

Digitizing the CCS value chain

Erik Skjetne, Chief Digital Officer, Northern Lights

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CO₂ transport & storage at scale



NORTHERN LIGHTS SCOPE

CO₂ capture

Capture from industrial plants.
Liquefaction and temporary storage.



Transport

Liquid CO₂
transported by ship.



Receiving terminal

Intermediate onshore storage.
Pipeline transport to offshore
storage location.

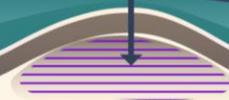


Permanent storage

CO₂ is injected into a saline aquifer.

100 km

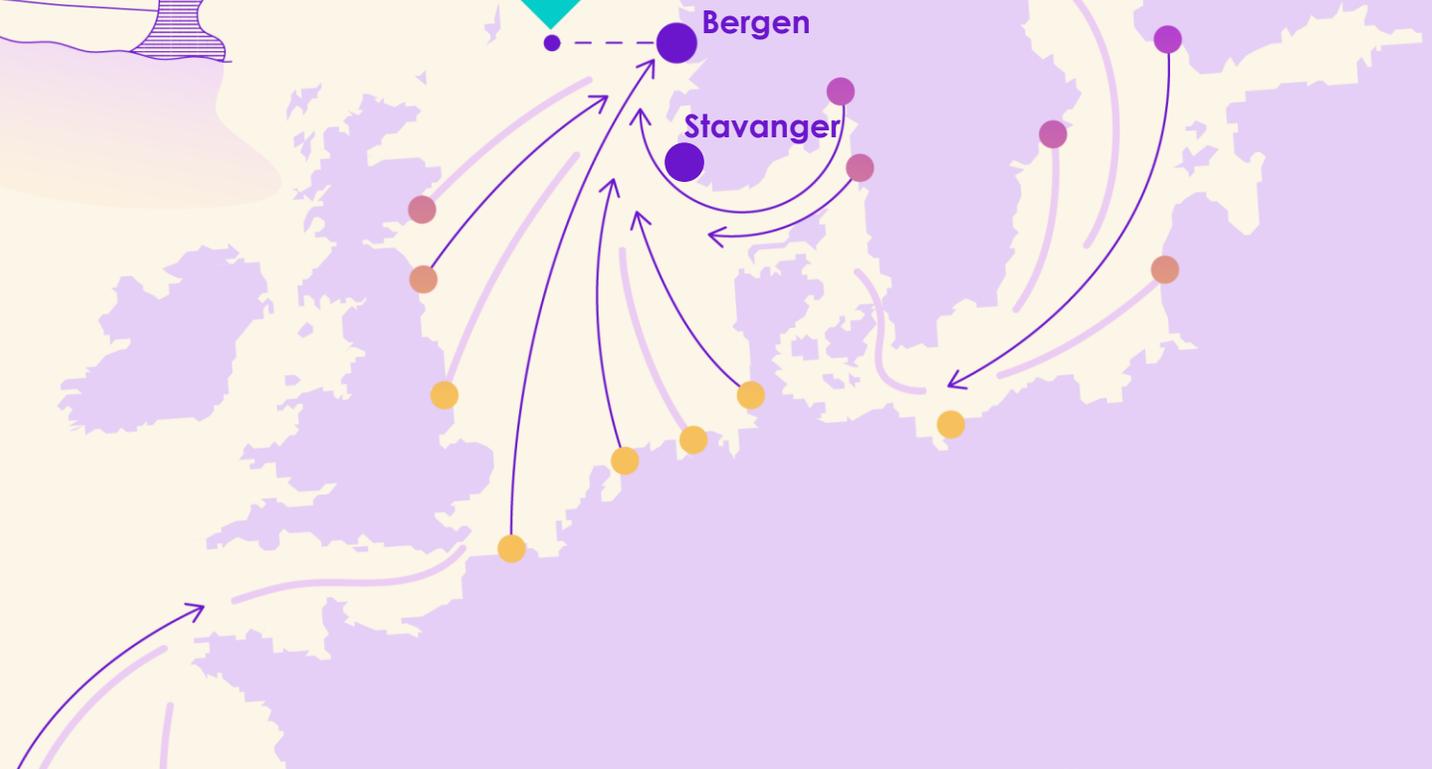
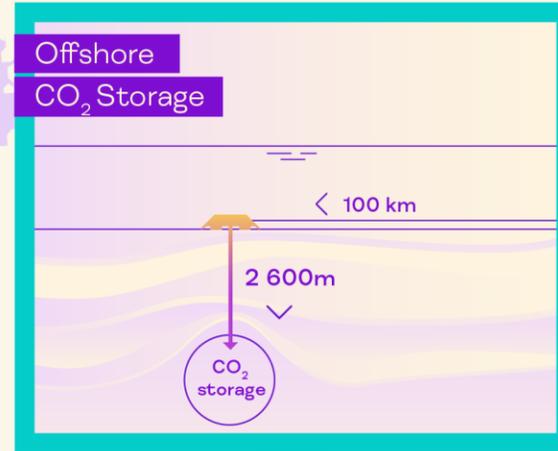
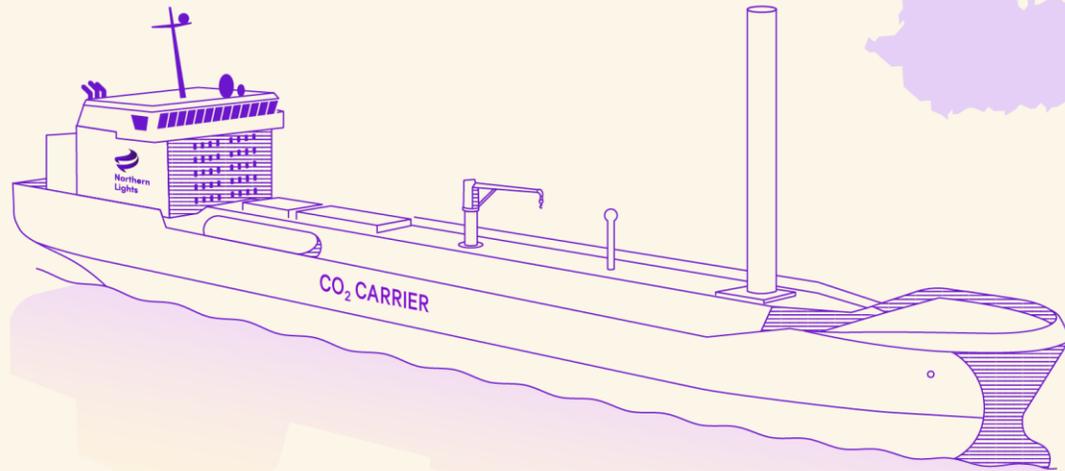
2 600m



