

Bifrost Project, Asset conversion for a CCS hub

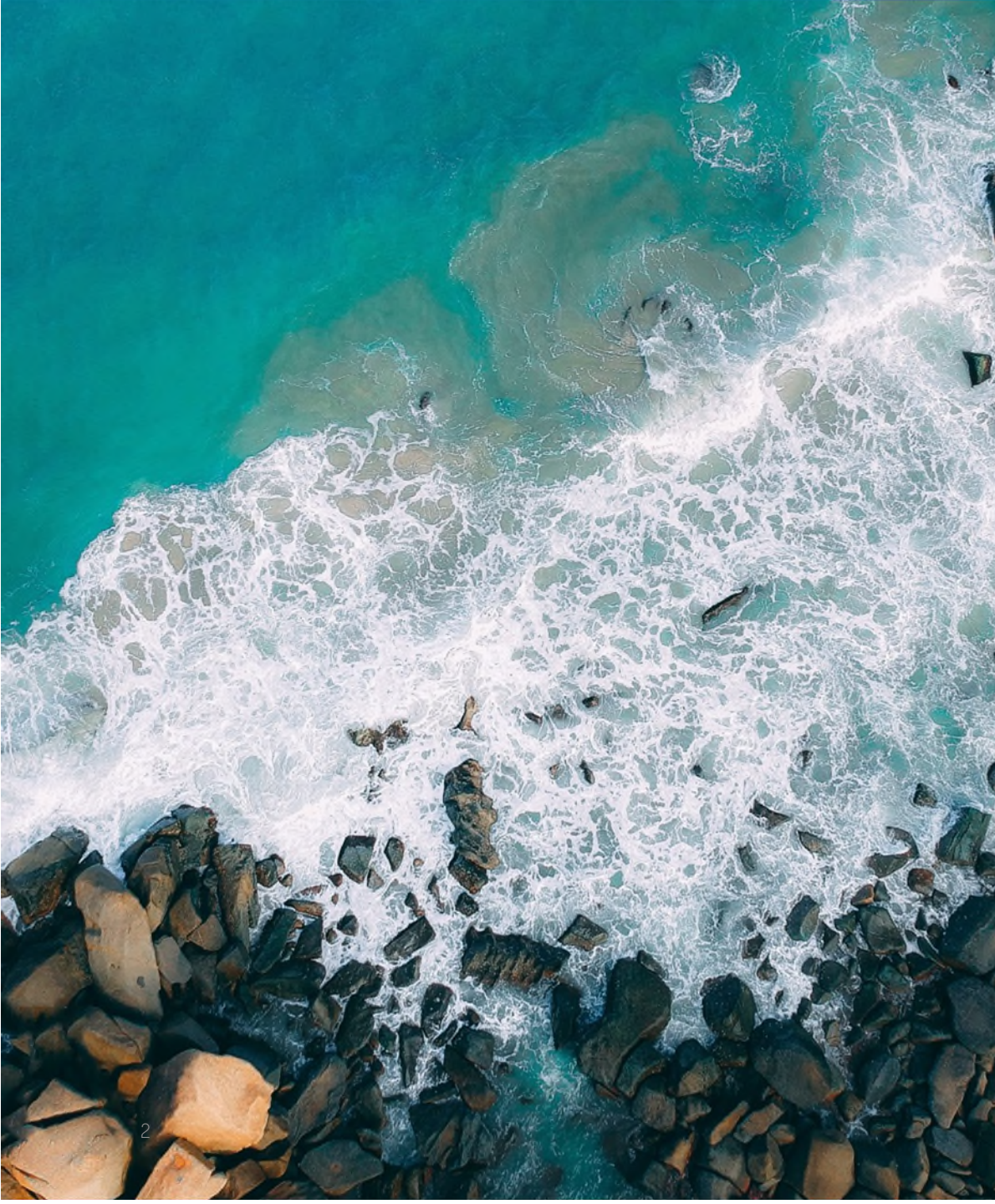
Denmark CCS Conference 2023 -- June 6, 2023 – Rungstegaard

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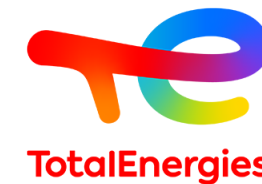


