CO_2 STORAGE IN DEPLETED GAS FIELDS

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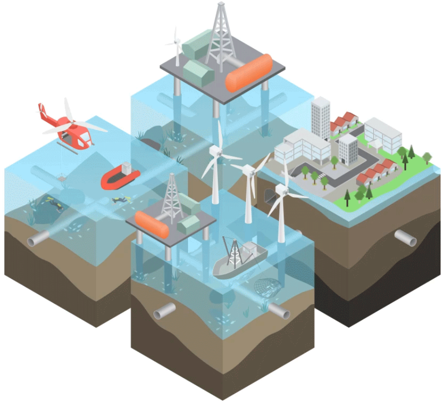
STORAGE IN DEPLETED GAS FIELDS

- First choice for CO_2 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)



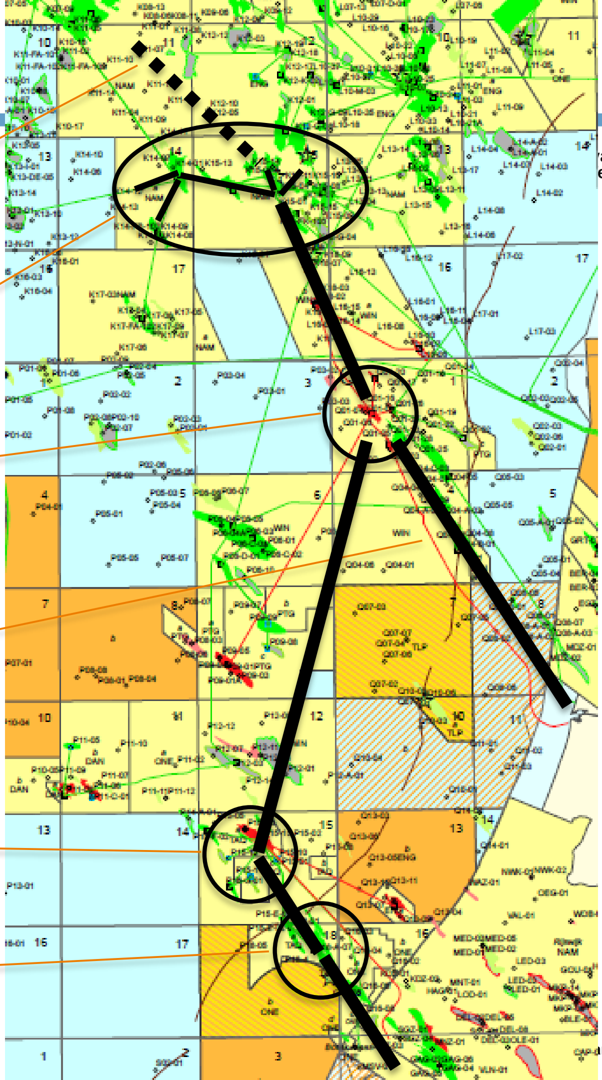
North Sea Energy
www.north-sea-energy.eu

