CLIMIT

SUMMIT

SIDE EVENTS

INTERNATIONAL COLLABORATION | 20 YEARS

Programme

Moderator: Eva Halland

08:30 CO_2 monitoring projects supported by the CLIMIT programme, Kristian Stangvik

08:40 Awarded exploration licenses for CO_2 storage Offshore Norway, Ann Helen Hansen

08:50 Catalina Acuna, Geophysicist – MMV Lead, AkerBP

09:00 Henrik Ohrt, Subsurface Manager, Northern Lights

09:10 Shared Insights for Shared Success: The Power of Joint and Collaborative Monitoring, Volker Oye, Norsar

09:20 Discussion

CLIMIT SUMMIT

Large-scale CO_2 storage on the Norwegian continental shelf – Can collaboration on monitoring lead to a reduction in risk and costs?

#CLIMITSUMMIT2025

25–28 February

CLIMIT's Contribution to CO_2 Monitoring Technology

Kristian Stangvik
Senior Advisor, Geophysicist
Gassnova SF

Larvik, February 26. 2025
CLIMIT Summit

POWERED BY GASSNOVA AND THE RESEARCH COUNCIL OF NORWAY

Why is Monitoring Necessary?

Challenges & Objectives

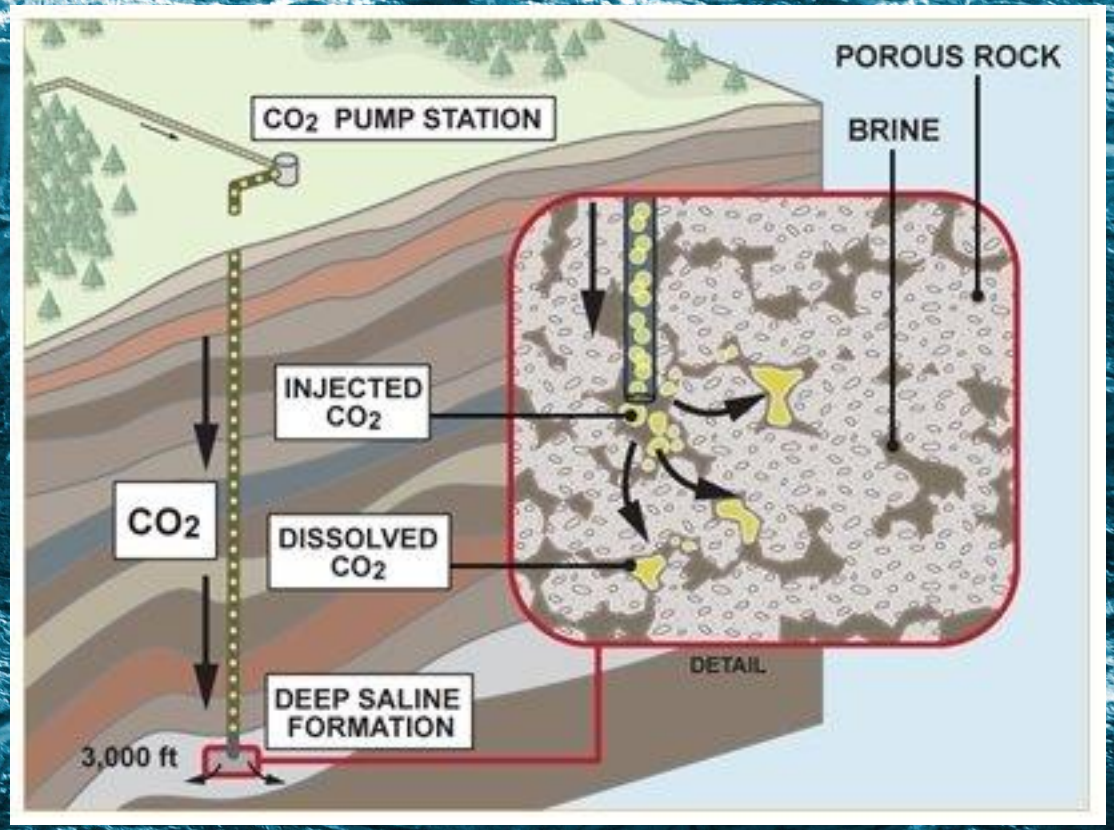
POWERED BY GASSNOVA AND THE RESEARCH COUNCIL OF NORWAY

Key challenges:

- Credibility
- Scale-up
- Cost reduction
- Market-building

Key objectives:

- Ensure compliance with EU regulations (2009 CCS Directive
- Verify storage integrity & detect anomalies early
- Develop cost-effective, scalable monitoring solutions



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Monitoring Technologies Supported by CLIMIT

