Use of existing infrastructure and knowledge: Examples from Northern Lights project

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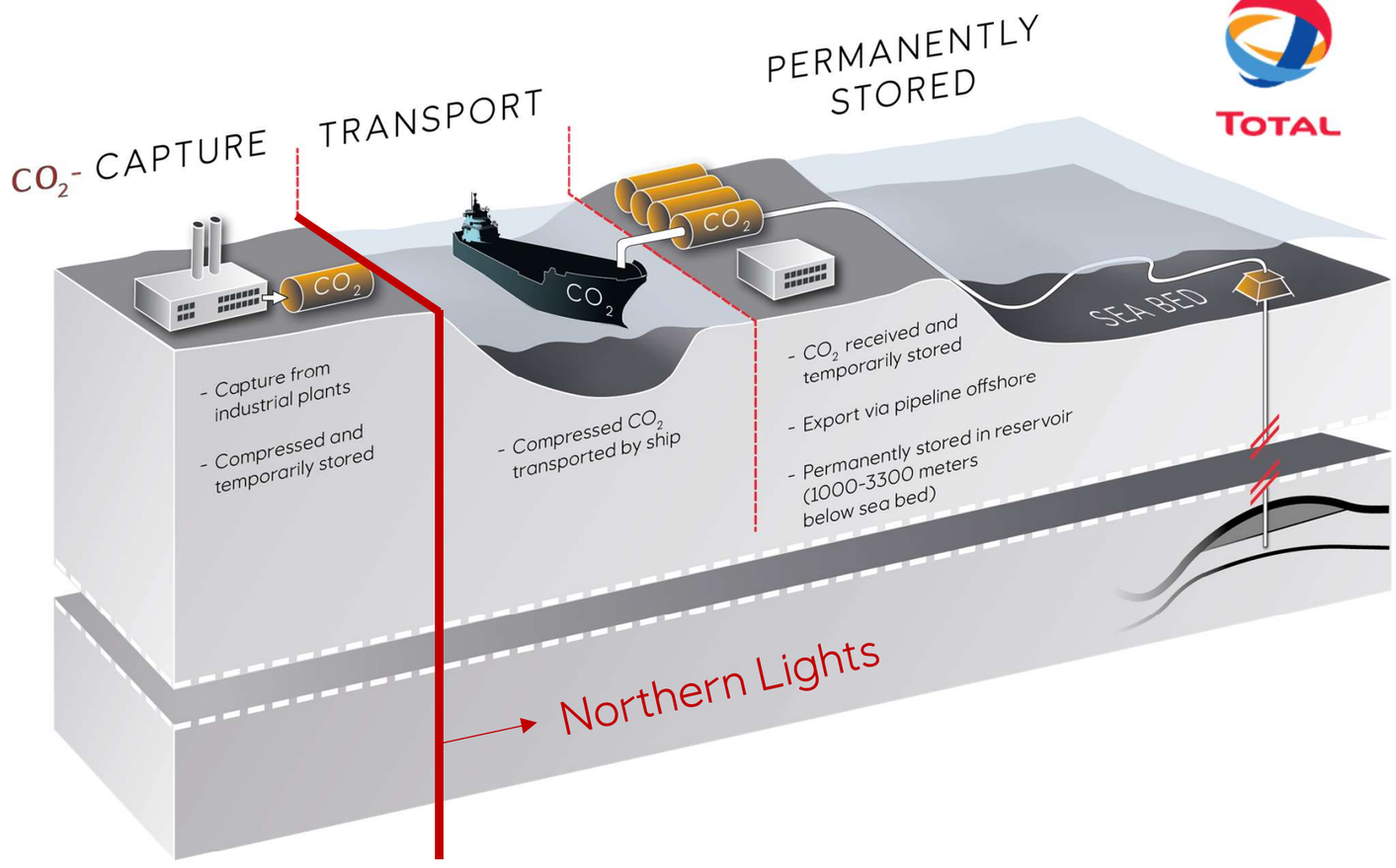
Using material from Northern Lights project team and Equinor R&T Storage scale-up team

Northern Lights Overview

Setting:

- The Northern Lights project is focused on CO_2 captured from industrial sites
- The project will use saline aquifer storage
- However, the project benefits from technology and insights acquired though oil and gas activities

