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DTU Offshore – Danish Offshore Technology Centre

# Research to support $CO_2$ storage in existing Oil & Gas fields

# Why $CO_2$ storage in existing oil and gas fields?

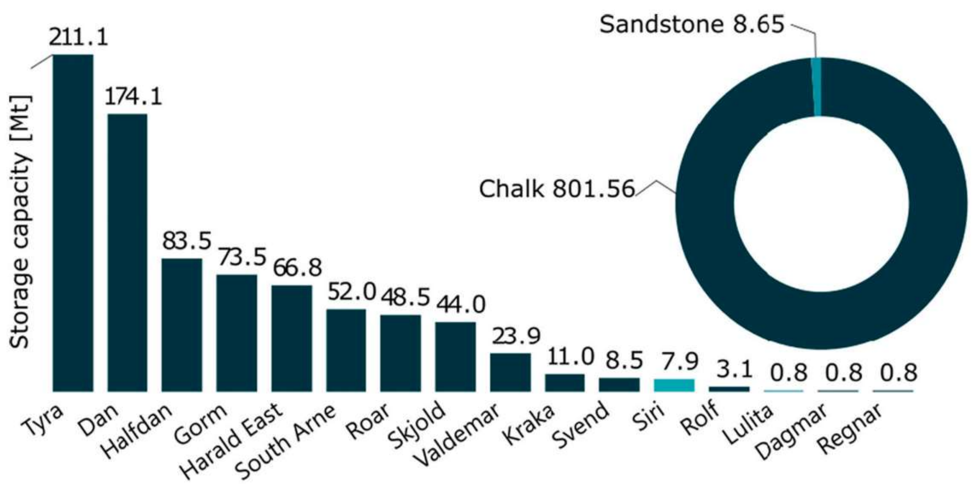
Depleted reservoirs and existing infrastructure in oil and gas fields represent an opportunity for accelerated implementation of $CO_2$ storage with;

- *a large, well described and proven storage capacity*
- *containment seal proven over geological time*
- *decades of accumulated knowledge/data of subsurface*
- *existing subsurface and surface infrastructure*
- *distance to shore and inhabited areas*

But added complexity:

- In DK majority of existing O&G fields are chalk
- Adds a potential risk of leaks through abandoned wells
- Adds consideration of remaining lifetime of existing infrastructures