Funded by





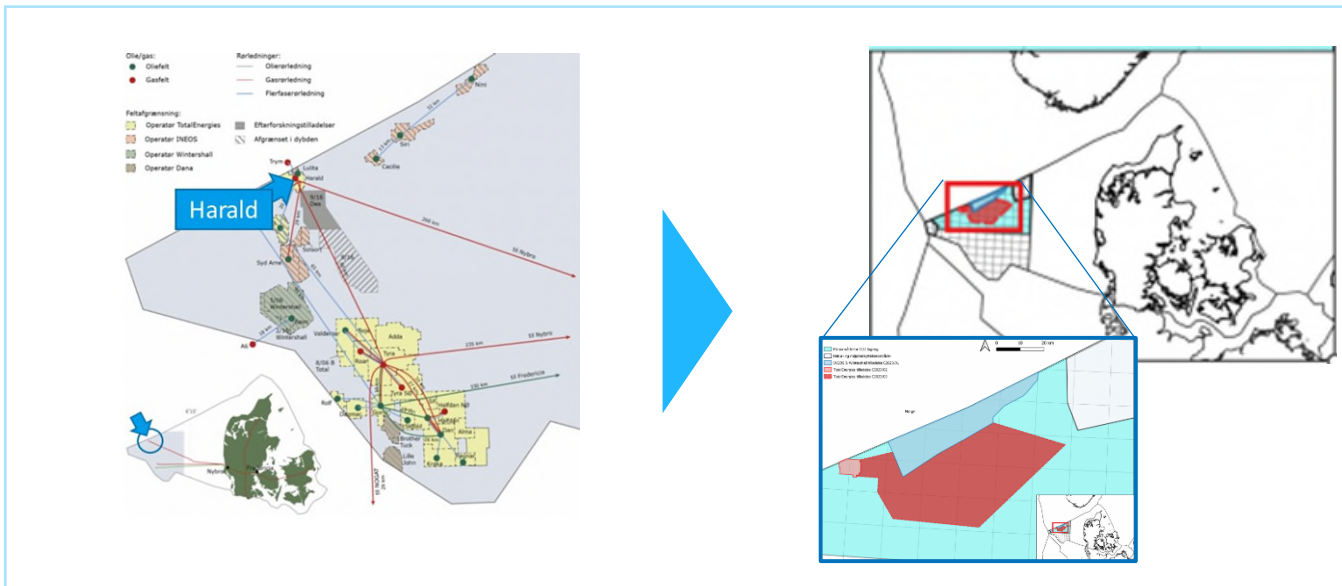
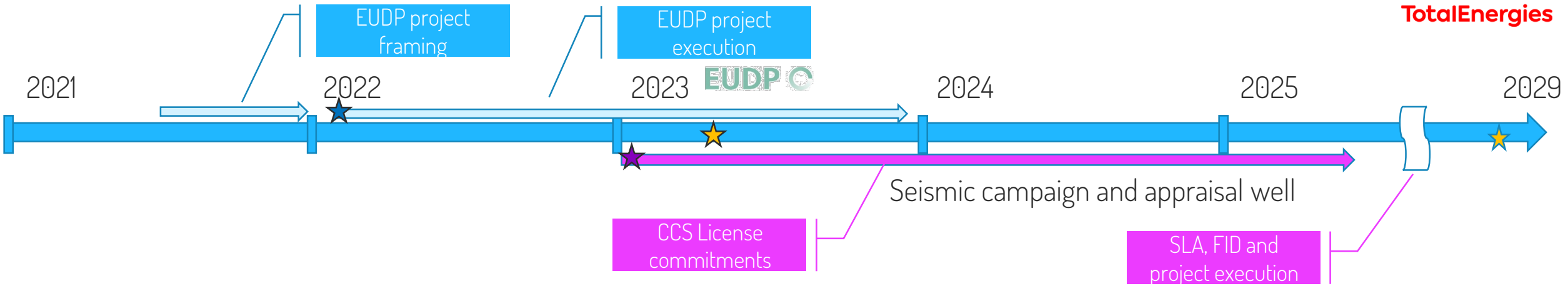
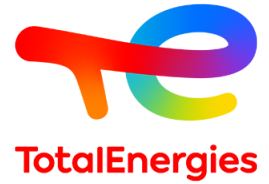
Agenda