Question?
How can the CCS industry benefit from the oil and gas industry

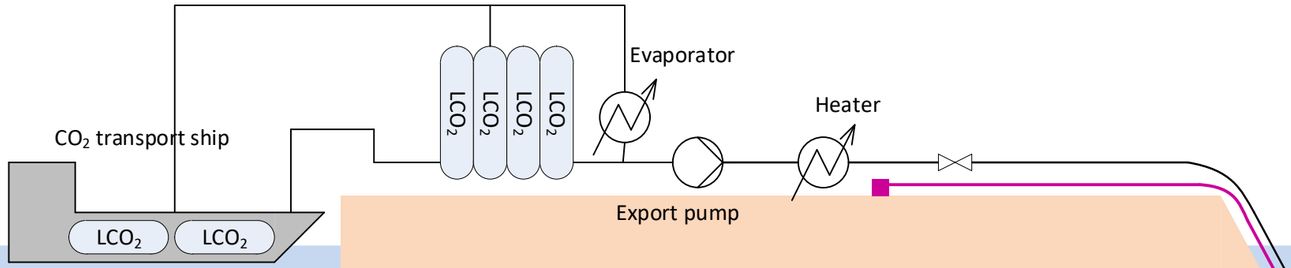


So what are we learning for CCS and how does it save on costs?

Technology arena	What benefits?	What cost savings?
Surface infrastructure	Huge leanings from oil and gas operations	Very substantial
Wells	Slightly modified standard well technology	Substantial
Exploration	Use of exploration well databases, 3D seismic and geological knowledge	Nearly priceless!
Reservoir technology	Modified reservoir modelling tools and approaches	Substantial