CLIMIT drives innovation and supports a variety of monitoring technologies

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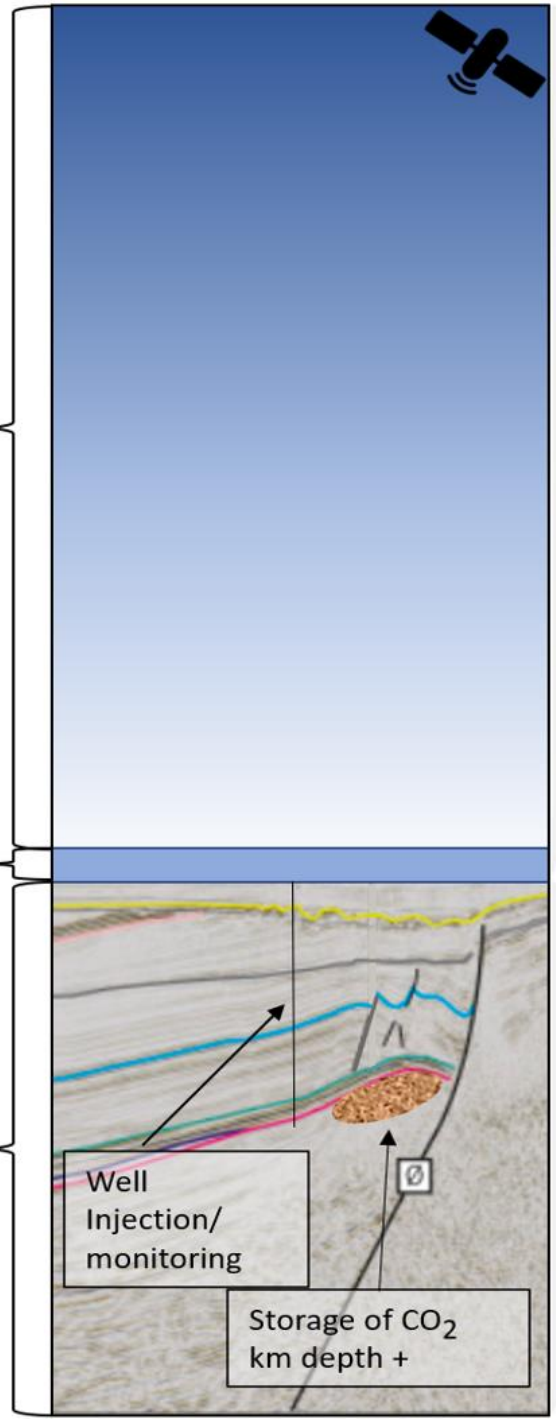
Atmosphere
From seasurface and upwards

Sea
From seabed to seasurface

Subsurface
From seabed and down



Atmospheric/airborne monitoring
- A few different methods
- Ex: InSar
  - 800 km hight – measures uplift of the underground

Surface/near surface monitoring
- A variety of methods
- Ex: Tracer
  - CO2 is given a signature (added element) before storage
  - Monitor surface for gas with that signature
- Ex: Microseismic
  - Receivers along well path
  - Listening for seismic activity

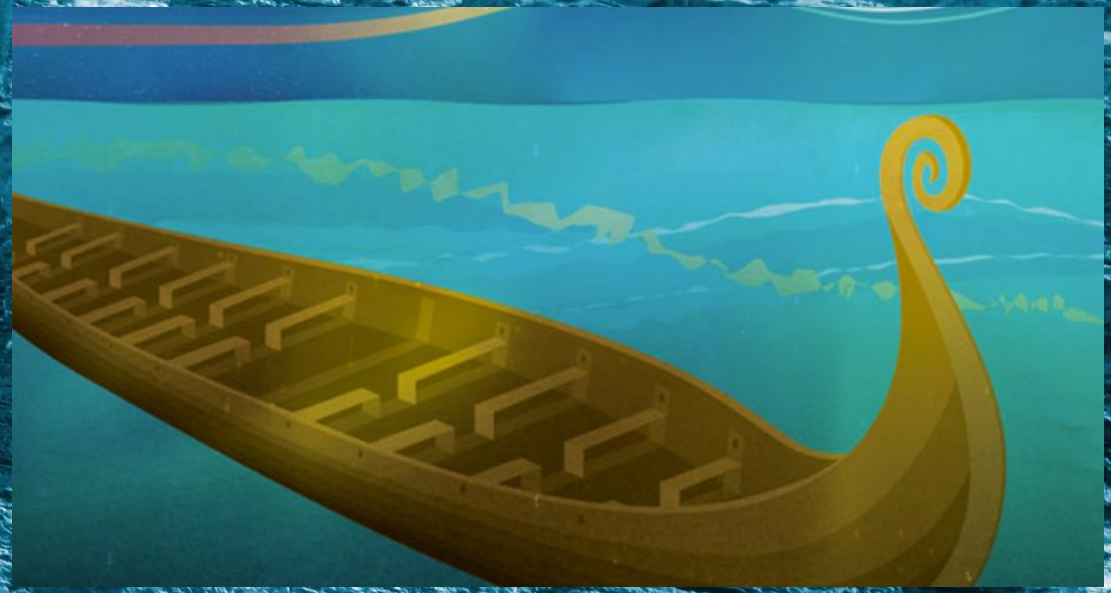
Subsurface monitoring
- Ex: Seismic imaging (4D seismic)
  - Imaging the underground and CO2-plume movement
  - 4D refers to 3D and time as the 4th dimention
- Ex: Pressure monitoring
  - Receivers along well path
  - Monitoring pressure development

Longship's guiding light

Longship is Norway's flagship CCS project, and one of the most advanced in the world

It will set the benchmark for offshore CCS monitoring, defining best practices for future large-scale storage projects