1. Context
2. Store qualification
3. Well integrity assessment
4. Surface Facility concepts
5. Link with company DK CCS roadmap



An ambition: CCS hub leveraging existing facilities



- TotalEnergies involvement in DK CCS started with commitment of a 2-year EUDP-funded project focusing on offshore
- Project is scaling up with appraisal of nearby aquifer structures to propose a merchant CO₂ hub for national and transborder emitters



A rigorous staggered project maturation framework

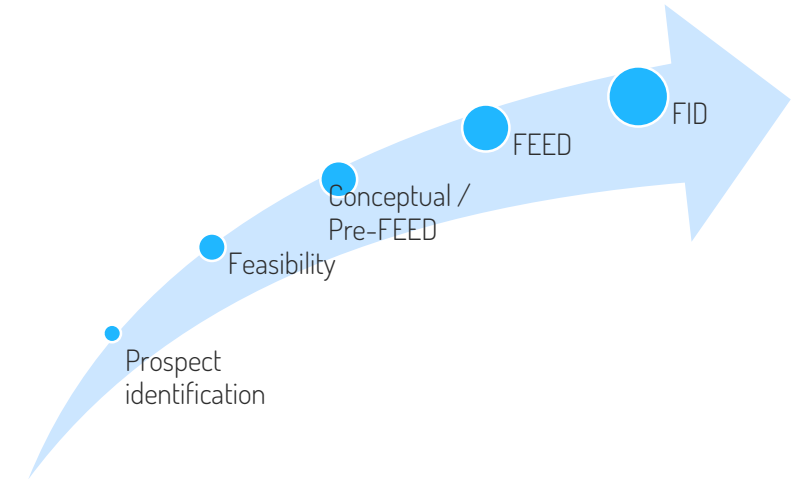


Pre-development

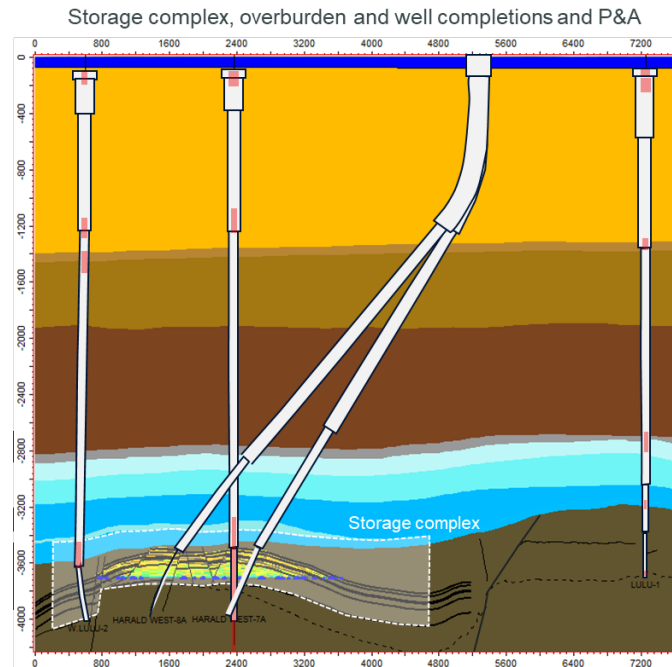
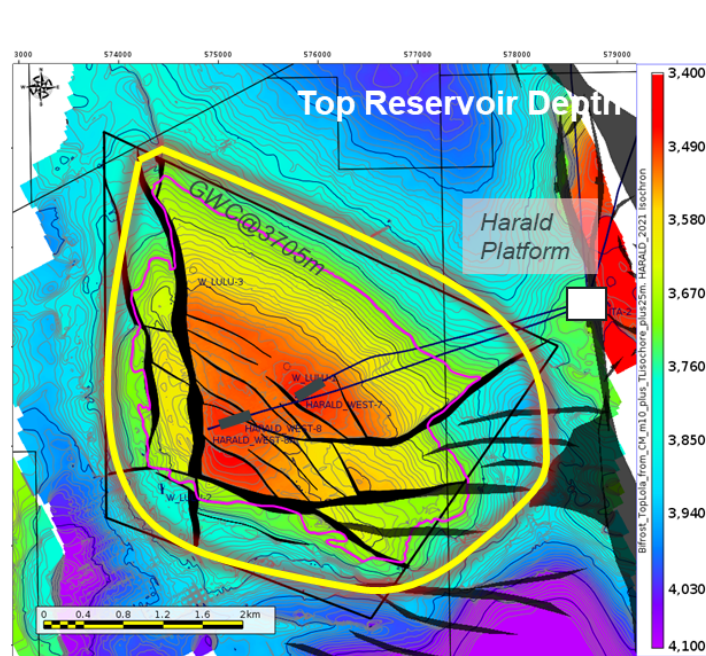
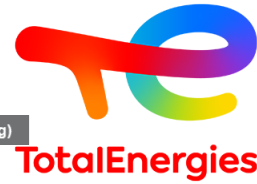
- Learning curve for parties involved in CCS projects: legislators, operators, service providers, partners, potential customers...
- TotalEnergies applies a structured project maturation process where the technical definition increases in relation with project decisions