Northern Lights Infrastructure

Shipping, pipeline and well technology are all based on oil and gas technology



Ship
- One ship per capture site
- 7,500m^3 of CO_2 per ship

Pipeline
- 110km 12 inch pipeline

Subsea structure

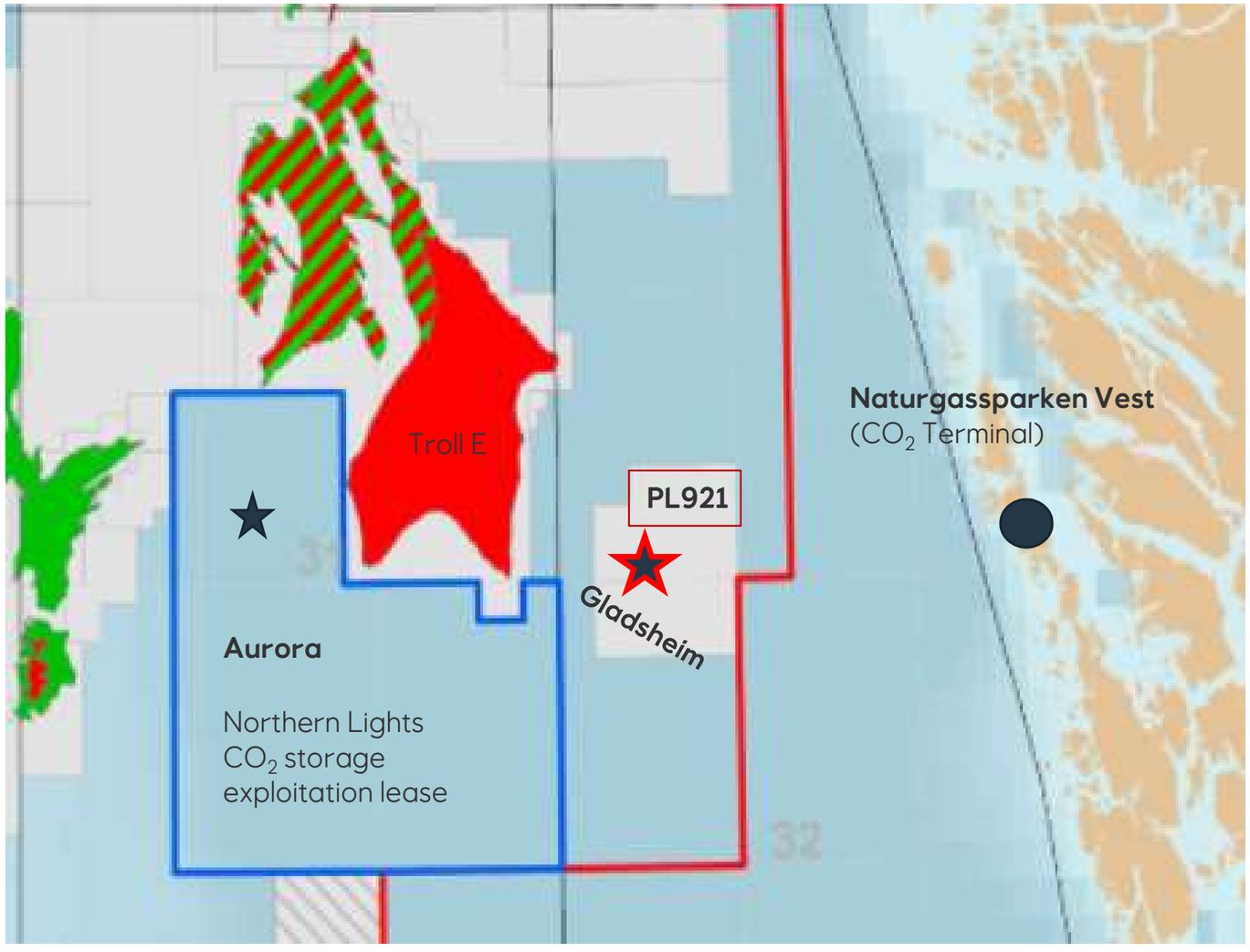
Umbilical

Subsea injection well
- Injection of CO_2 into reservoir at ~3000m depth

Capacity (Mt/y)

5	+ ship(s)	Additional jetty, tank and pumping facilities		Additional well(s)
1.5	2 x ship 1 x ship	Onshore facilities	Pipeline	1 x injection well (tbc)

CO_2 storage exploration 'piggy-backed' on HC exploration



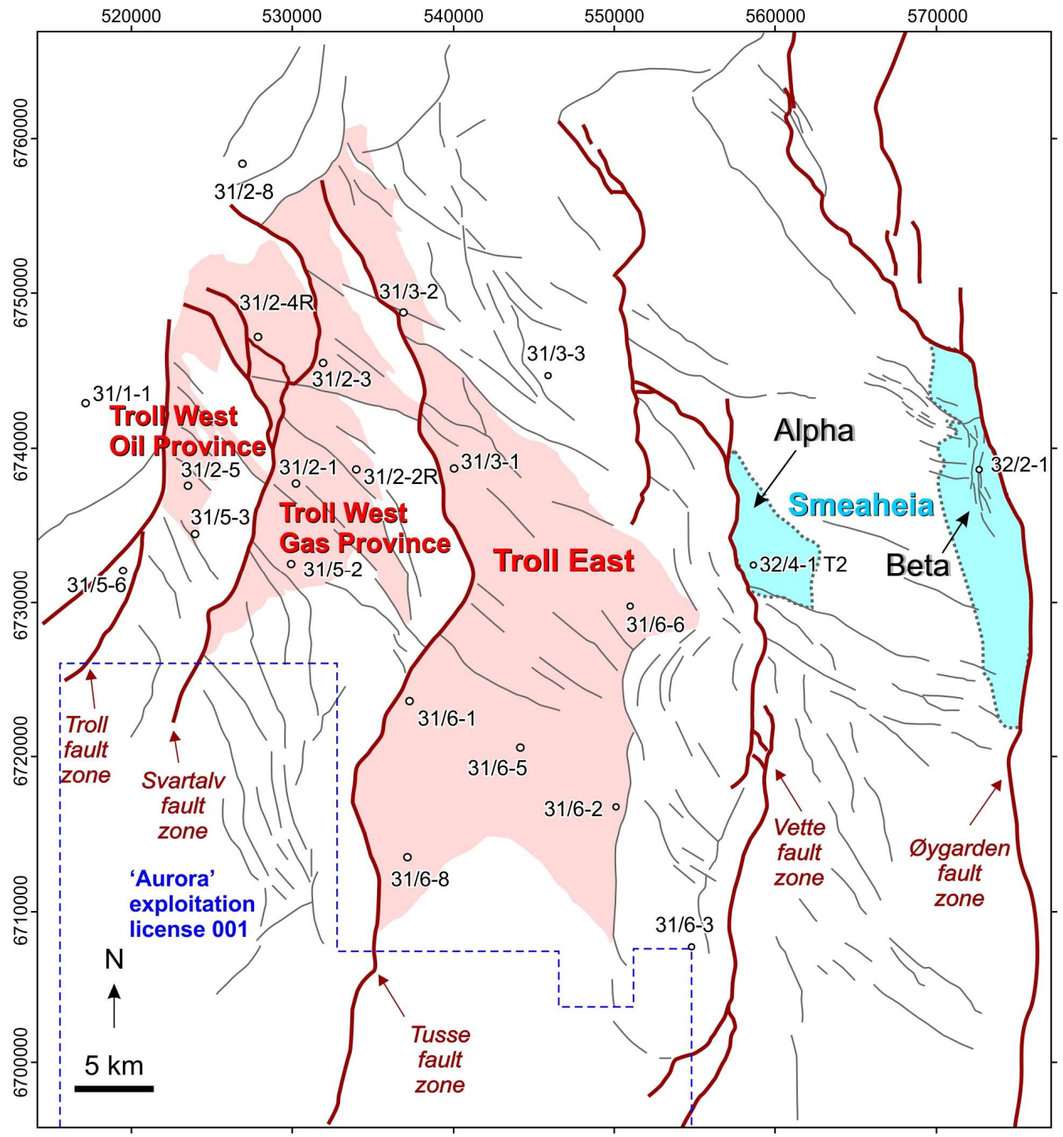
- Equinor and license partners drilled exploration well 32/4-2 in PL921 in August 2019
- The main target was petroleum exploration
- A CO_2 data acquisition programme was added with agreement of partners
- No hydrocarbons were found
- The well confirmed good saline aquifer storage potential