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

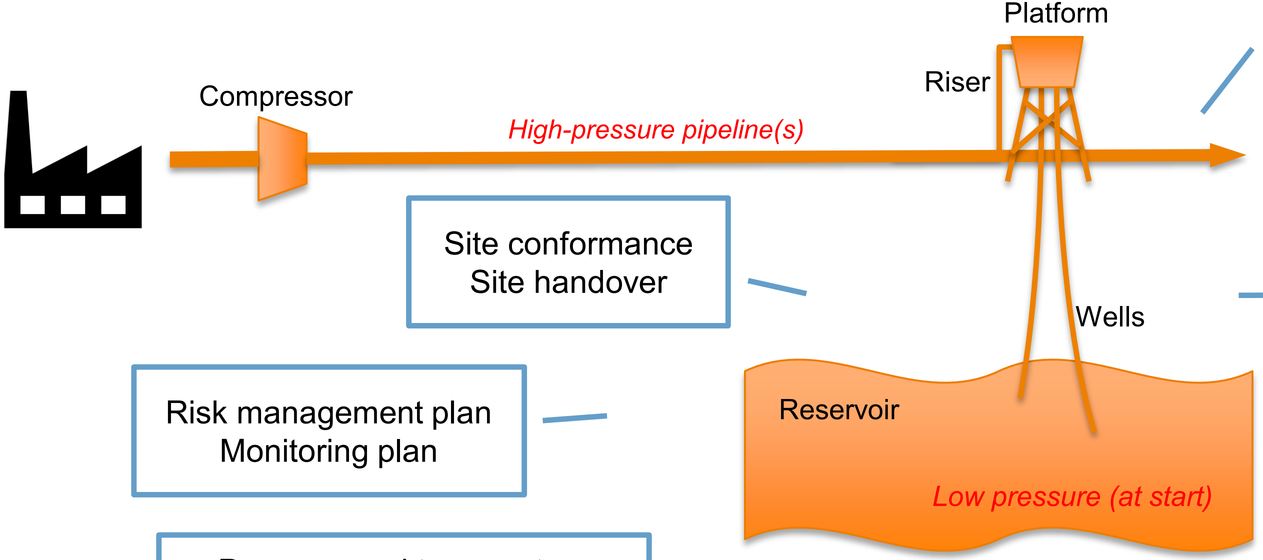
DSF: deep saline formation



T&S SYSTEM

Re-using platforms, wells, pipelines

Network development
Flexibility, robustness



Site conformance
Site handover

Large pressure drops in system – management of CO_2 temperature is key element of operations

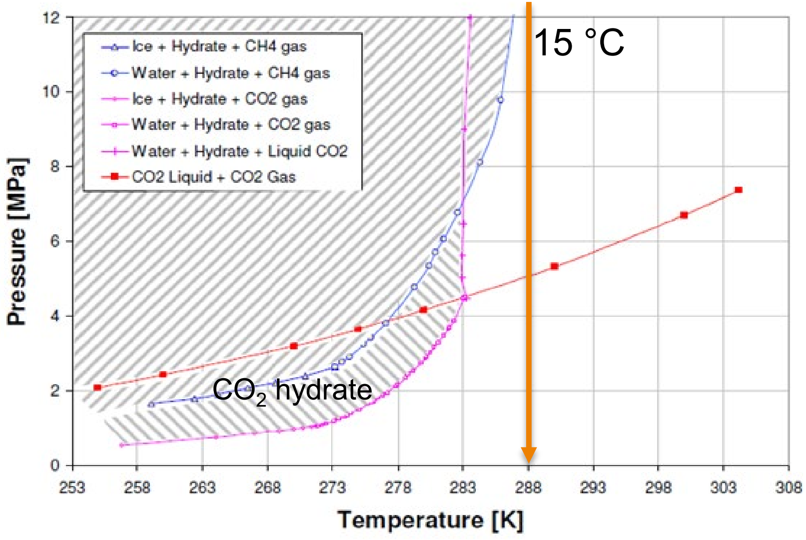
Risk management plan
Monitoring plan

Pressure and temperature distribution and development in reservoir (injection of cold CO_2)

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

RE-USING DEPLETED FIELDS
(AND THE WELLS)

- Safe storage
  - Well integrity maintained during operations
    - Injection on – off: temperature cycling in well
    - **Wellhead: T > -10 °C** (material constraint)
  - Reservoir and cap rock integrity preserved
    - Large contrast temperature CO_2 - reservoir
- Maintain operability of reservoir
  - Avoid salt deposition and hydrate formation
  - Hydrates: **bottomhole T > 15 °C**
- Flow rates through well: limits due to erosion, vibration



Need water…

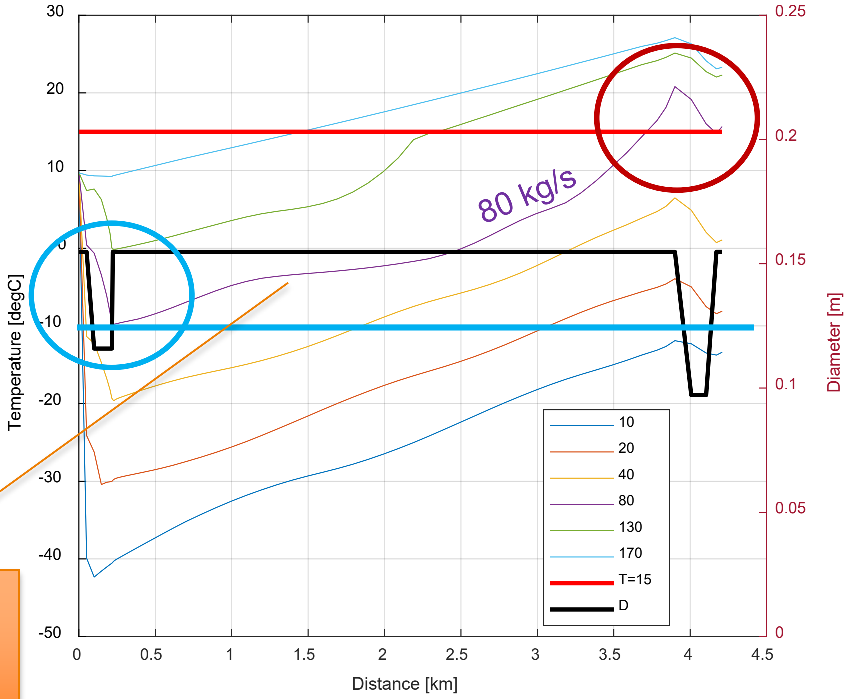
EXAMPLE: LIQUID, COLD CO_2

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)