# Unlock storage potential in Chalk – key for re-using existing O&G fields for storage in DK

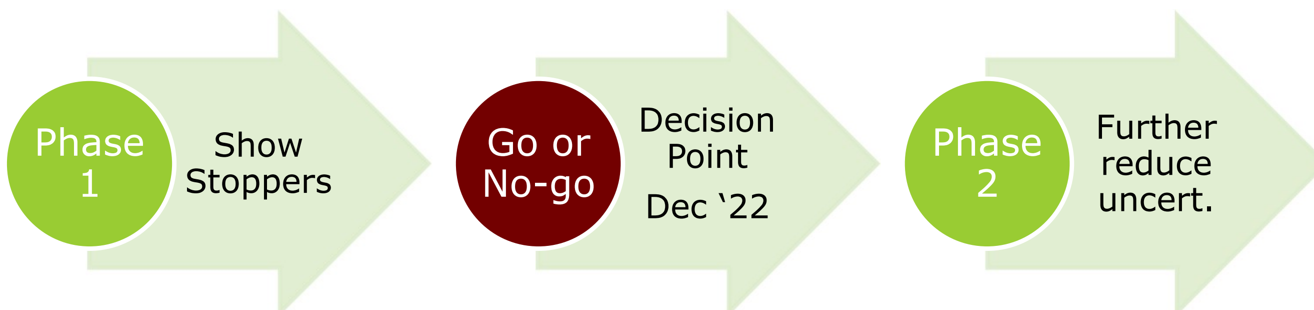



*Capacity estimated by Bergmo and Anthonsen, 2014*

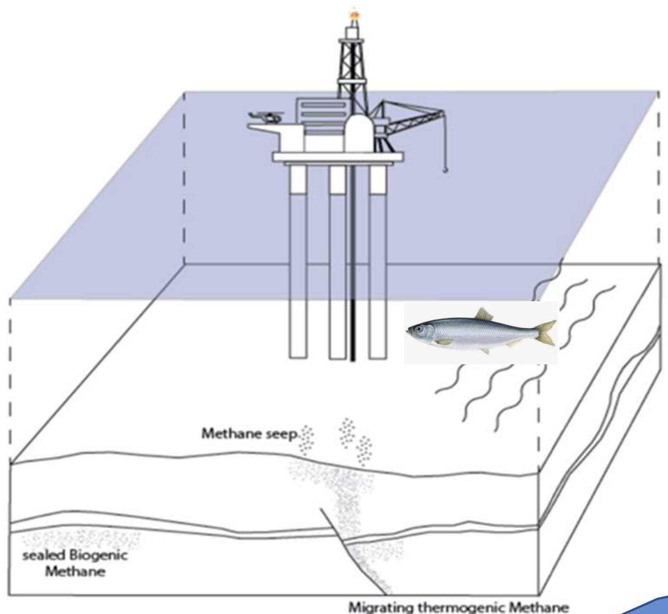
**Challenge:**

*If injecting $CO_2$ into the chalk reservoirs;*

- *will the rock retain is strength?*
- *will there be dissolution effecting the injectivity?*