Early stakeholders' engagement

- With the regulator for CO₂ Storage Licence Application
 - Anticipate the level of details required by the regulator to minimize the need for additional work and clarifications during the review process, in the critical path of the project execution
- Long-term commitment
 - Level of commitment of stakeholders' (service provider, clients...) increases with project maturation
 - Transportation and storage services implies binding long-term contracts as early as FID
 - Storage bears a subsurface range of uncertainty that needs to be characterized and continuously managed along the project life

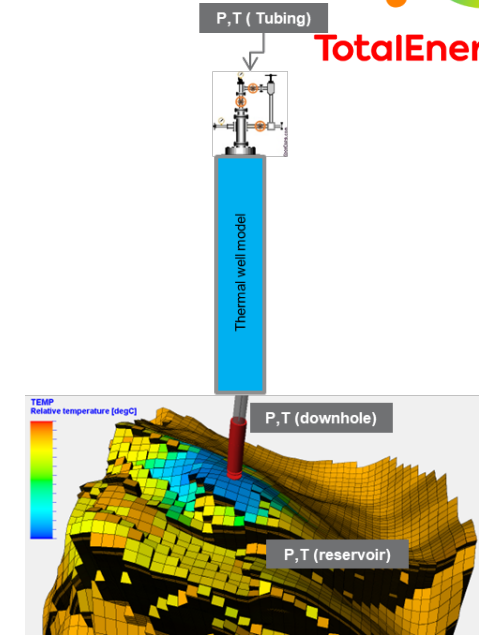


An extensive Store Complex qualification program: Harald West



Overburden

- Water column
- Pliocene / Pleistocene
Unconsolidated sand and clayst.
- Ørnhøj Fm.
Shale, Onset OP
- Upper Lark Fm
Diatomite, sand stringers.
- Lower Lark Fm
Diatomite, sand stringers.
Horda Fm.
- Rogaland Gr.
Balder, Sele, Lista, North Sea Marl
- Chalk Group, Ekofisk Fm.
- Tor Fm.
- Reworked Chalk
Volatile oil bearing
- Jurassic
Storage unit
- Triassic



Poster presentation available at DTU conference

- High resolution 3D full field model for storage capacity and plume predictions
 - Run in thermo-compositional mode since temperature effects are important, particularly near the well bore
- 3D geomechanical model to:
 - Prevent risks of fault reactivations or seal breach (including compaction and/or cooling effects)
 - Geochemical interactions between CO₂, caprock and reservoir fluids/rocks
- Well performance work linking the surface facilities to the reservoir with consistent enthalpy calculations for each simulation timestep
- Full risk register, bow-tie analysis and ALARP review of the injection and monitoring plans

Full adherence to legislation (EU & DK)
High bar set for quality of the analysis



Well integrity

- Old well plugged and abandoned on the complex receive careful assessment
- Integrity is reassessed in lights of today's practices (upgraded compared to O&G)