POWERED BY GASSNOVA AND THE RESEARCH COUNCIL OF NORWAY



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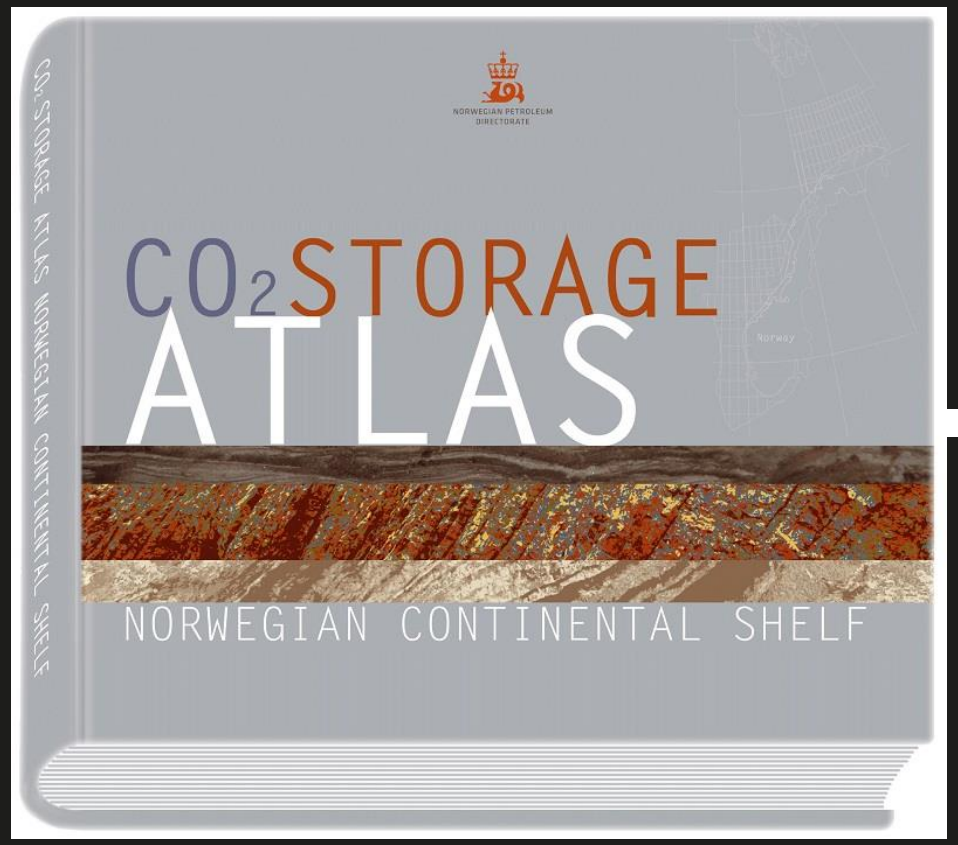
Awarded Licenses for CO_2 Storage Offshore Norway