In operation by mid-2024



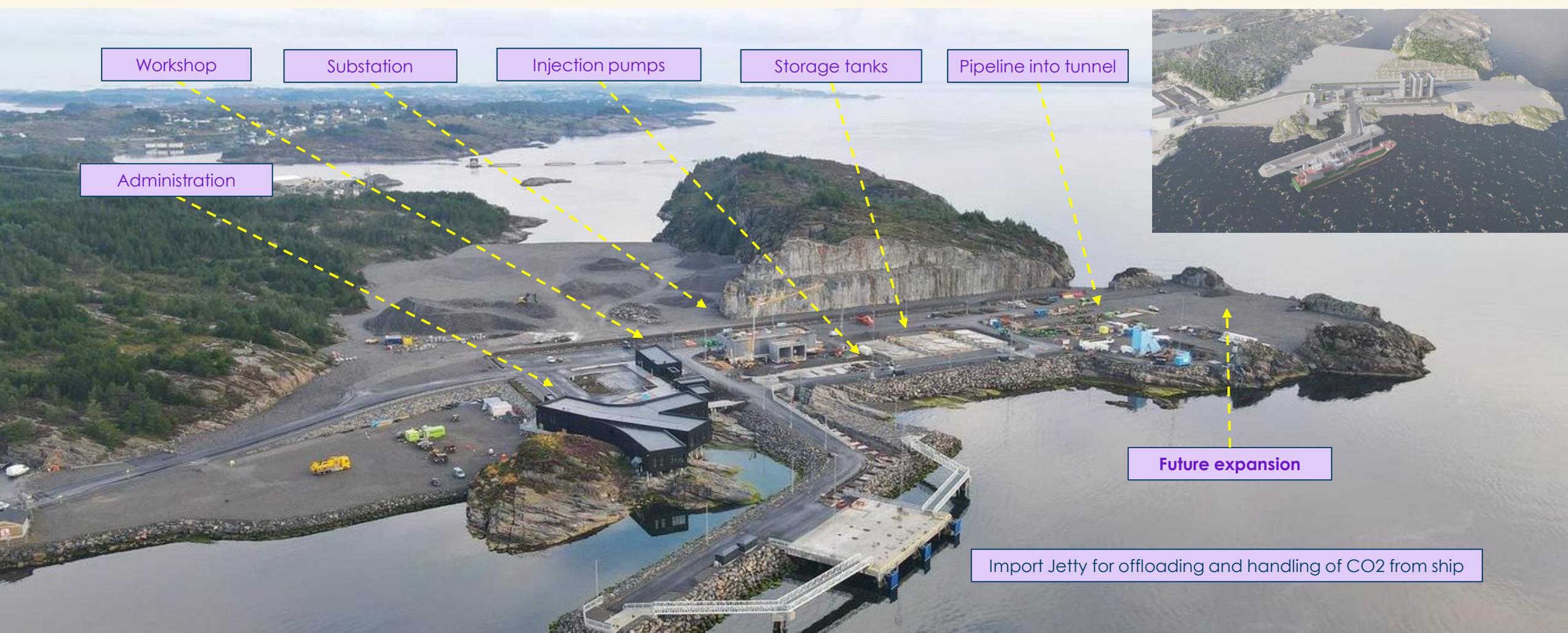
Northern European infrastructure



Becoming a reality



Receiving terminal at Øygarden



Workshop

Substation

Injection pumps

Storage tanks

Pipeline into tunnel

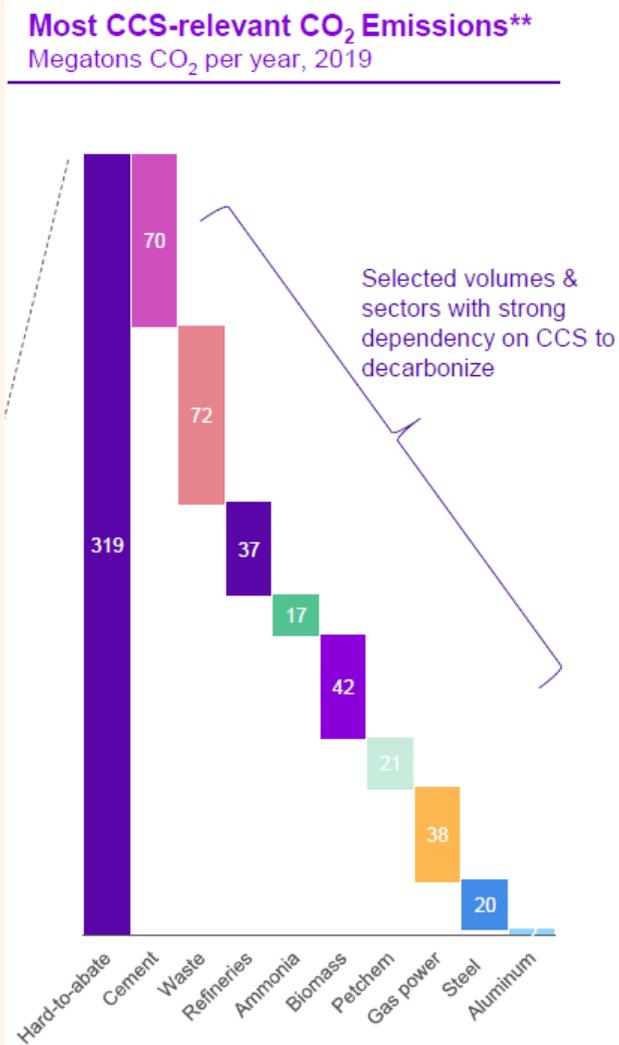
Administration



Future expansion

Import Jetty for offloading and handling of CO2 from ship

Building a market for CO₂ storage



→ **Significant interest and demand for our services**

→ **Focus:**

- Deliver Phase 1, operational in 2024
- Building a commercial business

→ **Secure commercial contracts**

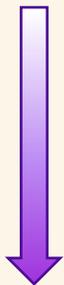
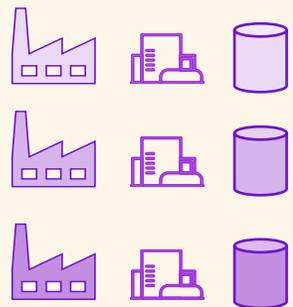
→ **Investment decision for capacity expansion**

