modular facility **to investigate CO_2 behaviour for e.g. bends, valves, chokes, instruments , other vertical & horizontal appendages, porous media**.

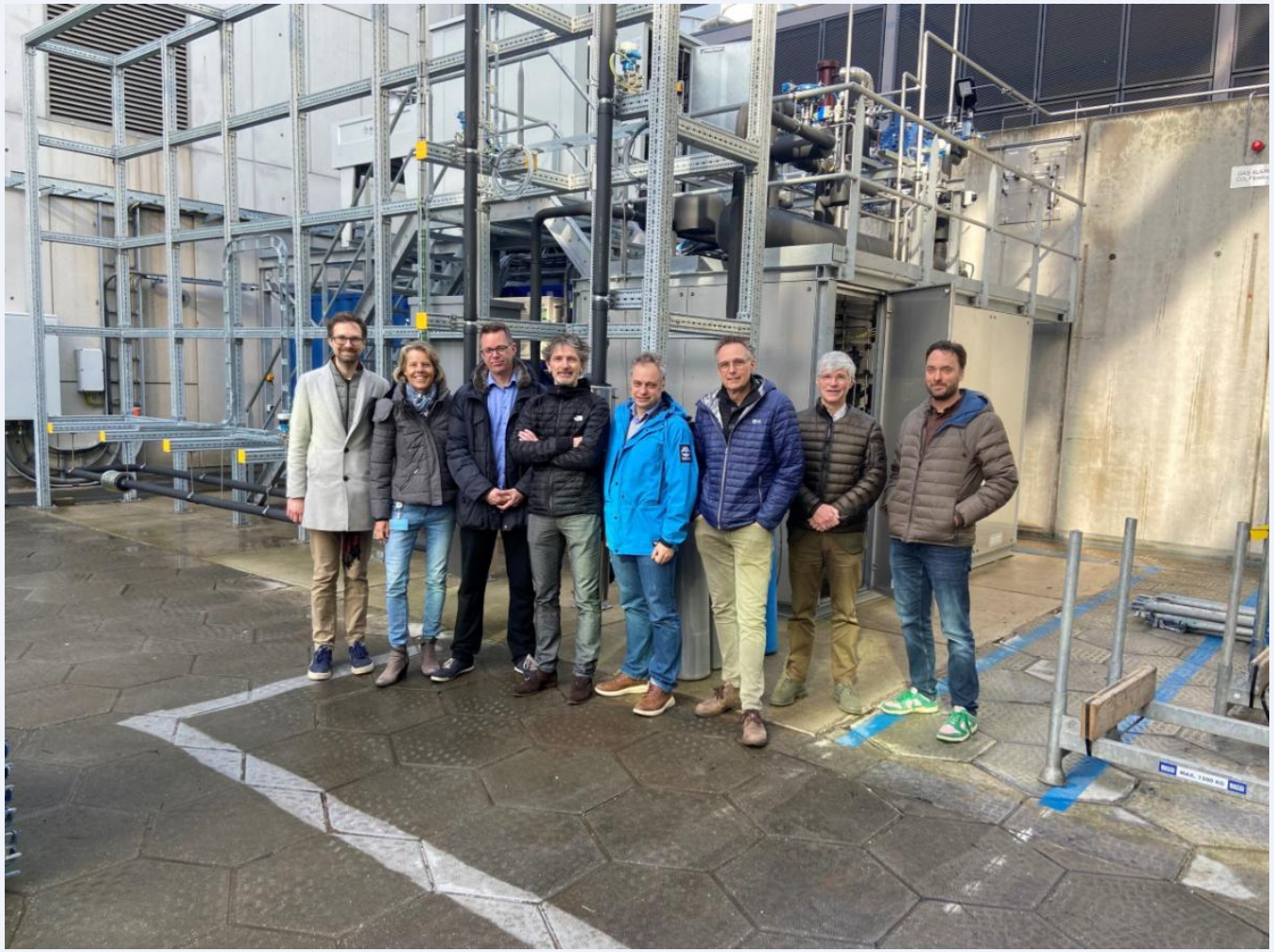


CO_2 flow loop

CO_2-TIME

- JIP with EBN, Shell, TotalEnergies, ENI and Harbour Energy

- Looking into:
  - Impurities
  - Forces on Bends
  - Flow through valves
  - Flow though porous media (with TNO Utrecht)



H-EU ENCASE

Horizon Europe project with 5 Research Institutes on CO_2 transport

Lead: IFE (Norway)

January 2023 – June 2026

- Key activities in the project:

- Build the experimental capacity of the research institutes (TNO further develops the Colorado flow loop)
- Measuring and simulating the thermo-physical properties of CO_2 with impurities
- Developing measurement and control techniques
- Investigating the safety of CO_2 transport (TNO to perform vapour collapse measurement)
- Social innovation and co-creation (TNO to develop exhibit in collaboration with the Energy Cave)

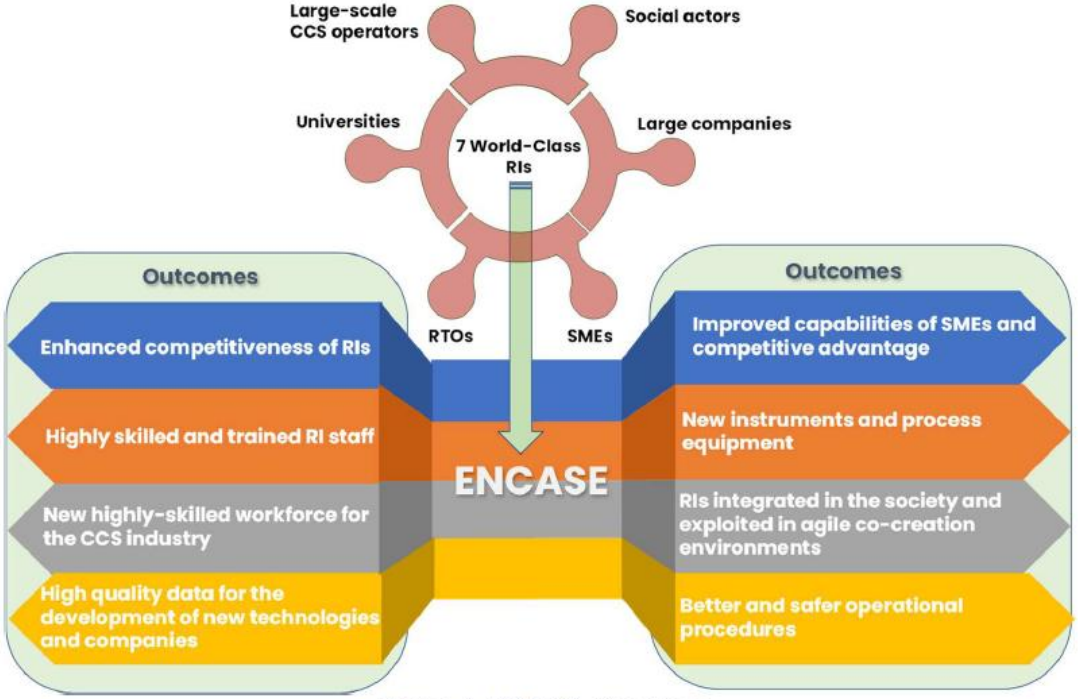


Figure 1. ENCASE at a glance

https://www.encase-eu.com/

YOUR QUESTIONS / DISCUSSION