Ann Helen Hansen – Norwegian Offshore Directorate

2014



CO_2 STORAGE ATLAS NCS

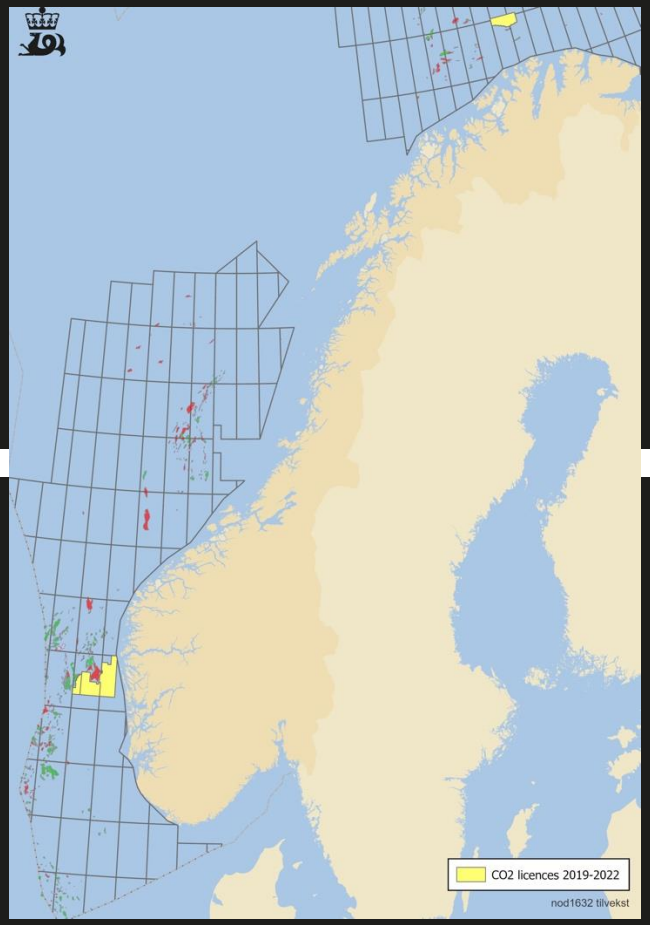
2019

EXPLOITATION LICENSE 001 AWARDED

2021

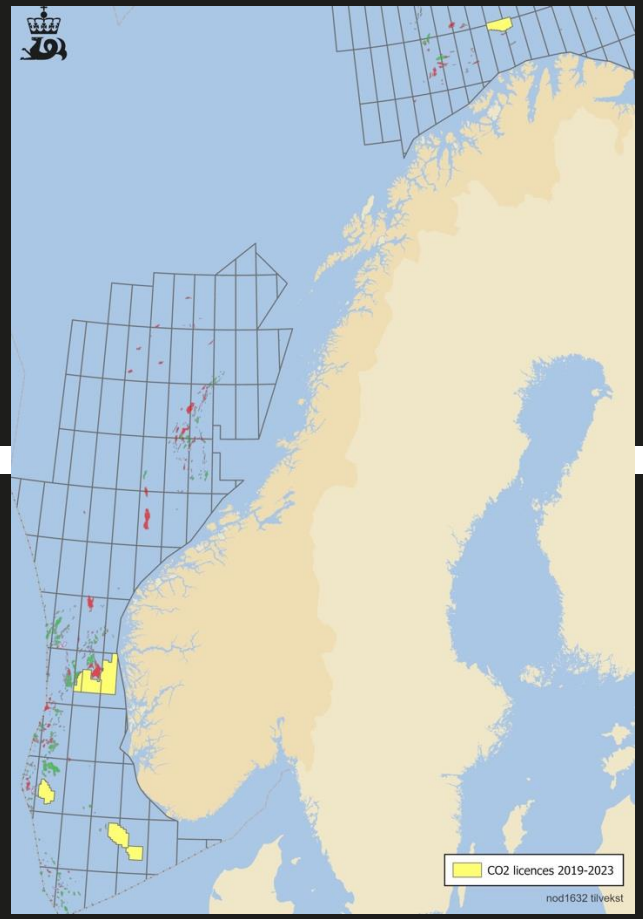
PDO APPROVED NORTHERN LIGHTS

2022



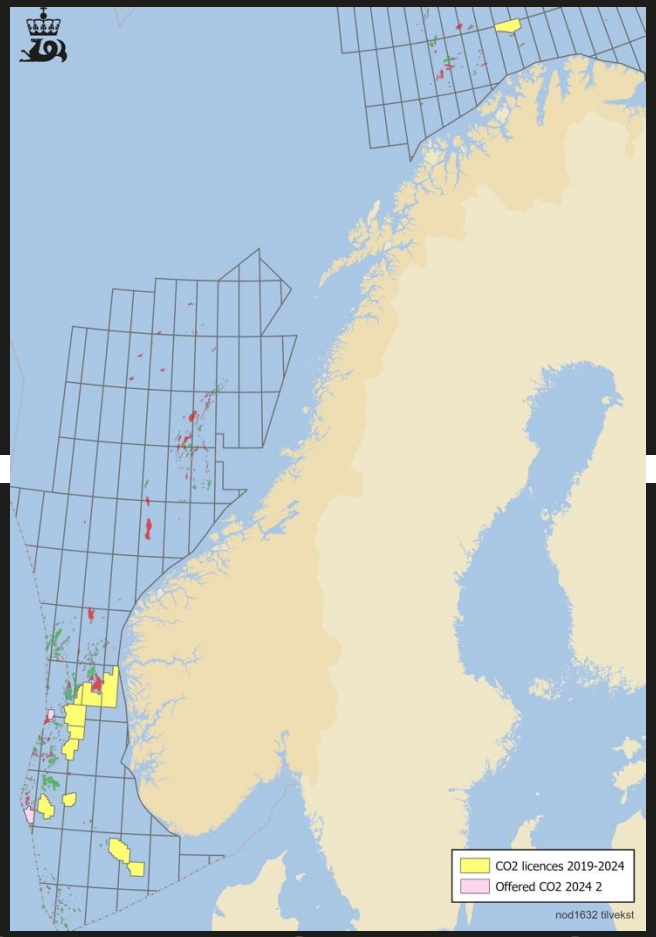
EXPLORATION LICENSE 002, 003, 004 AWARDED

2023



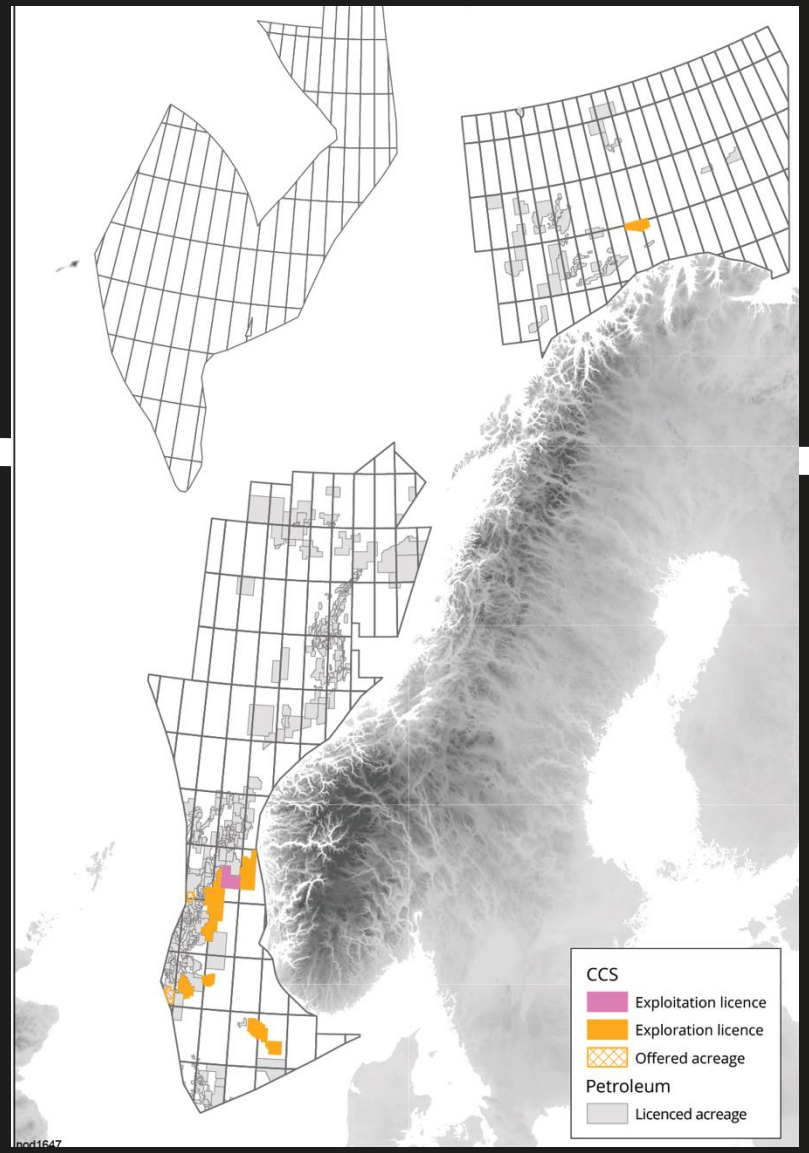
EXPLORATION LICENSE 005, 006, 007 AWARDED