→ **Hard to abate emissions from industry in Northern Europe**

- Process industry
- Cement
- Steel
- Waste incineration
- Negative emissions

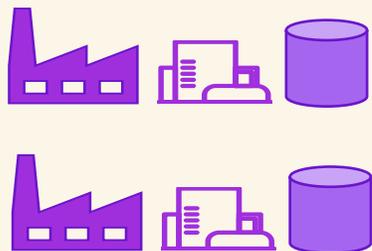
→ **Market potential: 319 Mtpa**

Value Chain

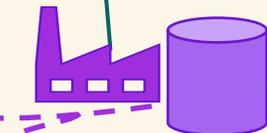


Feed in of New Customers

CO₂ Source-Capture-Storage



Transport



Plant-Storage
Øygarden

Pipeline

100 km



Subsea Template

Wells

2.6 km vertical depth

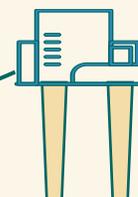
CO₂ Storage



Control room
Sture

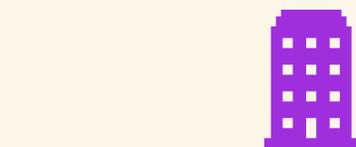
Umbilical

Umbilical



Platform services
Oseberg A

Umbilical



Authorities

Norway, European Union



Northern Lights Office

Stavanger

Interoperable digital CCS value chain

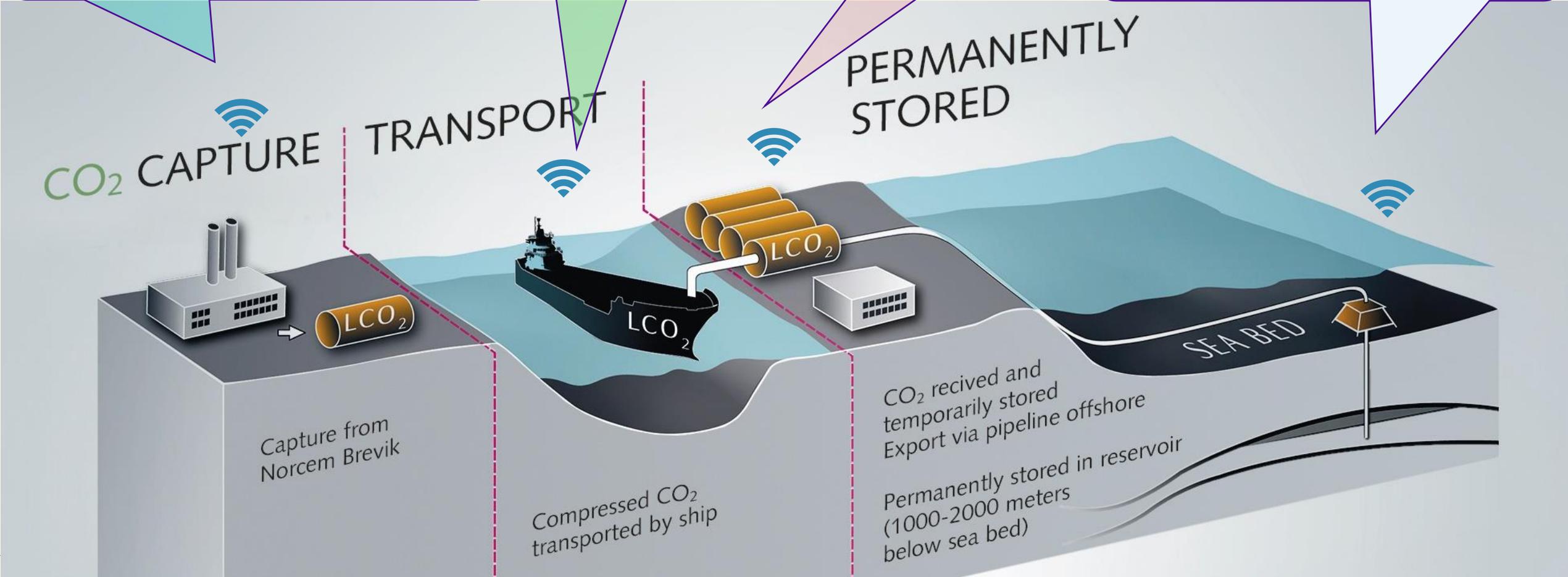


“Vessel 2, I am at 70% of max CO₂ capacity. Please, see my 5 days forecast. When do you pick up CO₂?”

“Plant 5, I will slow down to save fuel. Ready to load in 3 days, OK?”

“Port 1, here are your report for the CO₂ off-loading yesterday”

“Guys, based on AI, I predict the optical fiber switch will fail in 3 months. Suggest to replace while Plant 4 has turnaround, OK?”



