CO₂ STORAGE IN DEPLETED GAS FIELDS

Filip Neele, Stefan Belfroid, Aris Twerda
STORAGE IN DEPLETED GAS FIELDS

- First choice for CO₂ storage in The Netherlands
  - ~1.5 Gt capacity in ~100 offshore fields
  - Re-use of pipelines, platforms, wells

- Competition with other uses for offshore area
  - Wind farms
  - Energy storage or conversion

- First gas fields (cluster) under development for CCS
  - Porthos consortium (Rotterdam)

North Sea Energy
www.north-sea-energy.eu
ALIGN - CCUS
DEVELOPING CAPACITY

Abundant storage capacity, but how to develop it?

Potential timeline of field development

Ranking of options – unit storage cost, location, capacity, etc.

DGF: depleted gas field
DSF: deep saline formation
Re-using platforms, wells, pipelines

Network development
Flexibility, robustness

Large pressure drops in system – management of CO₂ temperature is key element of operations

Well integrity, fault stability, flow rates, intermittency, low-temperature cycling, …

Risk management plan
Monitoring plan

Pressure and temperature distribution and development in reservoir (injection of cold CO₂)

Site conformance
Site handover

High-pressure pipeline(s)
RE-USING DEPLETED FIELDS (AND THE WELLS)

- Safe storage
  - Well integrity maintained during operations
    - Injection on – off: temperature cycling in well
  - **Wellhead**: $T > -10 \, ^\circ\text{C}$ (material constraint)
  - Reservoir and cap rock integrity preserved
    - Large contrast temperature $\text{CO}_2$ - reservoir

- Maintain operability of reservoir
  - Avoid salt deposition and hydrate formation
  - Hydrates: **bottomhole** $T > 15 \, ^\circ\text{C}$

- Flow rates through well: limits due to erosion, vibration
EXAMPLE: LIQUID, COLD CO₂ CONDITIONS ALONG WELL

› TVD ~ 3.5 km (deviated well)

› At wellhead:
  › Massflow: 10 - 170 kg/s
  › Pipeline pressure 100 bar
  › Wellhead temperature: 10 °C

› Near bottom of well:
  › Reservoir pressure: 20 bar
  › Reservoir temperature: 120 °C

-10 °C (wellhead)

15 °C (bottom hole)

Minimum safe injection rate 80 kg/s (~2.5 Mtpa) (only for this particular set-up!)

Results depend on well completion, reservoir properties, etc.: system design to take the flow phenomena into account
DYNAMIC OPERATIONS – SHUTIN

- Shutin
  - Reservoir pressure 20 bar
  - Initial mass flow rate 30 kg/s
  - Well shut in

- During shutin
  - Wellhead pressure decreases
  - Liquid is formed
  - Conditions shift to phase line
  - Results in temporary low temperatures

- Requires detailed heat transfer calculations including heat capacity
  - Tubing temperatures
  - Annulus temperatures
  - Cement bonding

Total time: 90 minutes
CONFORMANCE MONITORING

- Define site conformance indicators
  - Pressure, temperature in places in system

- Compare measured and observed field performance indicators
  - Measured: noise
  - Modelled: uncertainties, model limitations

- What is magnitude of signal in monitoring data from risks that do occur, compared to noise and uncertainties?

Regulations in place, but not tested yet

EU Storage Directive & ETS: emphasis on monitoring, measuring and verification

How well can we assess conformance?
Correct assessment depends on (a.o.): Uncertainties in a priori model, variations in CO₂ quality, noise in monitoring data.

False negatives, false positives

Improve: decrease uncertainties, add other monitoring techniques

**EXAMPLE: BHP BASED MONITORING**
CONCLUSIONS

- Depleted fields: blessing in disguise?
  - Abundance of data from production period
  - Well-defined storage capacity
  - Pipelines, platforms and wells to be re-used
  - Low pressure represents challenge – injection project becomes temperature management project
  - For NL fields: size (capacity) of fields requires many fields to be developed
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