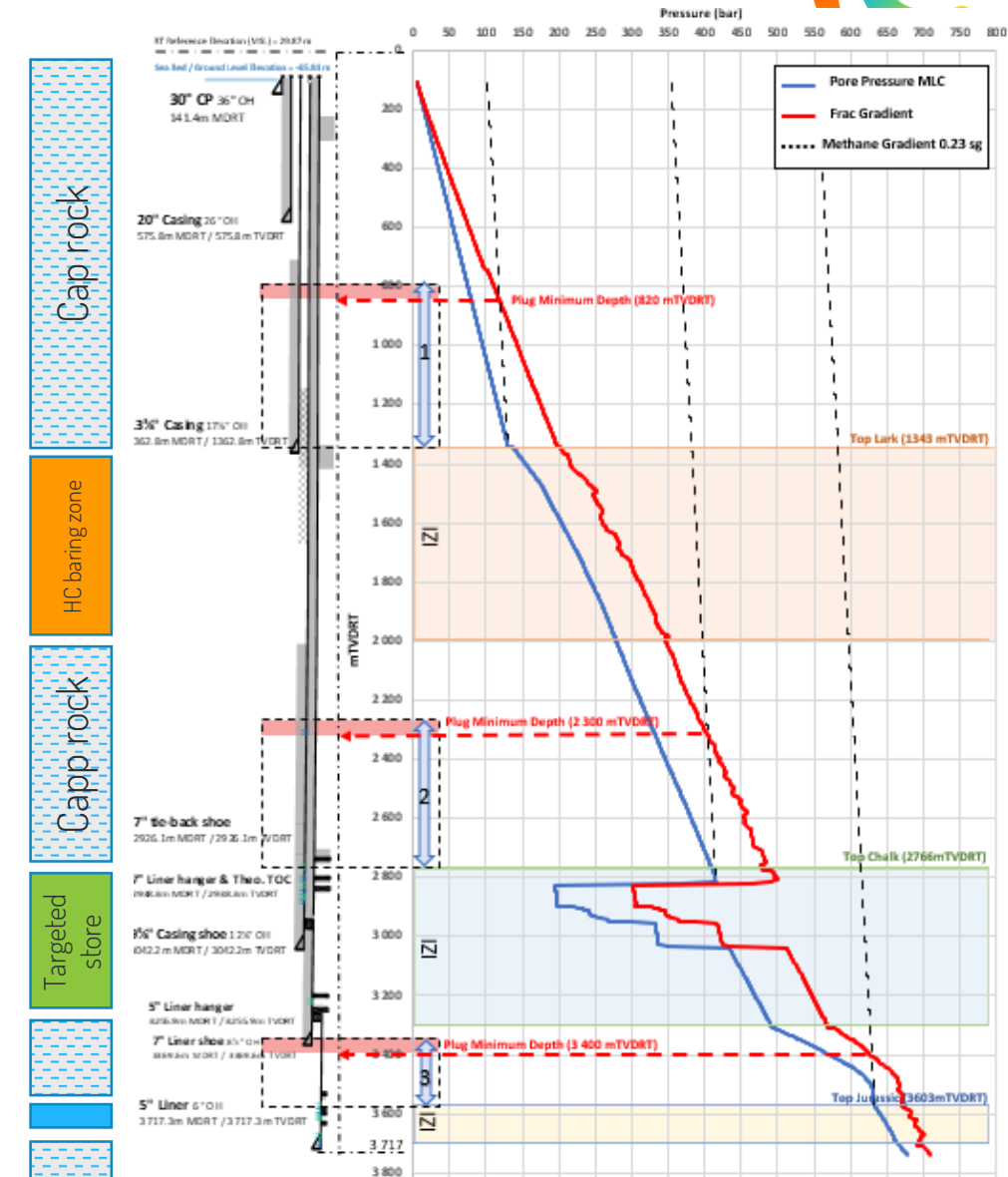
Legacy wells

- Internal evaluation performed
- External contractors provide special quantitative and probabilistic analysis
- Third party certification participates to store qualification
Integrity Risk should be As Low As Responsibly Possible

Example on Bifrost depleted stores

- One of Harald West development well cannot be repurposed and will be re-entered and PnAed
- Section milling will be deployed to permanently secure confinement