Digital CCS value chain

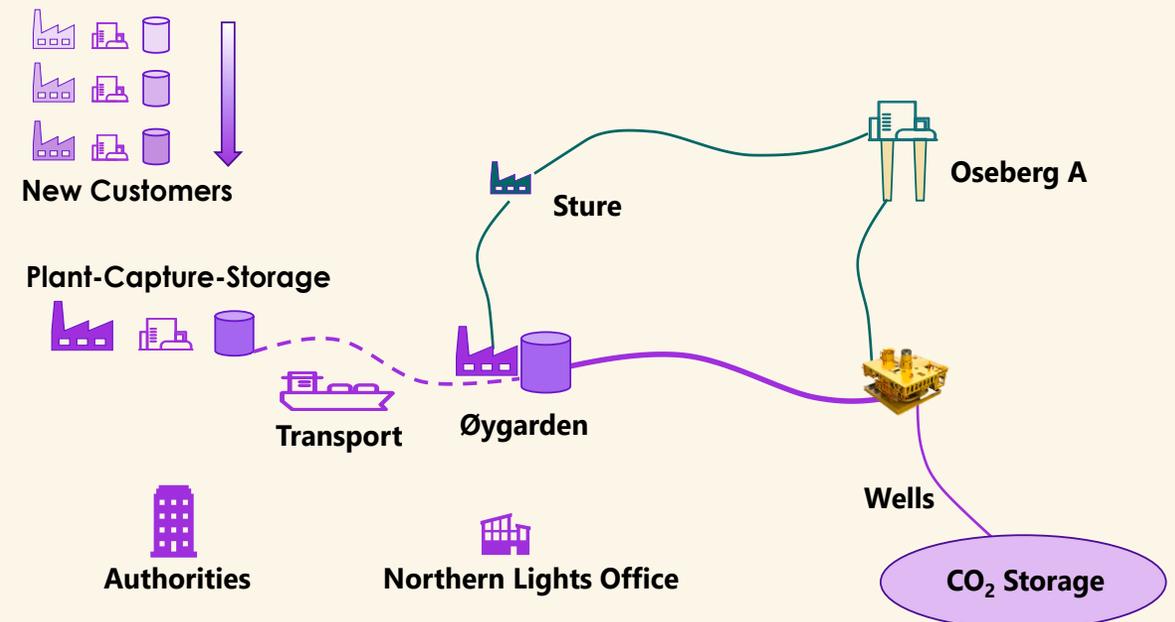
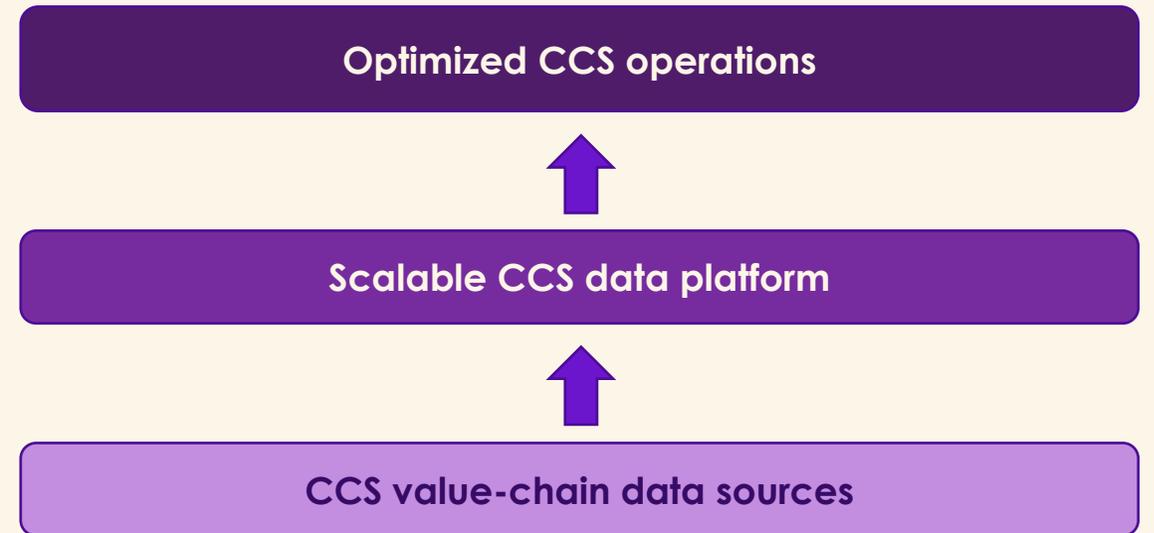


→ Use Case examples

- Automatic reporting
- Logistics simulation & optimization
- Subsurface simulation & optimization

→ Enablers for value-chain optimization

- Sharing data across value chain elements
- Scalable & secure solutions
- Open industry standards



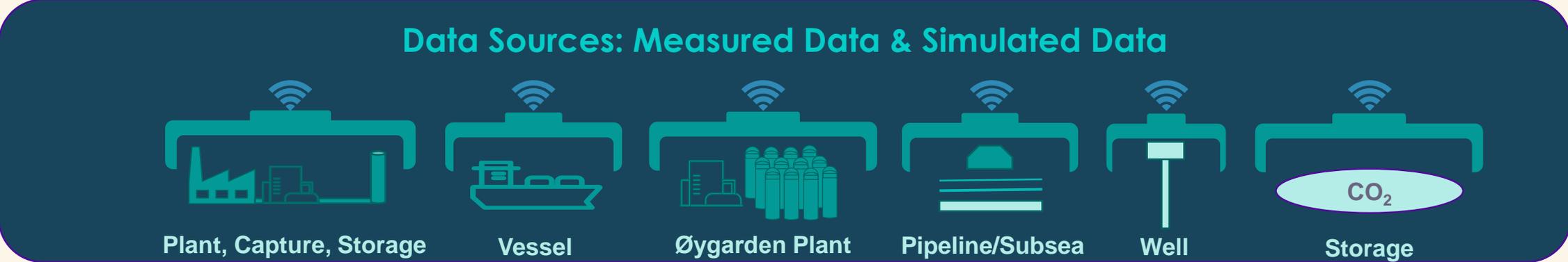
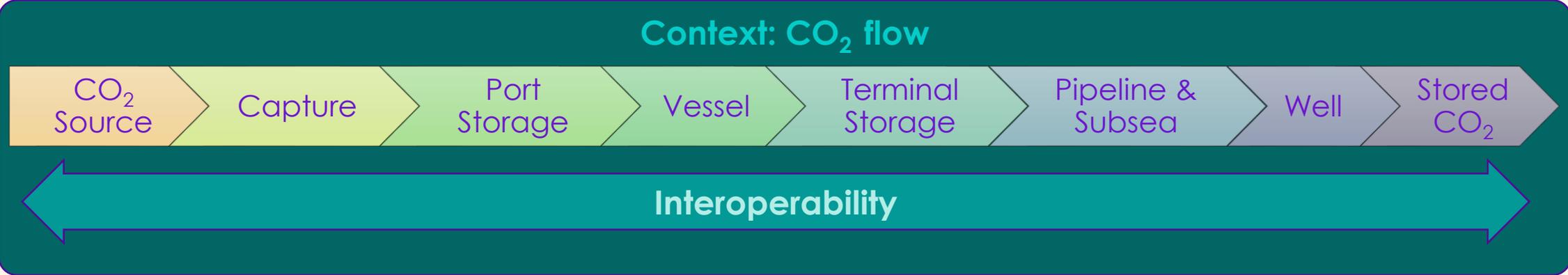
CCS digital ecosystem