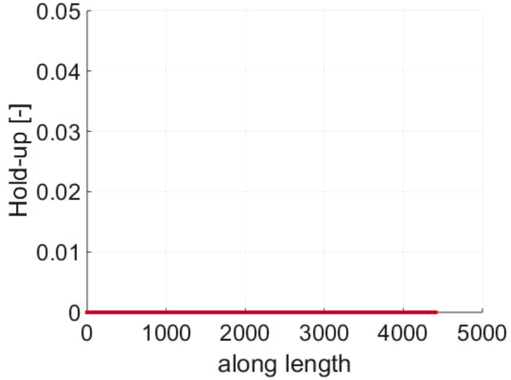


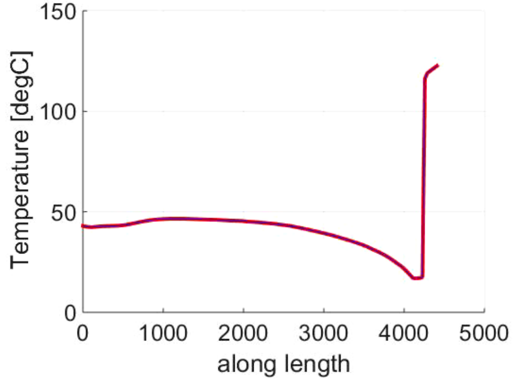
Results depend on well completion, reservoir properties, etc.: system design to take the flow phenomena into account

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

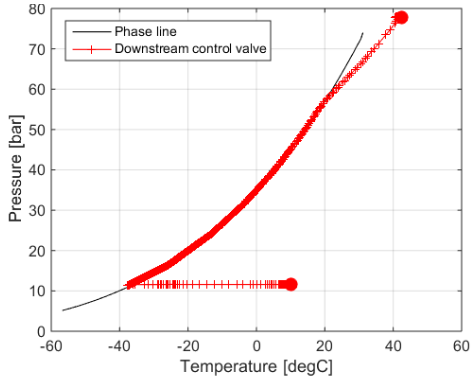
DYNAMIC OPERATIONS – SHUTIN

- 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?

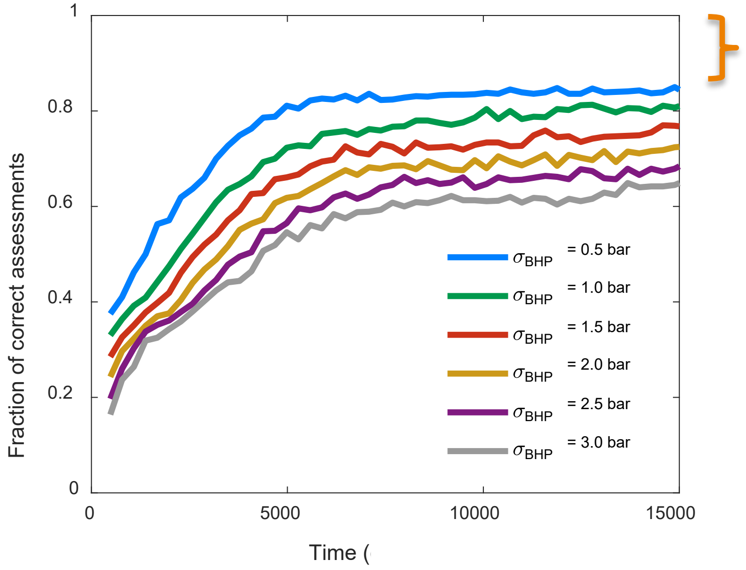
Regulations in place, but not tested yet

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

How well can we assess conformance?

EXAMPLE: BHP BASED MONITORING

Correct assessment depends on (a.o.): Uncertainties in *a priori* model, variations in CO_2 quality, noise in monitoring data



False negatives, false positives

Improve: decrease uncertainties, add other monitoring techniques

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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