2024



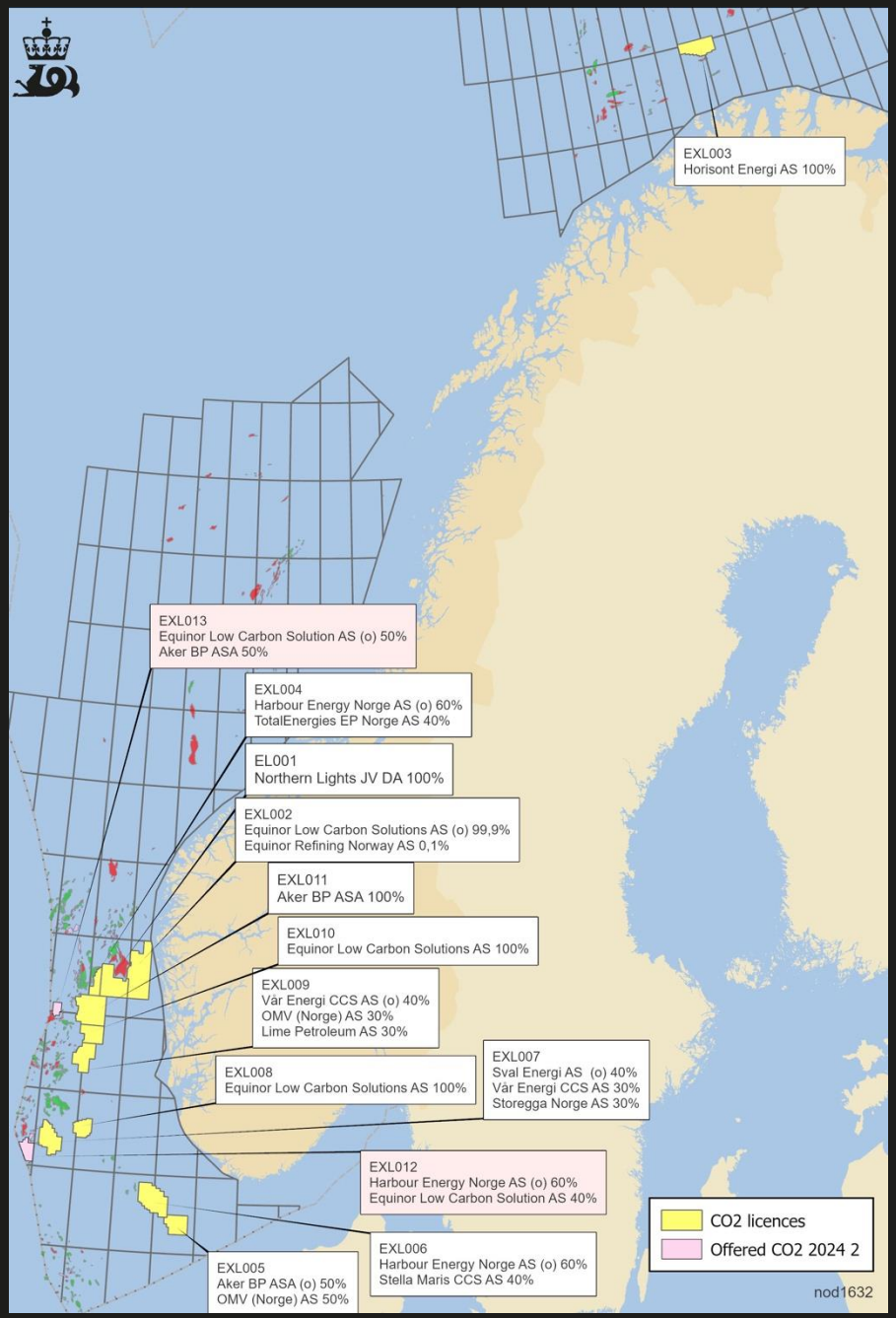
EXPLORATION LICENSE 008, 009, 010, 011 AWARDED