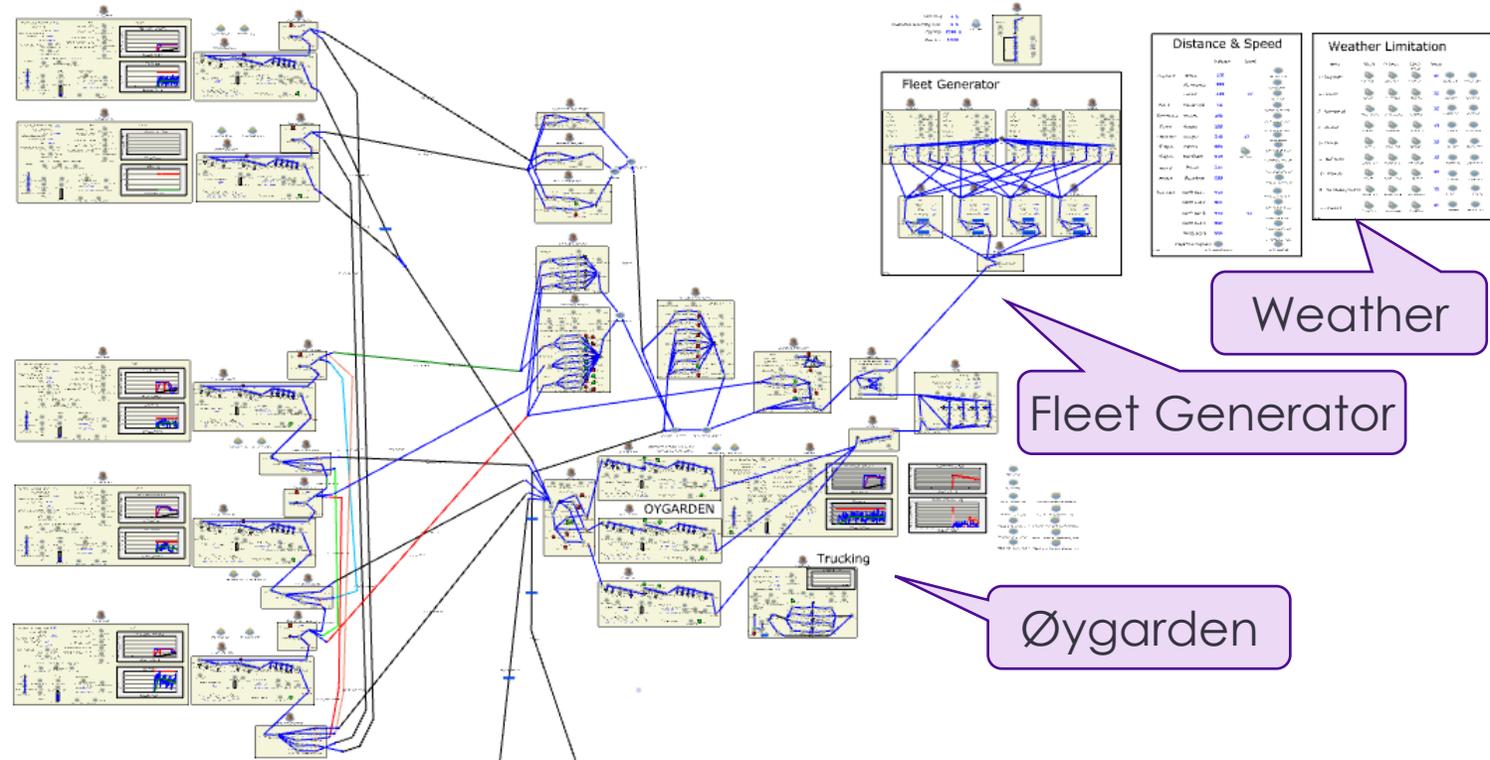
Use Case Value Realization

Business Applications
Independent Software Vendors (ISVs)
Global System Integrator (GSI)

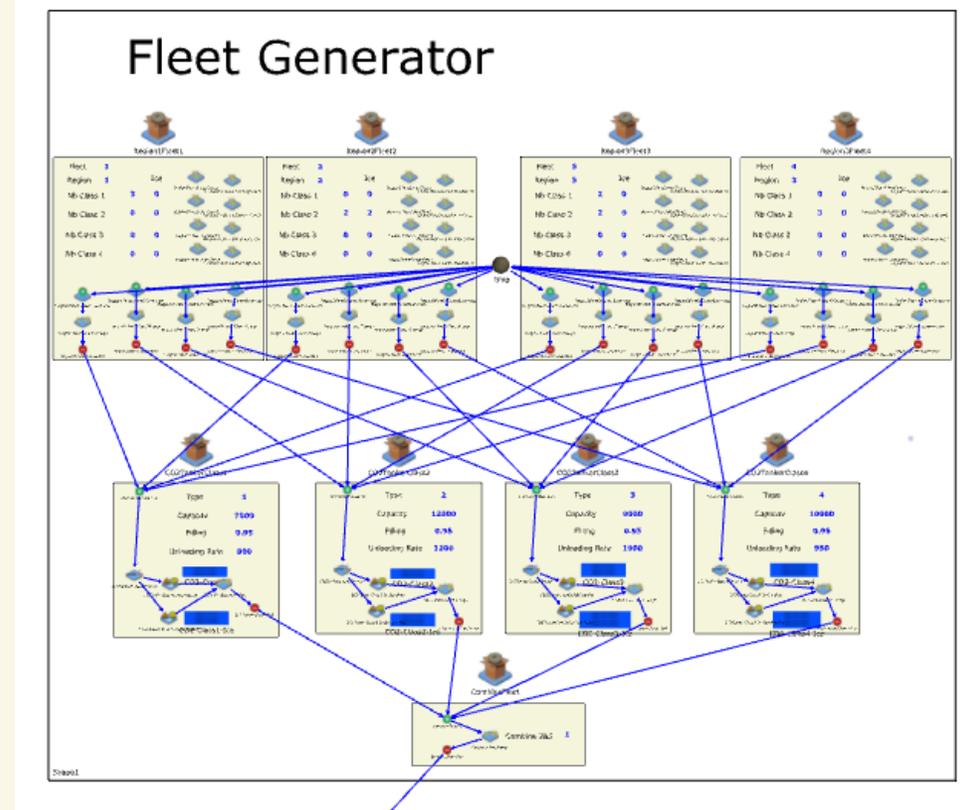
Data Platform Based on Microsoft Azure
Cloud solution