Integrity breach scenarios

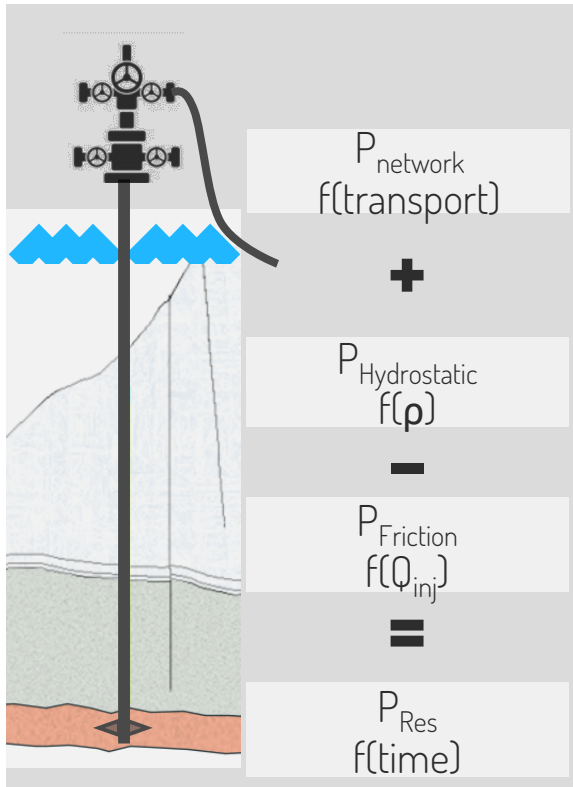
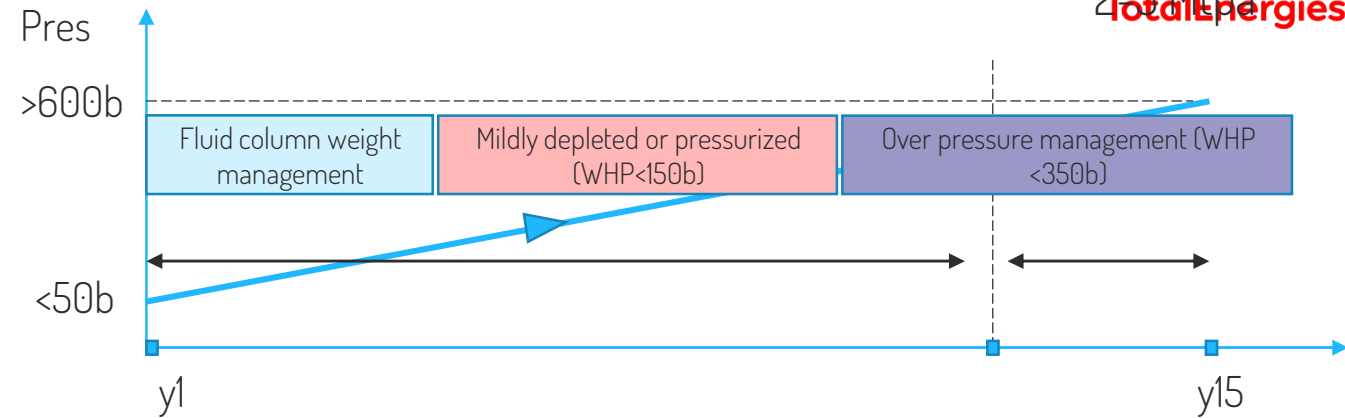


Challenges and merits of depleted stores

Depleted gas field



+ Well characterized, confined, re-pressurization



- Depleted store with a target injection rate of 2-3 Mtpa over 15 years
- Gas reservoir initially over pressured
- Store Initially very depleted with low pressure
- Limited number of injection points, maintain a well sparing philosophy to secure contracts
- Injection stops when BHP > Pinit, commercial turn down rate
➔ Reservoir nearly re-pressurized

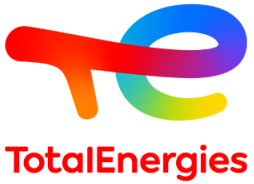
Well performance challenge, minimize heavy well interventions