2025 –

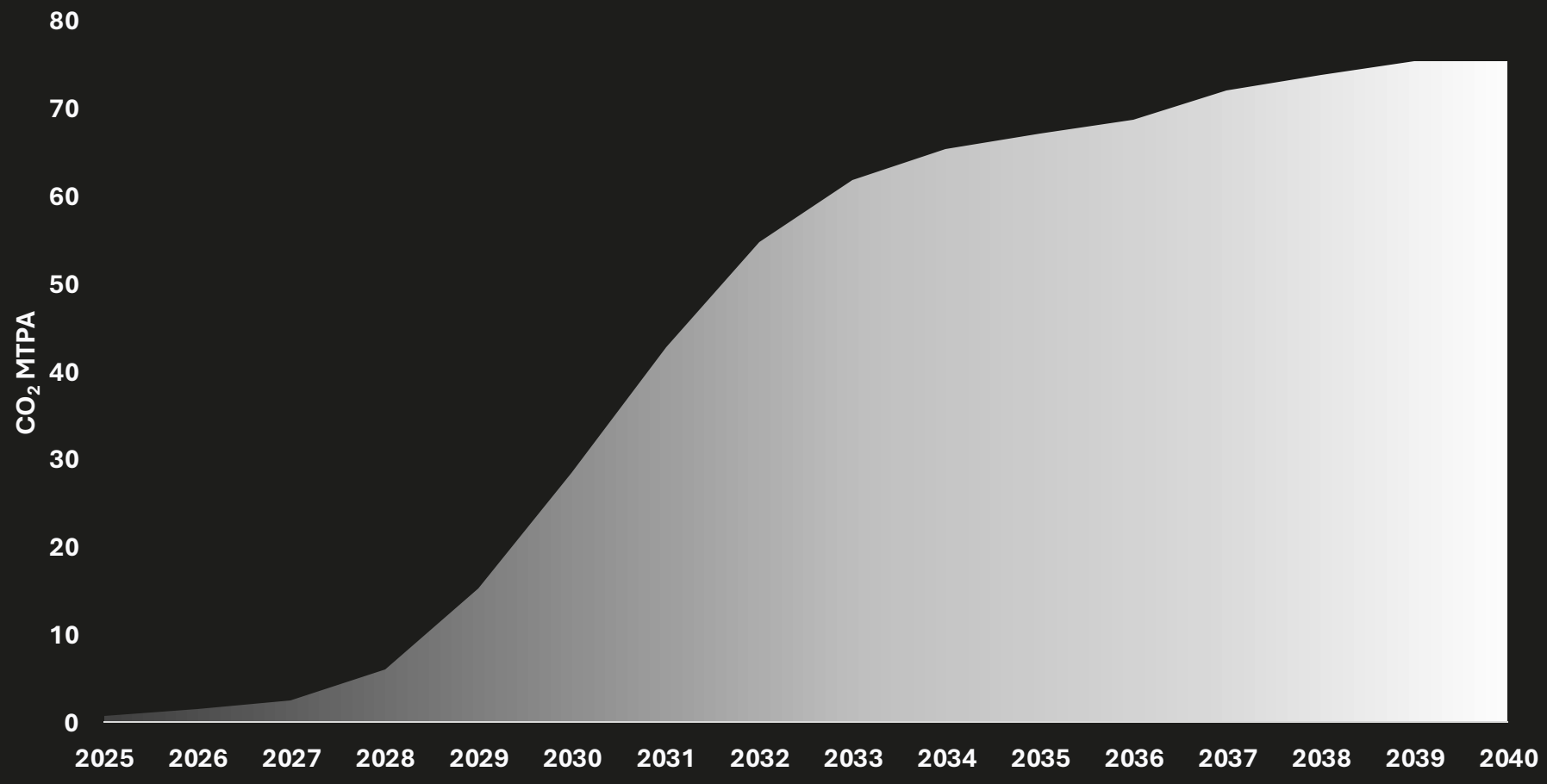

CCS
Exploitation licence
Exploration licence
Offered acreage
Petroleum
Licenced acreage