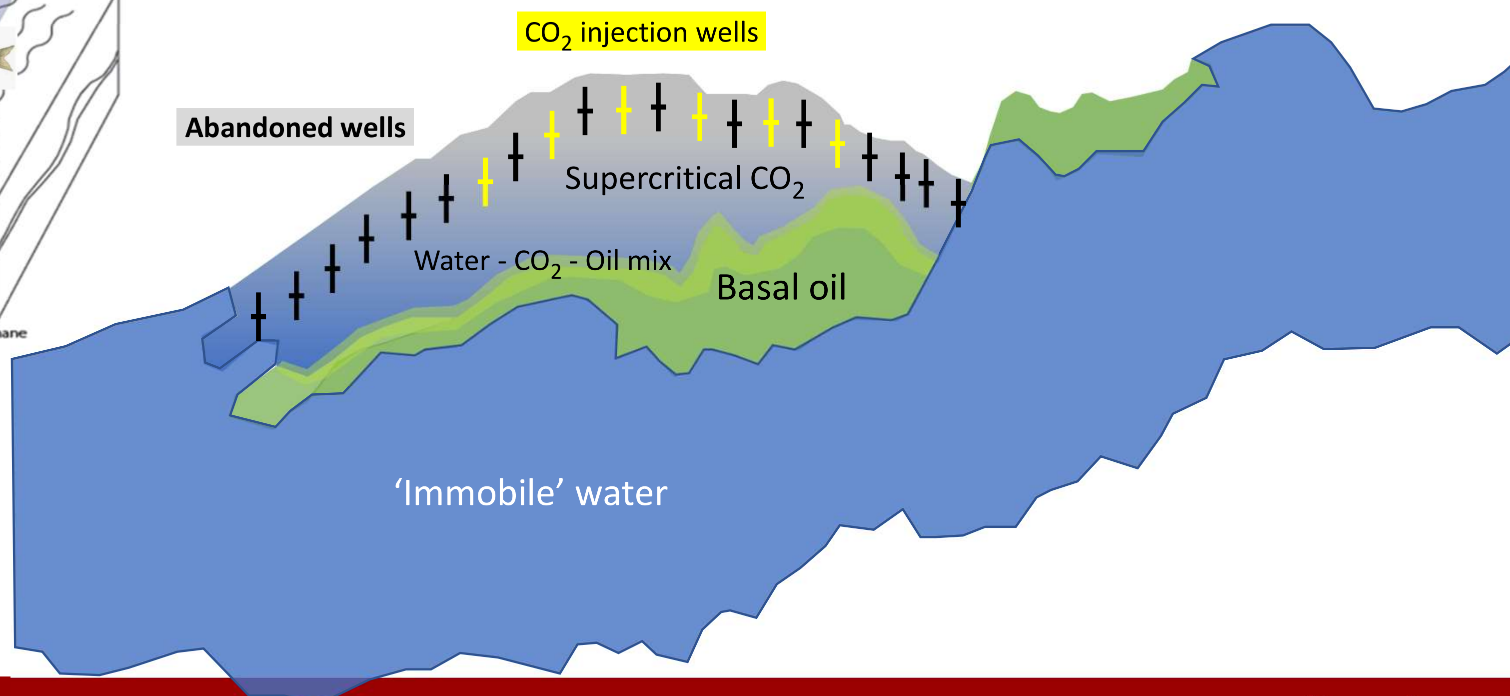
# Monitoring $CO_2$ storage complex




*Drawing by Lasse Prins, GEUS*

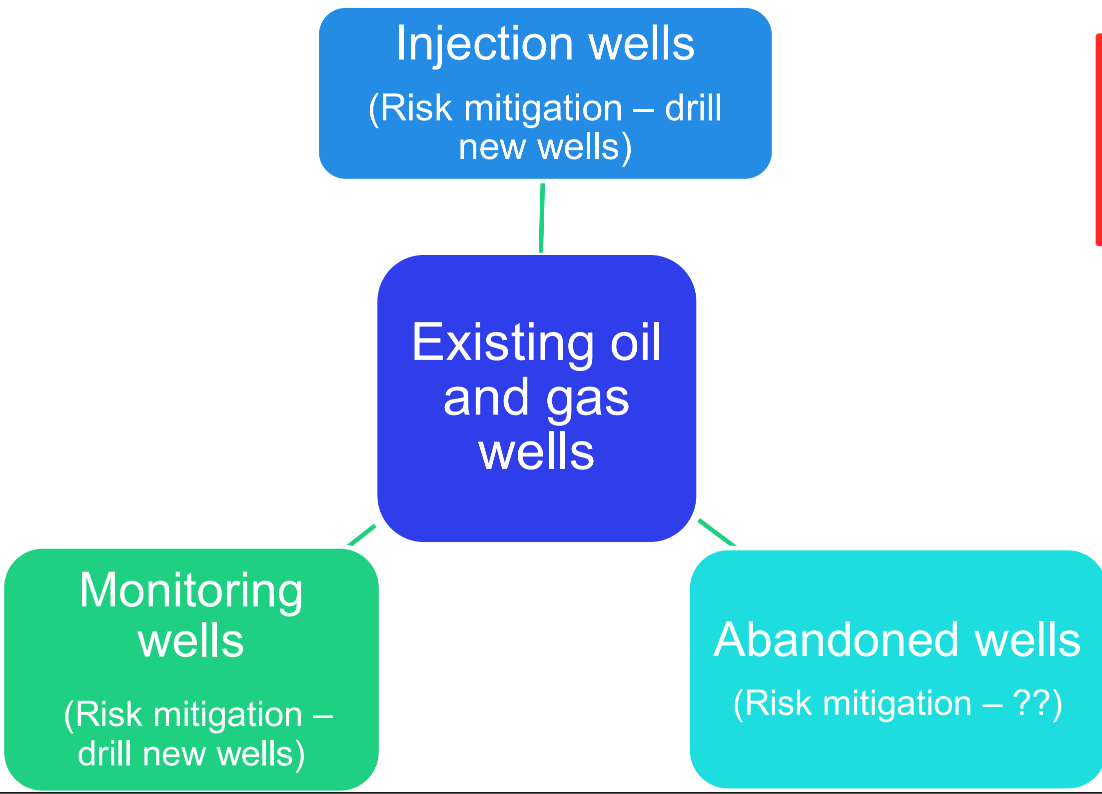
Requirement for monitoring containment – *(all storage sites)*:

- Monitor for $CO_2$ leaks and understand baseline
- Model and verify presence of $CO_2$ plume



# Fate of existing wells vs Potential Risks

## *Potential risk of leaks through abandoned wells*




Using existing wells makes it possible to select wells with history of good annular history

*(ref. Earth-Science Reviews: 'Challenges and enablers for large-scale $CO_2$ storage in chalk formations')*

Key remaining risk is the abandonment of existing wells

***Keep in mind that the abandonment will have to be performed anyway – focus on incremental risk***

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# How do we define zero leak rate?

ELSEVIER
International Journal of Greenhouse Gas Control
Volume 2, Issue 3, July 2008, Pages 289-296

## A perturbation analysis of the climate benefit from geosequestration of carbon dioxide

I.G. Enting [a], D.M. Etheridge [b, c], M.J. Fielding [a, 1]

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### Abstract

A simple climate model is used to calculate the benefit, over time, of geosequestration of $CO_2$ that would otherwise be released to the atmosphere. The analysis is performed relative to two reference cases. The first case is defined by a $CO_2$ concentration profile leading to stabilisation at 500 ppm. The second case is defined by 'business-as-usual' (IS92a) $CO_2$ emissions until 2100. The benefits are considered in terms of incremental change (per unit of displaced emission) in temperature and its rate of change, concentrating on the period to 2200. An automatic differentiation procedure has proved a convenient way of performing the calculations. The 'temperature benefit' of avoided carbon emission is found to be of order 1 mK/GtC on the time-scale of decades to centuries. This result is model-specific and would scale in proportion to the climate sensitivity of the model. Because of non-linearities in carbon-climate processes, the results have a small dependence (of order 10–20%) on the future emission scenario with a rather smaller contribution to uncertainty arising from model calibration uncertainties that reflect uncertainties in the 20th century carbon budget.