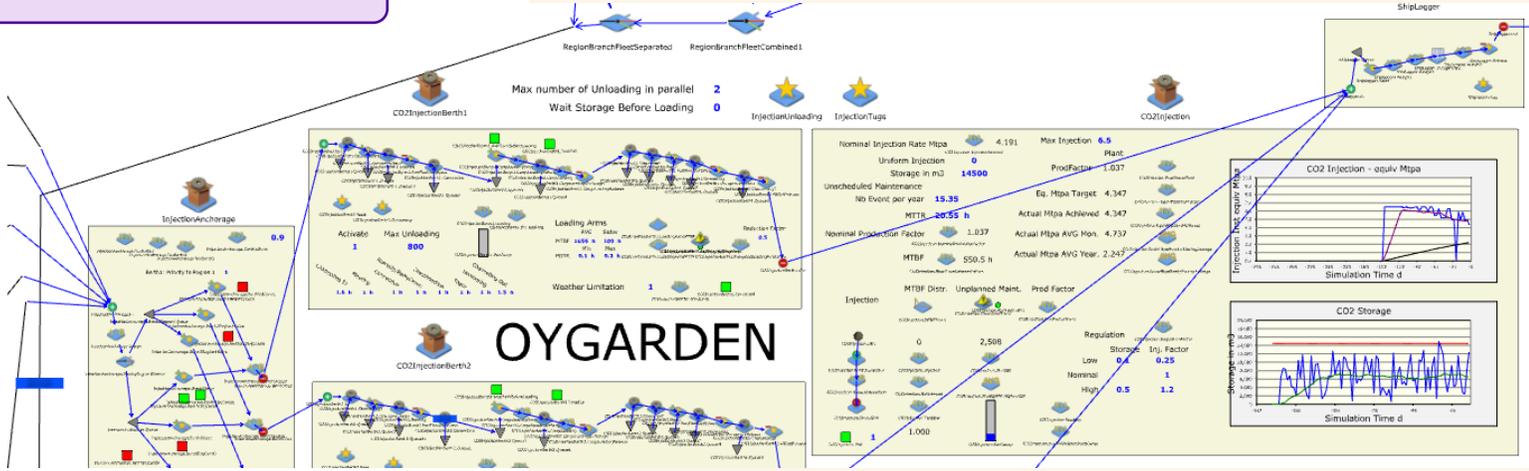
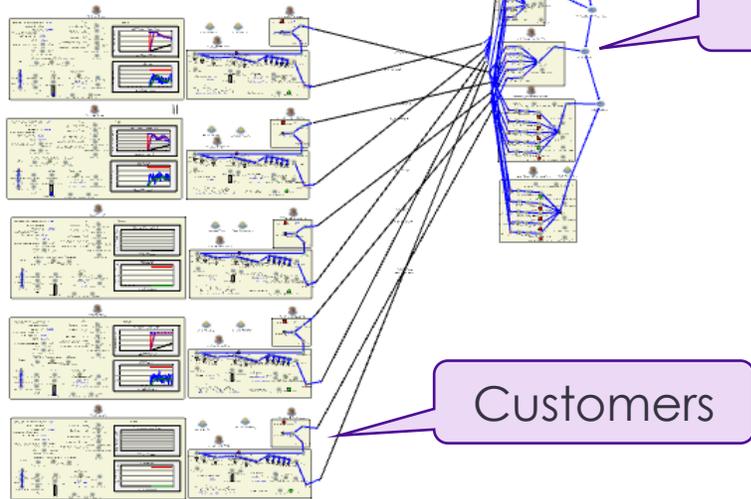
Logistics Simulator: JaamSim