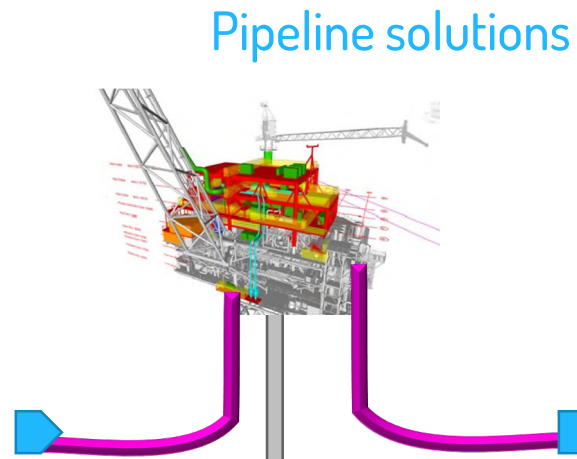
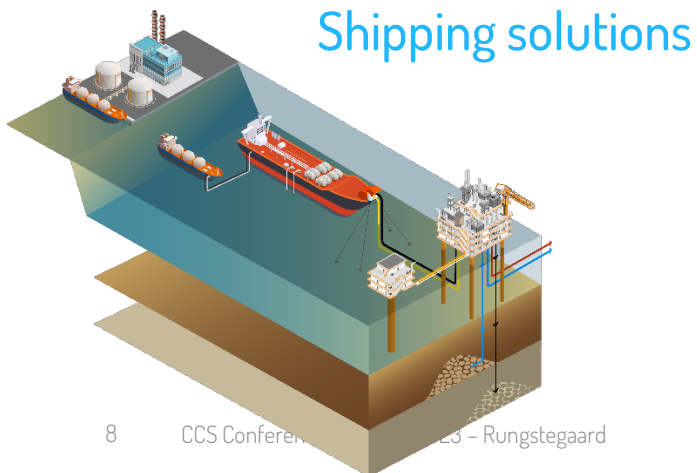
Two concepts selected

Build a Portfolio to create a CCS hub

- Build from a reused facility and well-known depleted stores
- A solid basis allows to complement hub store capacity with lesser characterized saline aquifers
- Mutualize facilities and adapt operating principles to maximize availability of the portfolio and reduce costs
- Ability to run tests and pilot on less mature reservoir type (chalk)
- Ability to produce other reservoirs from the facility is an important aspect but delaying abandonment not a real driver



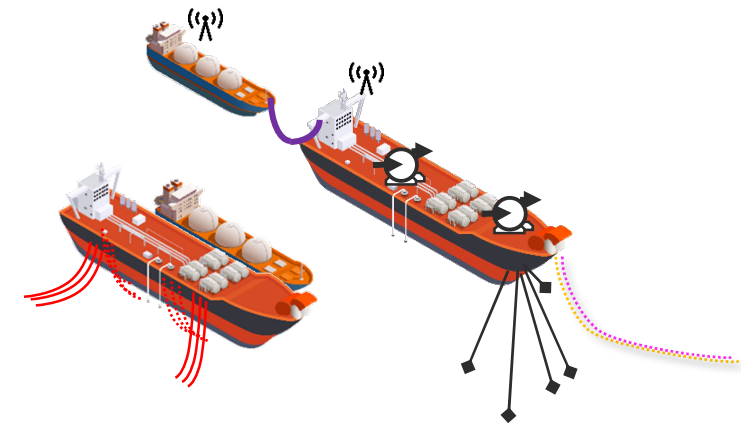
Harald West Facility



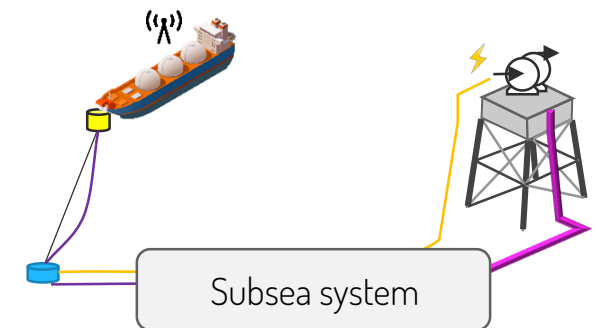
Design and technologies for a scalable storage solution

- Pipeline solution to be developed, opportunity for cost saving with repurposed pipe
- Floater solutions (ex: for alternate onshore terminal)
- Direct injection with subsea CO₂ conditioning system
- Platform life extension, power generation, CCS Platform integration
- Technology maturation of key component, marine, process, well design

Floater concepts



Subsea concepts



Completing design @Pre-FEED level



Integration into concept developed in aquifer appraisal

Way forward



- Completing EUDP project
- Assessing other scalable cross-border transportation concepts
- Preparing platform integration
- Bridging technological gaps
- Fulfilling an extensive appraisal work program on 2 CCS licenses

Designing a CO₂ transportation and storage hub
for Denmark and cross-border emitters



Thank you!