Quantifying storage risks

In support of the Northern Lights project and for future storage scale up, Equinor and many partners are working on:

- Fault mapping from seismic
- Fault Seal and fault permeability
- Pressure communication
- 3D geological modelling
- Geomechanics and strain
- Micro-seismic monitoring
- Flow simulation

Uses seismic datasets and wells to develop a CO_2 storage play alongside an historic hydrocarbon play



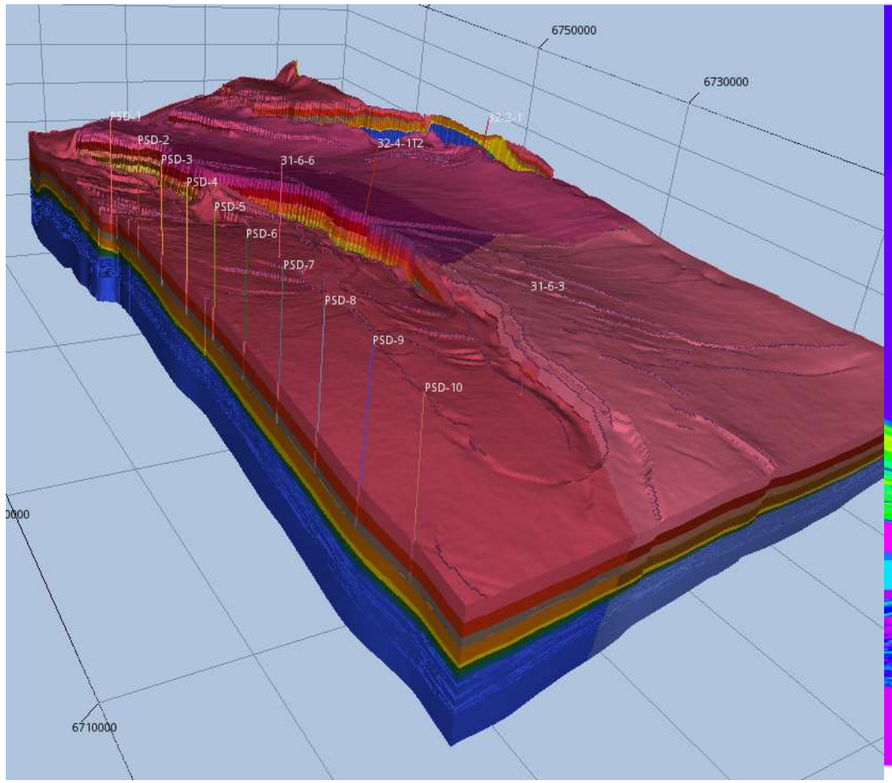
Long Wu et al (2019), EAGE Fault & Top Seal Conference