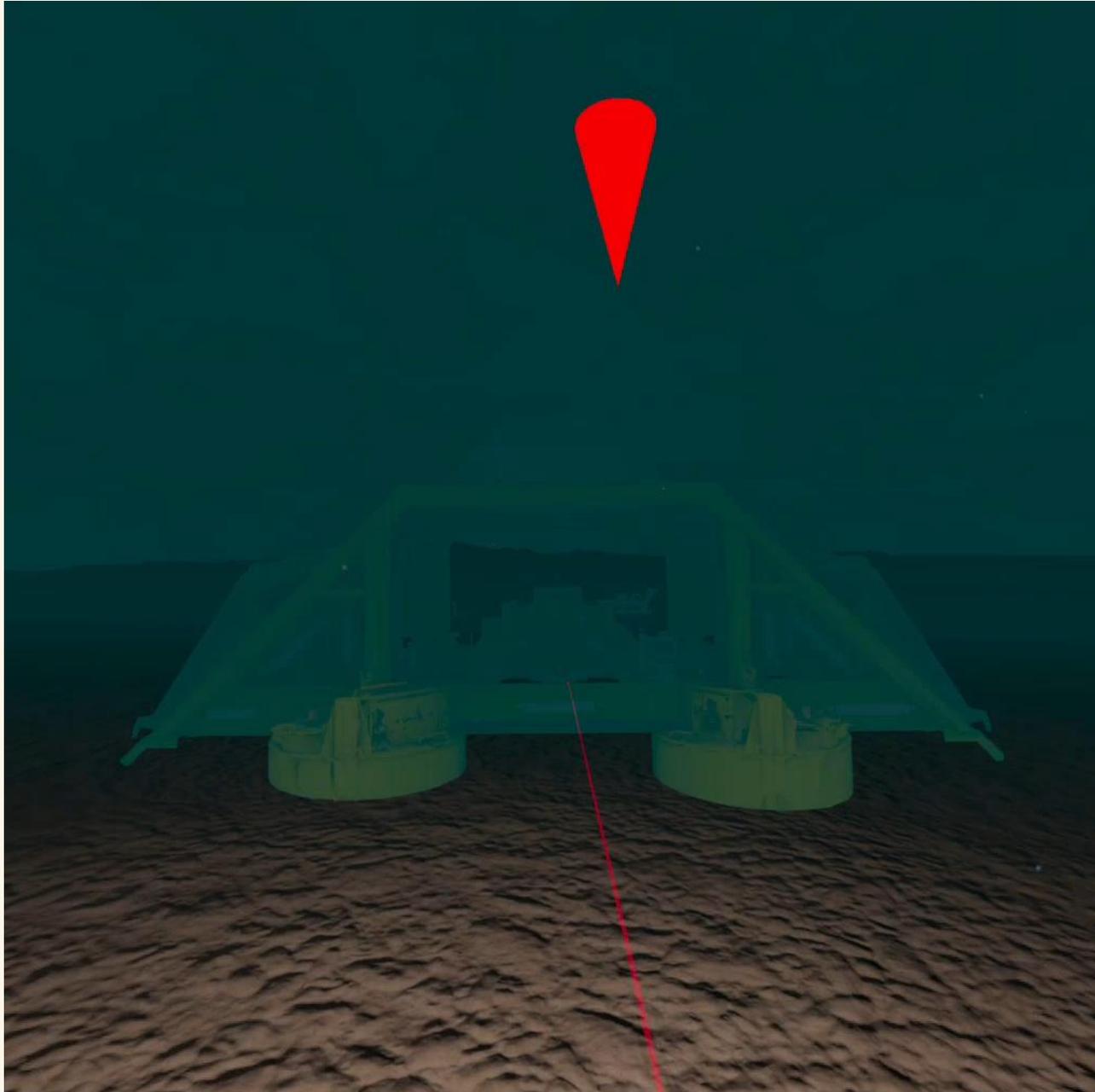
Distance & Speed		Weather Limitation	
Region	Speed	Region	Limitation
Region 1	100	Region 1	0
Region 2	100	Region 2	0
Region 3	100	Region 3	0
Region 4	100	Region 4	0



Dispatcher: Milk routes



Subsea Metaverse



Metaverse

- Gaming multiplayer environment
- Operational training
- HSE: Hazid & Hazop
- What if scenarios in digital twins

Technology (courtesy Equinor, Echo):

- Digital twins
- Unreal Engine 4
- Meta Quest 2

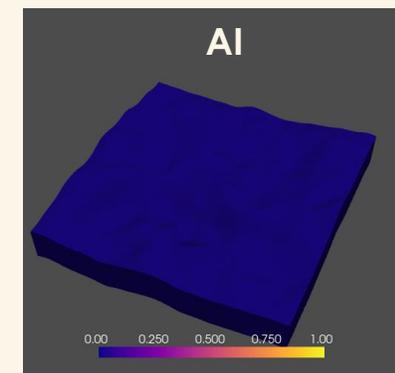
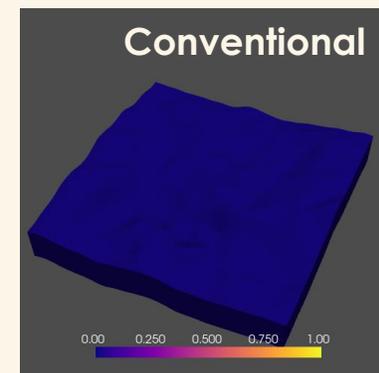
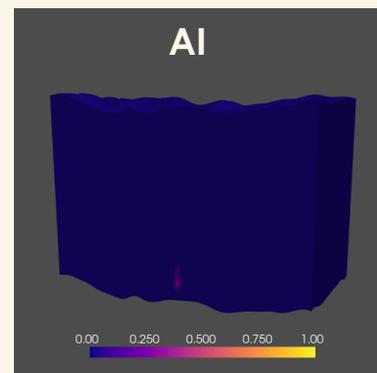
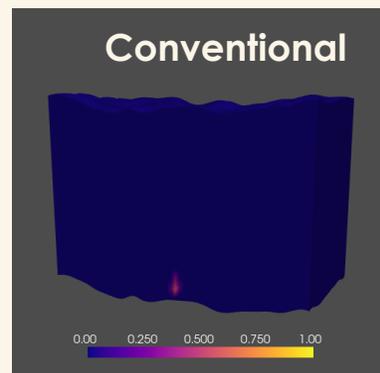
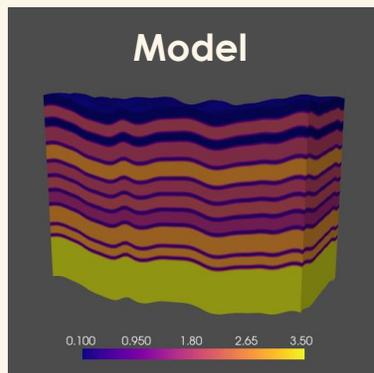
Subsurface CCS focus



- Safe CO₂ storage by geological seal of storage complex: Rock mechanics & large models
- Commitment of future CO₂ injection volume: Injectivity & storage capacity, uncertainty
- Monitoring CO₂ for safe storage in saline aquifer