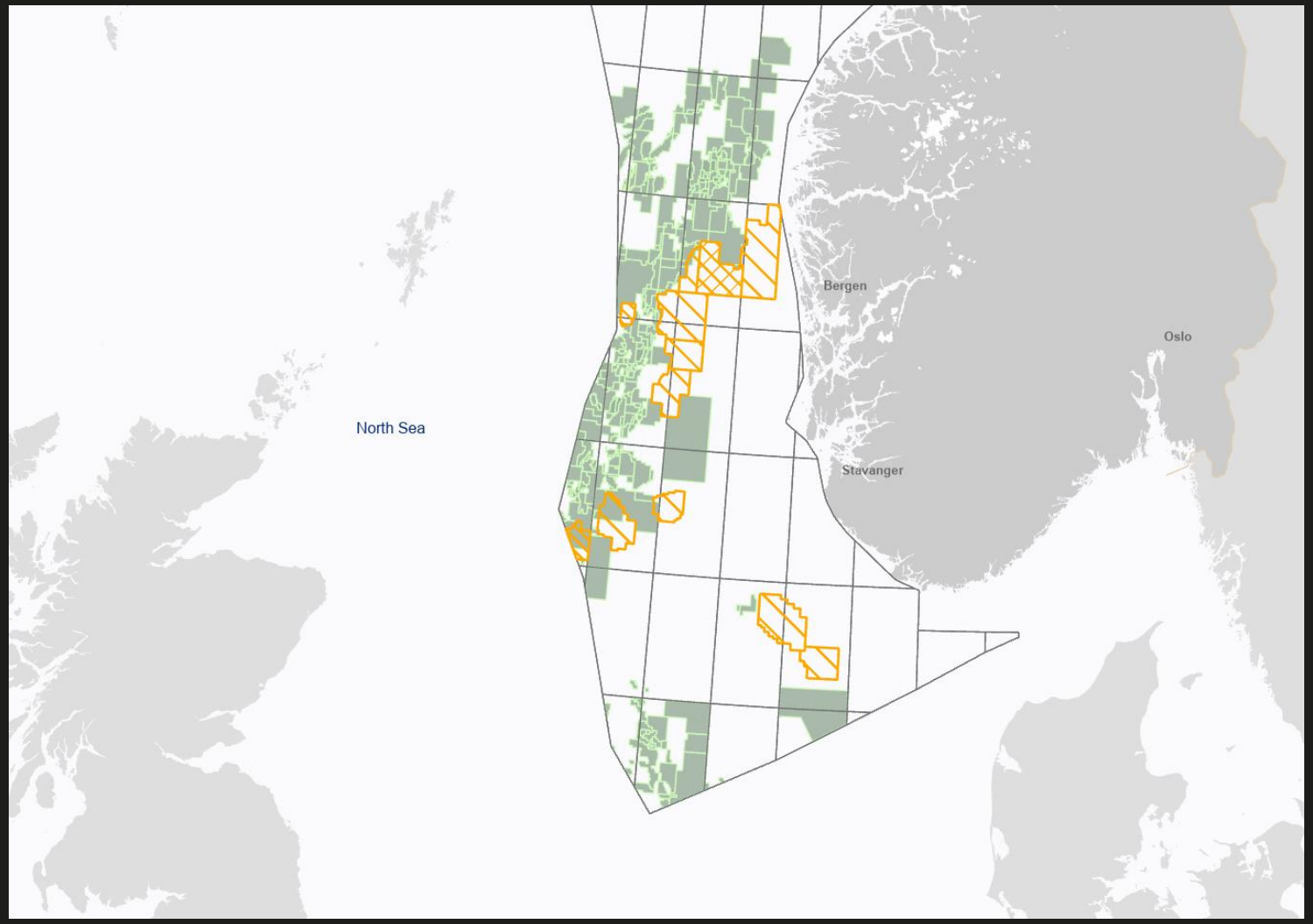
Current Status: CO_2 Storage Licenses

- 1 Exploitation License
- 10 Exploration License
- 2 Offered Exploration Licenses



A possible future for CO_2 storage on NCS





CO_2 STORAGE POTENTIAL

THANK YOU FOR YOUR ATTENTION

NORWEGIAN OFFSHORE DIRECTORATE

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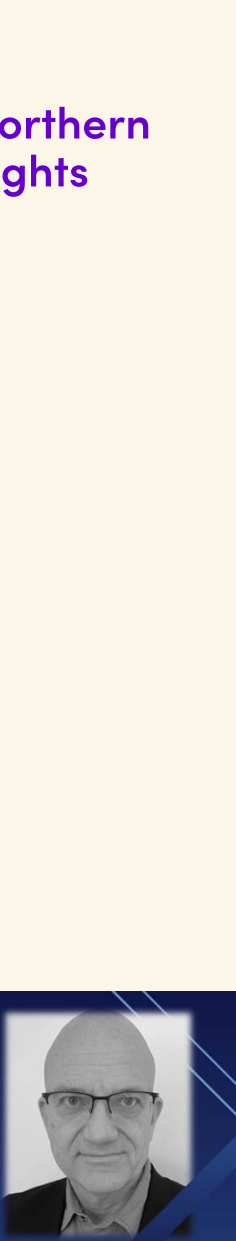
Northern Lights Monitoring of CO_2 storage

Larvik, 26 February 2025

- World-class subsurface storage complex
- State-of-the-art monitoring
- Collaboration

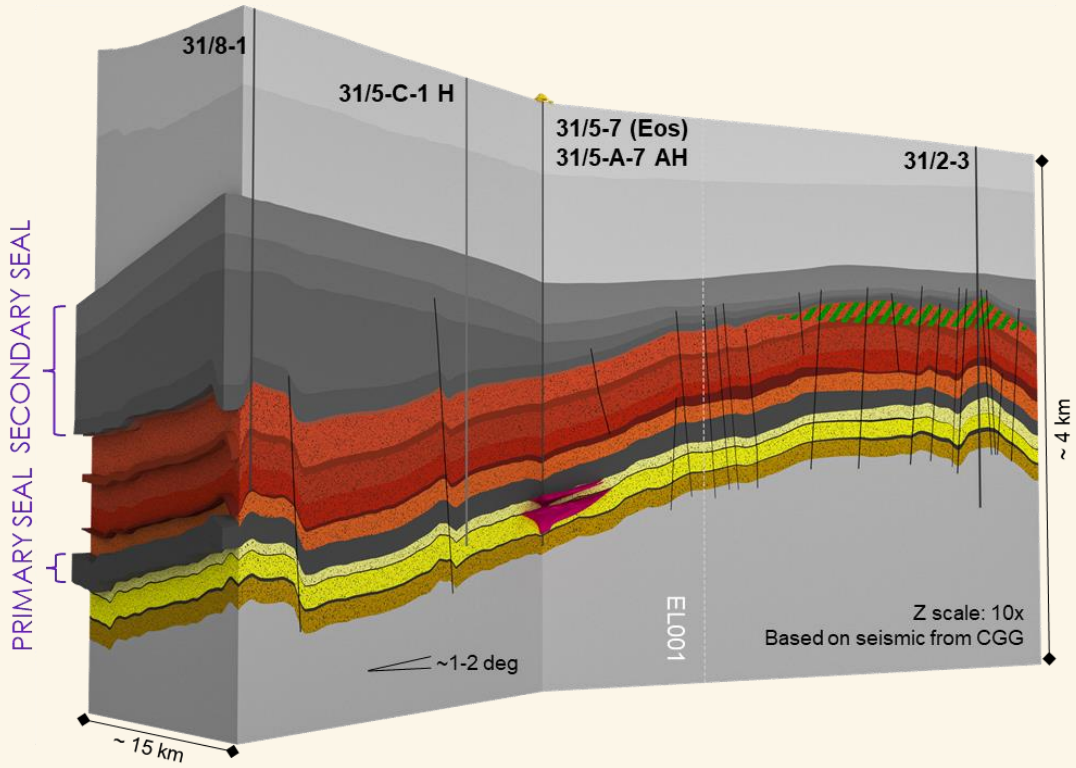


Henrik Bjerre Ohrt
Subsurface Manager, Northern Lights

World-class subsurface storage complex – How? Why?

Northern Lights Storage

- Is confirmed – dynamically tested - very permeable
- Has two proven - dynamically tested - seals (cap rocks)
- Is located in a tectonically quiet area
- Has no legacy wells within the license
- Has a pressure and temperature that allows CO2 to stay in one phase (critical fluid, no gas & no liquid)



Saline aquifer at ~2 700 m depth, 100 km offshore

- Primary "storage units": Cook & Johansen Fms. - Shallow marine Jurassic sands
- Primary seal: Drake Fm, thick package of deepwater, organic rich, shales
- Secondary seal: Draupne Fm. (Troll field seal)

State-of-the-art monitoring of CO2 storage – Why?