Reservoir modelling and simulation

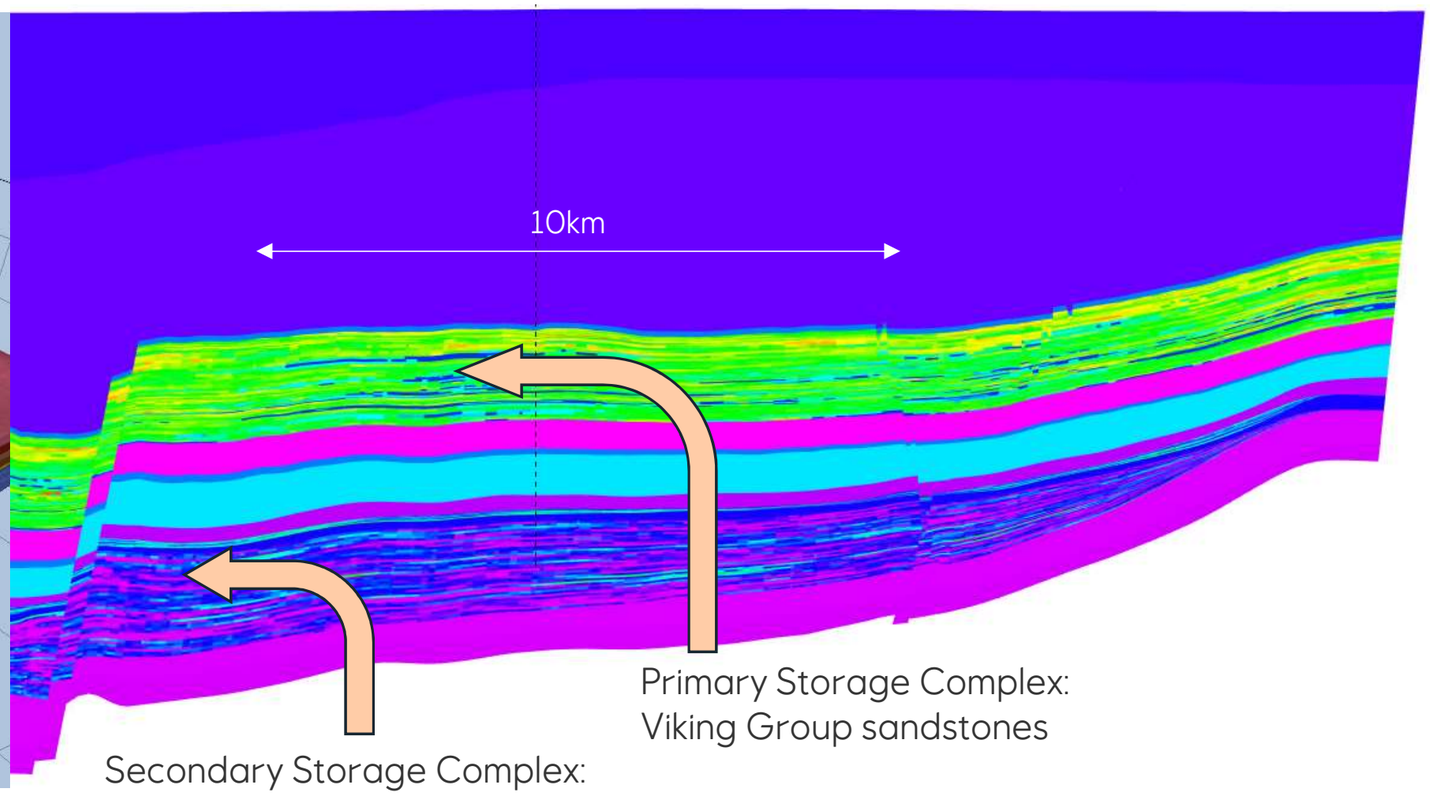
Future storage prospects at Smeaheia being quantified using detailed reservoir models:

- simulation of different injection well concepts and effects of pressure communication across faults