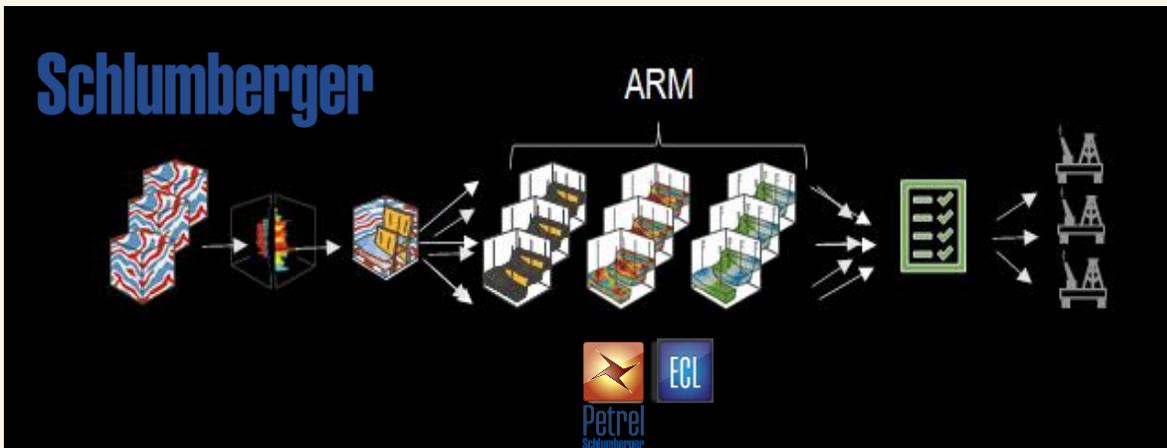
→ Digital collaboration with Schlumberger and Microsoft:

- Data platform
- Uncertainty modeling: Agile Reservoir Modeling
- Optimize subsurface tools for CCS
- Super-fast CO₂ flow simulation: 30 000X speedup by Artificial Intelligence



Courtesy: Philipp Witte, Microsoft Research for Industry

DELFI Agile Reservoir Modeling (ARM): Stochastic modeling



NL-SLB Workshop: Way Forward

Objective: Transition FMU workflow to DELFI and demonstrate added value of DELFI technologies for uncertainty centric modeling workflow for CO2 storage project.

Digital Forum 20-22 Sep

Activity	July	August	September
1. Geomodel RMS-to-Petrel migration	[Progress bar]		
2. Sim. model to Petrel conversion	[Progress bar]		
3. Integrated Geo-Sim. modeling loop in Petrel Uncertainty	[Progress bar]		
4. Agile Reservoir Modeling - proof of value	[Progress bar]		

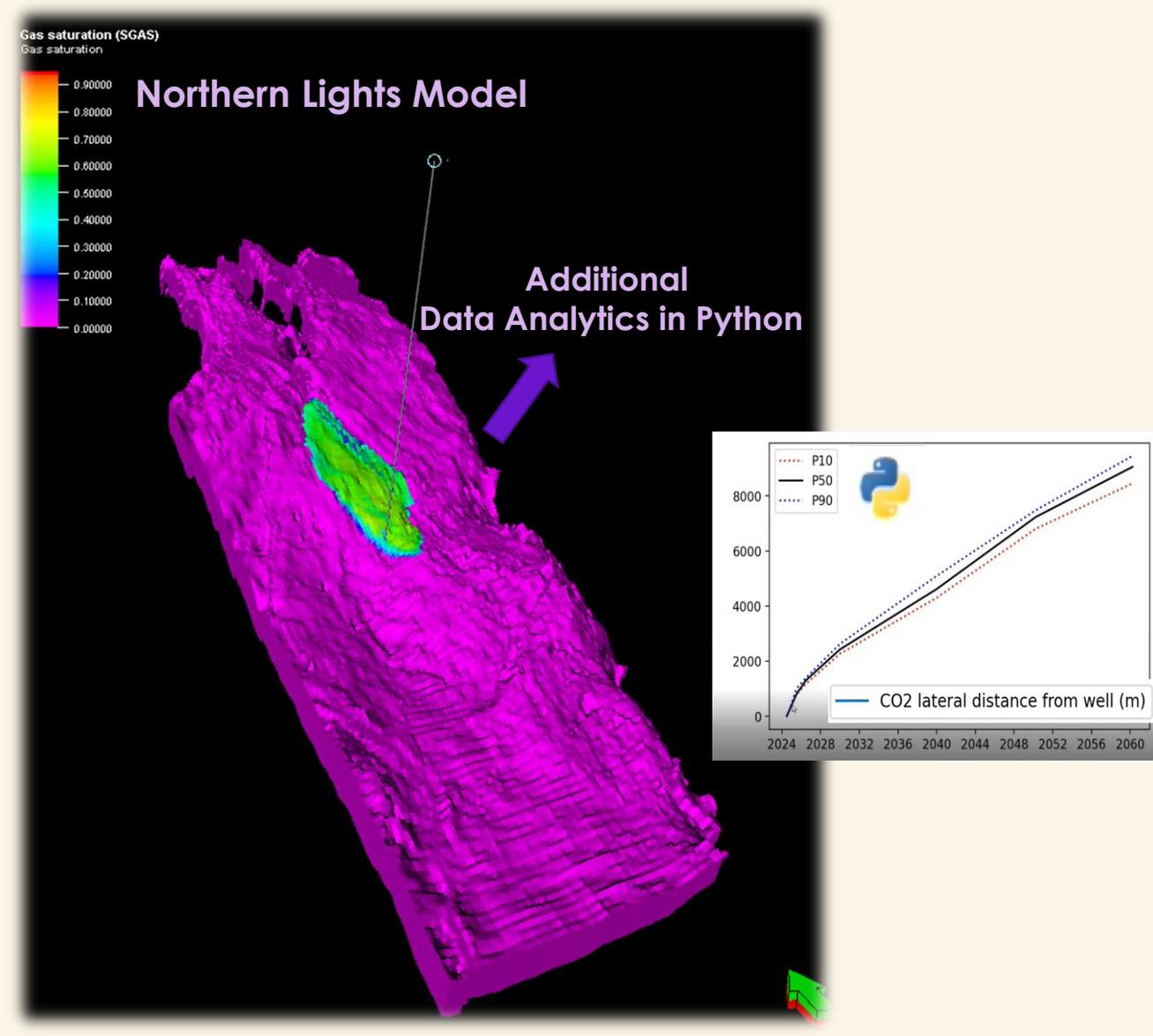
Workflow:

FMU: RMS, ERT, E300, ECL

ARM: Agile Reservoir Modeling

Ensemble Analytics

Schlumberger/Norther Lights confidential





Northern Lights

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