Analysis over the longer term, to 2500, considers the effect of leakage of geologically stored $CO_2$ to the atmosphere, and shows that even at 0.1% per annum leakage, about half the climate benefit remains after 500 years.

- Potential storage site with such fault would be rule out
- Can we use the findings when trying to put a potential well leak in prospective?
- A fault might not be easy to monitor – but a well might be easier

## 420,000 year assessment of fault leakage rates shows geological carbon storage is secure

Johannes M. Miocic, Stuart M. V. Gilfillan, Norbert Frank, Andrea Schroeder-Ritzrau, Neil M. Burnside & R. Stuart Haszeldine

*Scientific Reports* **9**, Article number: 769 (2019) | Cite this article



An Author Correction to this article was published on 20 February 2020

This article has been updated

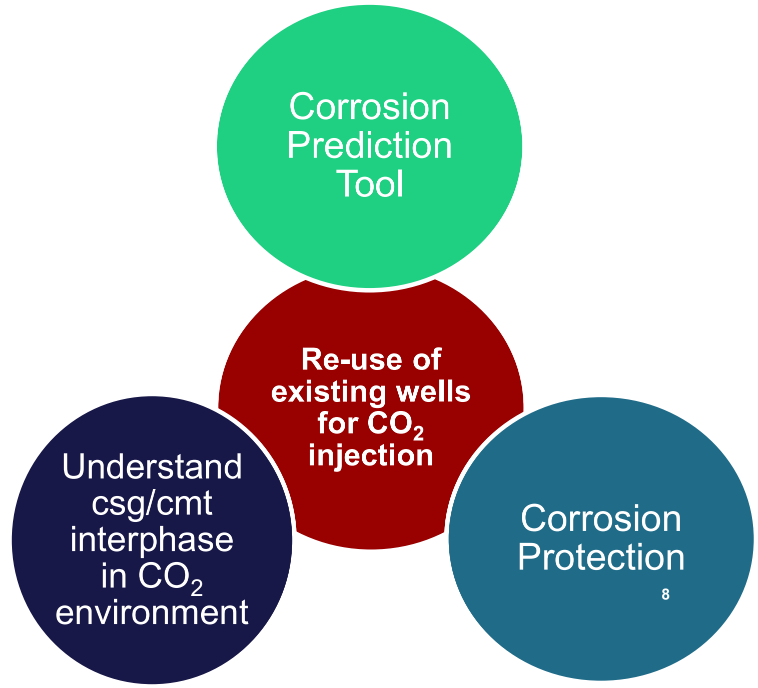
### Abstract

Carbon capture and storage (CCS) technology is routinely cited as a cost effective tool for climate change mitigation. CCS can directly reduce industrial $CO_2$ emissions and is essential for the retention of $CO_2$ extracted from the atmosphere. To be effective as a climate change mitigation tool, $CO_2$ must be securely retained for 10,000 years (10 ka) with a leakage rate of below 0.01% per year of the total amount of $CO_2$ injected. Migration of $CO_2$ back to the atmosphere via leakage through geological faults is a potential high impact risk to $CO_2$ storage integrity. Here, we calculate for the first time natural leakage rates from a 420 ka paleo-record of $CO_2$ leakage above a naturally occurring, faulted, $CO_2$ reservoir in Arizona, USA. Surface travertine ($CaCO_3$) deposits provide evidence of vertical $CO_2$ leakage linked to known faults. U-Th dating of travertine deposits shows leakage varies along a single fault and that individual seeps have lifespans of up to 200 ka. Whilst the total volumes of $CO_2$ required to form the travertine deposits are high, time-averaged leakage equates to a linear rate of less than 0.01%/yr. Hence, even this natural geological storage site, which would be deemed to be of too high risk to be selected for engineered geologic storage, is adequate to store $CO_2$ for climate mitigation purposes.