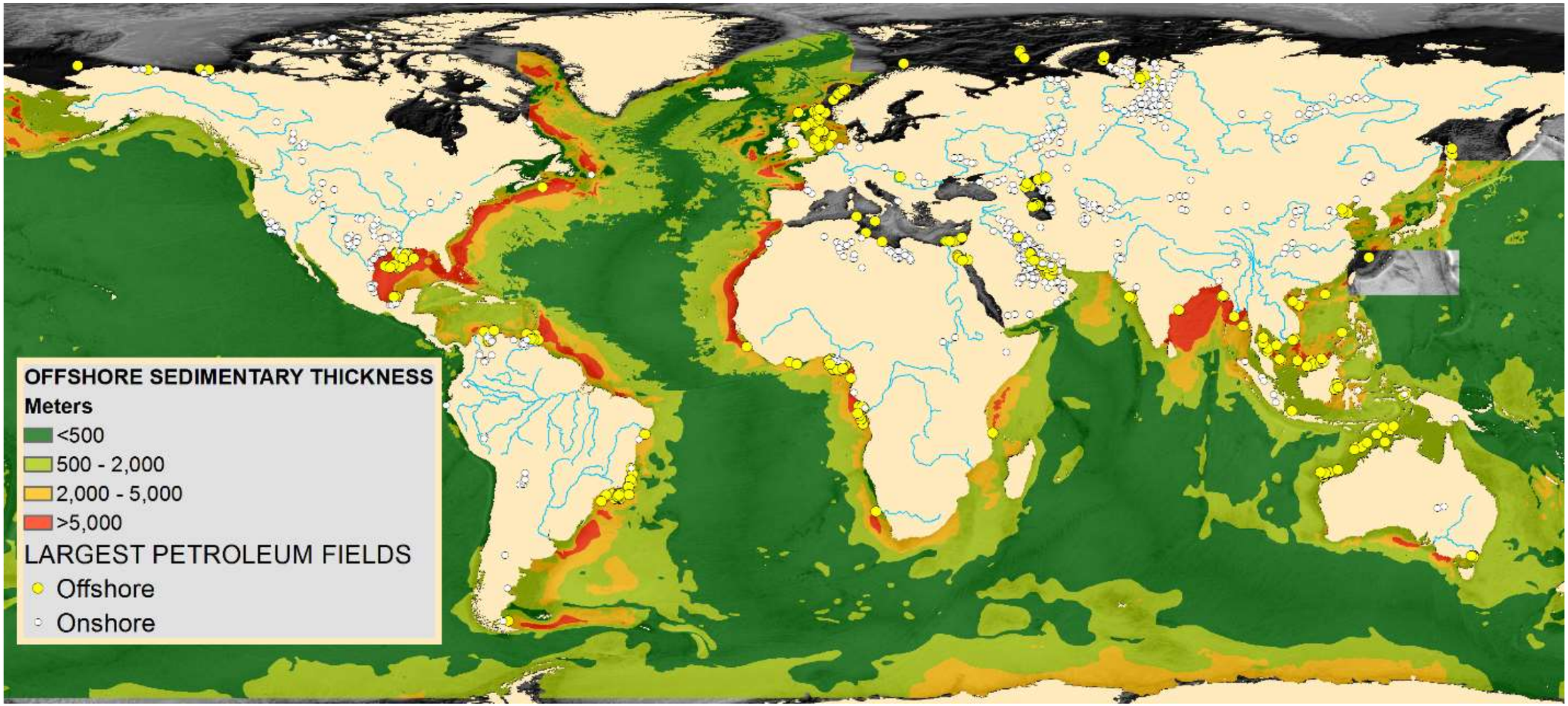
Regional 3D geomodel of Smeahiea prospects



Cross section of property model – Gladsheim prospect



Taking the challenge to the global scale

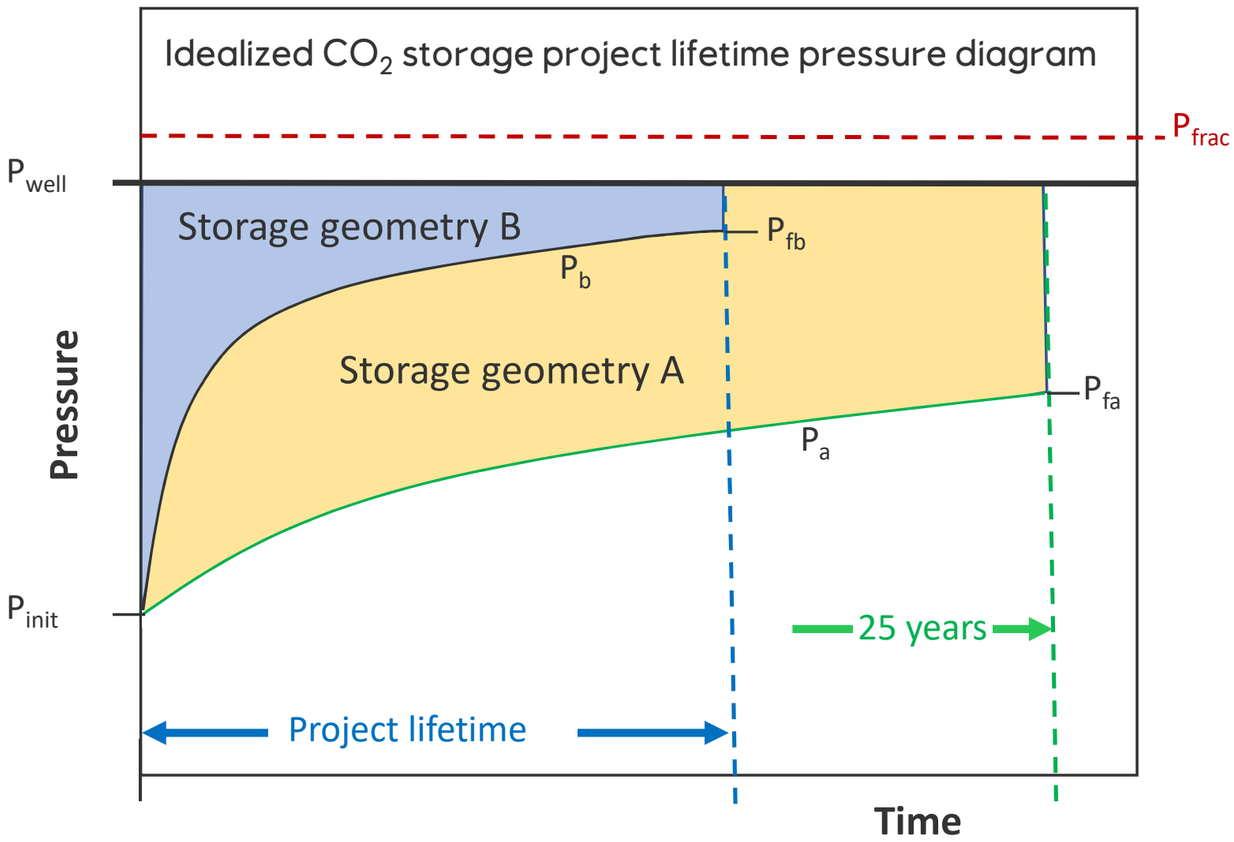


Global distribution and thickness of sediment accumulations on continental margins, with largest oilfields and main river systems (Ringrose & Meckel, 2019, Scientific Reports)

ΔP basin pressure model for global storage development

- Initial and final pressure per well can be used to estimate capacity

Mean capacity is ~17Mt per well



Generic 'basin ΔP' approach:

Integration of the injectivity equation over the project lifetime:

$$V_{project} = I_C \left[p_{well} - p_{init} + \int_i^f A\, p_D(t_D) \right] + F_b$$

where,

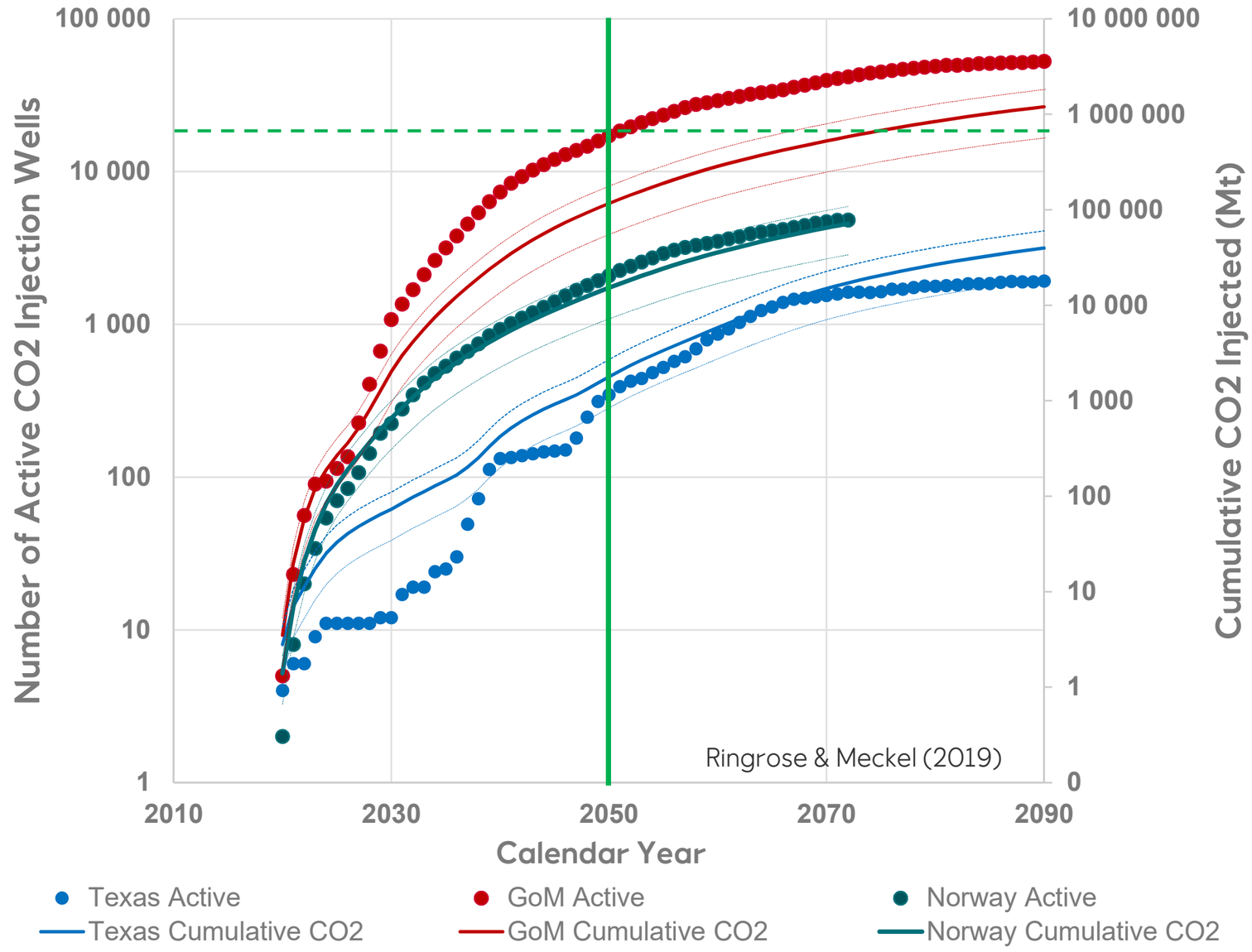
$V_{project}$	= estimated volume stored
I_c	= injectivity
P_{well}	= injection well pressure
P_{init}	= initial reservoir pressure
$Ap_D(t_D)$	= characteristic pressure function
F_b	= volume flux boundary condition