# Re-use of existing wells for $CO_2$ injection

**Value of re-use**

Both cost reduction and reduced environmental impact

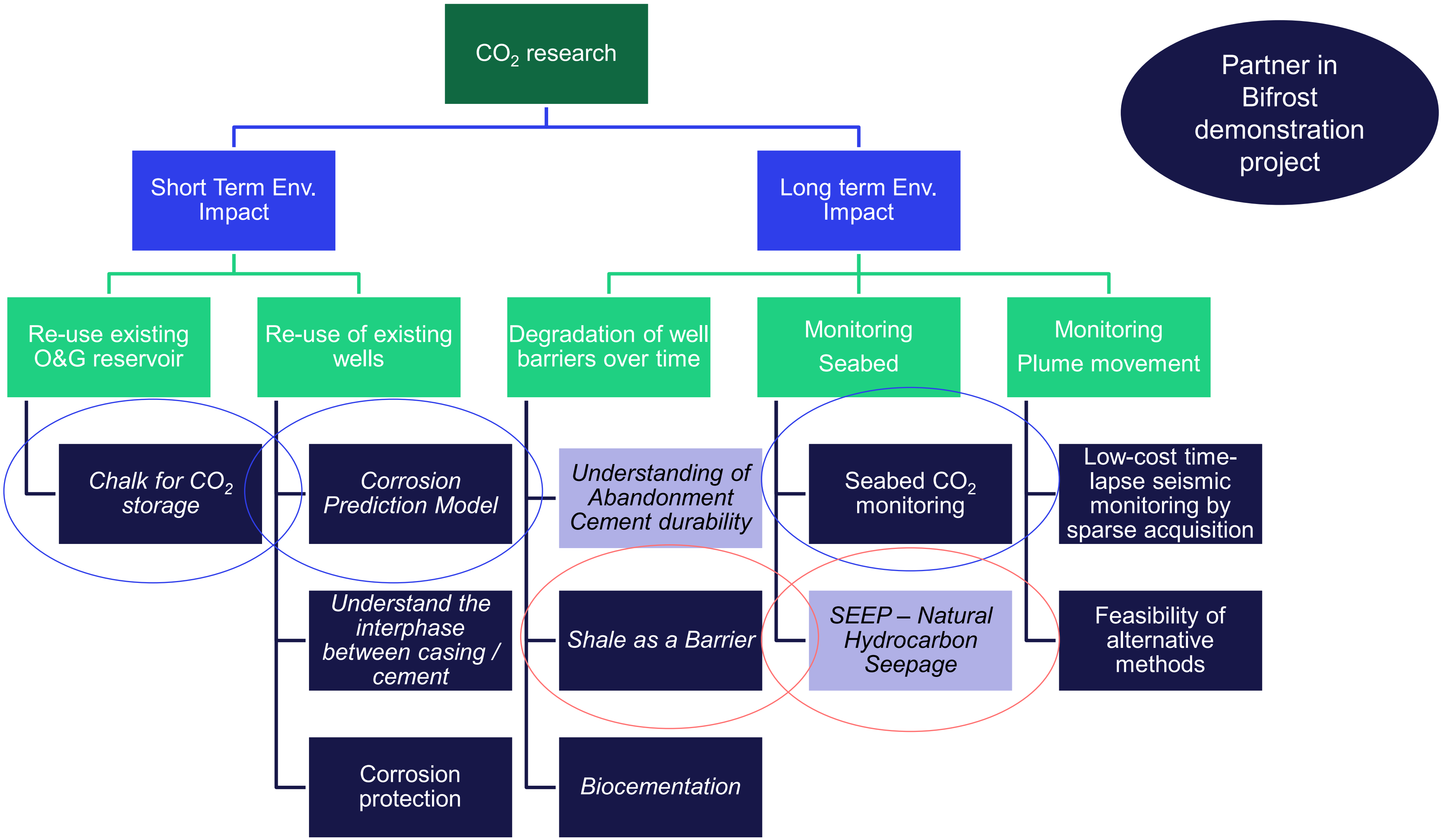



## Challenge:

*Drilling new wells for $CO_2$ injection require both large amount of material and results in emissions from the actual drilling operation.*

*In addition, using existing wells with long history for good barrier integrity might reduce risk for future risks.*

*However, existing wells are not designed for $CO_2$ environment.*



CO2 research
Short Term Env. Impact
Long term Env. Impact
Re-use existing O&G reservoir
Re-use of existing wells
Degradation of well barriers over time
Monitoring Seabed
Monitoring Plume movement
Chalk for CO2 storage
Corrosion Prediction Model
Understanding of Abandonment Cement durability
Seabed CO2 monitoring
Low-cost time-lapse seismic monitoring by sparse acquisition
Understand the interphase between casing / cement
Shale as a Barrier
SEEP – Natural Hydrocarbon Seepage
Feasibility of alternative methods
Corrosion protection
Biocementation
Partner in Bifrost demonstration project