Ringrose & Meckel (2019)

Application of ΔP method to basin-scale developments

- Projected growth of CO_2 injection wells based on historical hydrocarbon well developments.
- Concept captures industrial maturation phases for global CO_2 storage
- Uncertainty range based on bounds (P10 - P90) from empirical injection rates

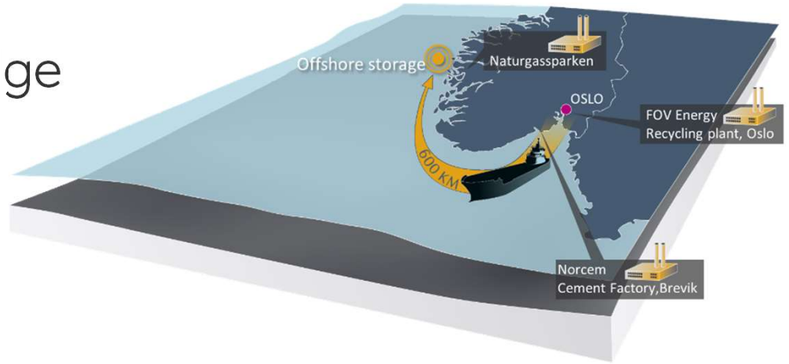
Main finding:
We will need ~12,000 CO_2 injection wells by 2050 to achieve 2DS goal



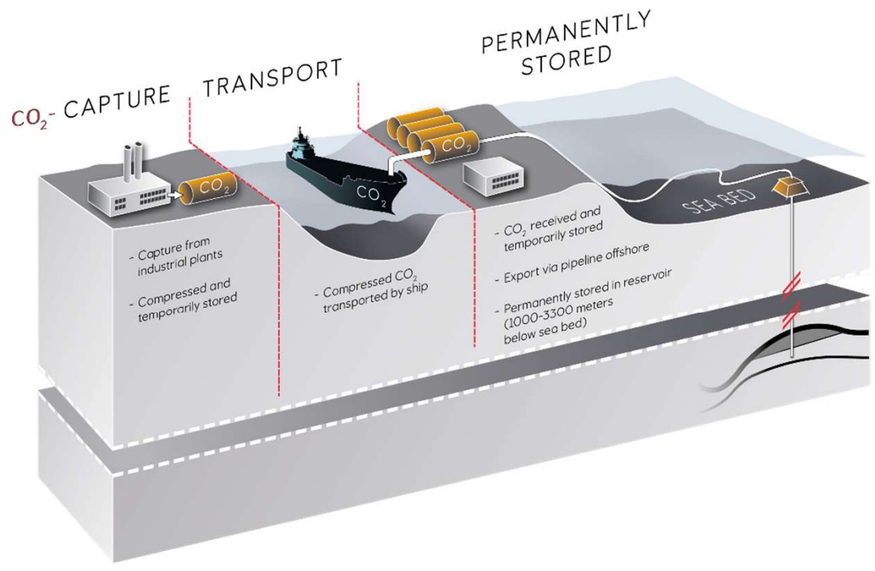
Summary

- CCS projects already making good use of experience and knowledge from hydrocarbon activities:
  - ➢ Infrastructure
  - ➢ Wells
  - ➢ Exploration
  - ➢ Reservoir technology
- We can use this foundation to rapidly and cost-effectively scale up CCS (especially storage)
- Number of wells needed for climate goals (2DS) is small compared to historic oil and gas industry

Northern Lights is an important next step in building out the infrastructure for future CCS



Norwegian full-scale CCS project



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