To:

- Confirm safe storage in targeted hydraulic unit
- Potentially adjust / optimize the CO2 injection scheme

<u>Confirm effectiveness of CCS investments</u>

The investments in capture, transport, and storage of CO2 in Northern Lights storage will amount to several 10s of billions NOK.

Demonstrating the success of the investments – i.e., an effective and safe CO2 storage - is crucial; - for the investors/customers, the authorities and the public.

State-of-the-art Monitoring of CO2 storage – How? What?

Northern Lights

IN-WELL MONITORING

Assessment of:

- Injection well performance
- Storage pressure development

Daily surveillance and analysis (as required) of:

- Well injection rates
- Well injection pressures
- Well injection temperatures

Periodic well testing with:

- Step-rate tests
- Fall-off tests

Include in-well monitoring results in review and updates of:

- Injection planning
- Operational windows and alarm settings for injection wells
- Reservoir monitoring and management plans
- Reservoir models, estimated storage capacity, etc.

State-of-the-art Monitoring of CO2 storage – How? What?

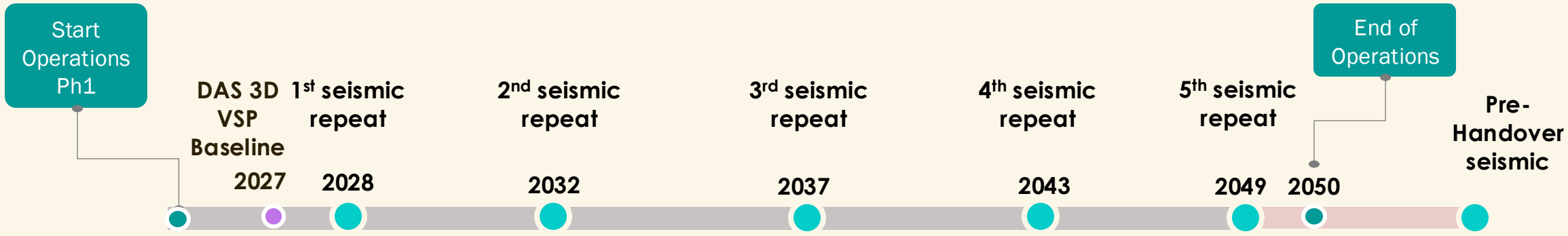
Northern Lights

ACTIVE / 4D SEISMIC MONITORING

Assessment of:

- CO_2 plume migration (dimension and speed)

Tentative Plan:



Timing and size of seismic repeats will be optimized based on monitoring results and updated reservoir modelling.

State-of-the-art Monitoring of CO2 storage – How? What?

Northern Lights

PASSIVE / NATURAL SEISMIC MONITORING

Assessment of:

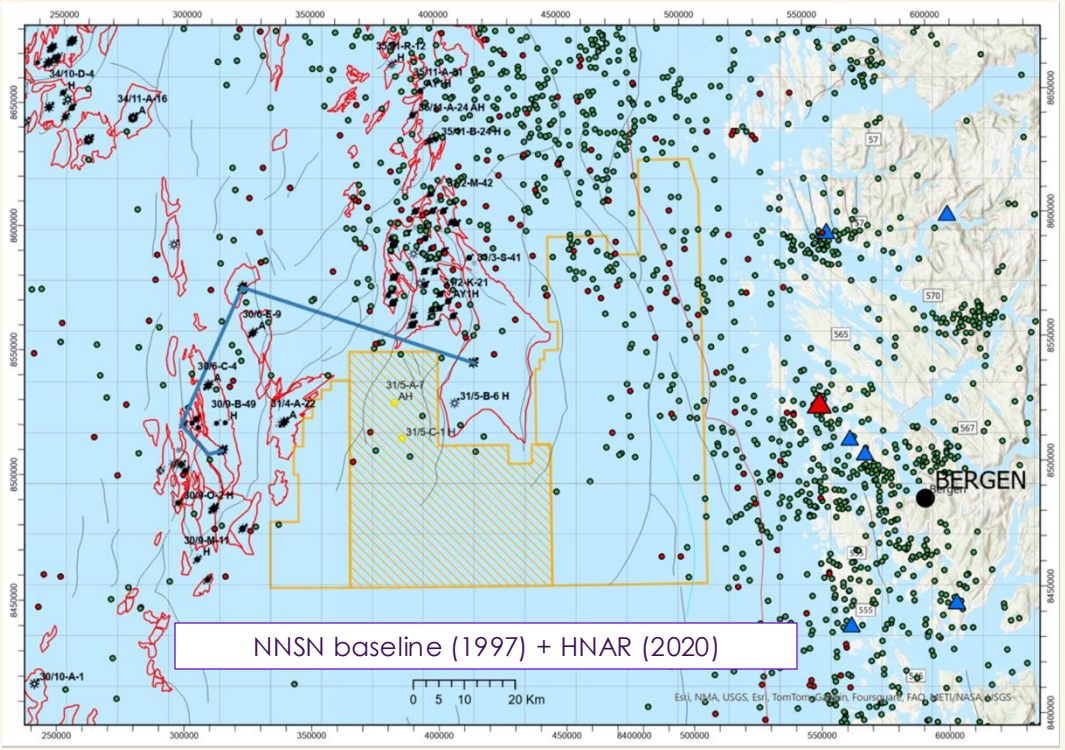
- Natural seismicity
- Potential induced seismicity

Onshore Sensors:

- NSNN – 34 National Seismometers onshore
- HNAR: Holsnøy Seismic Array

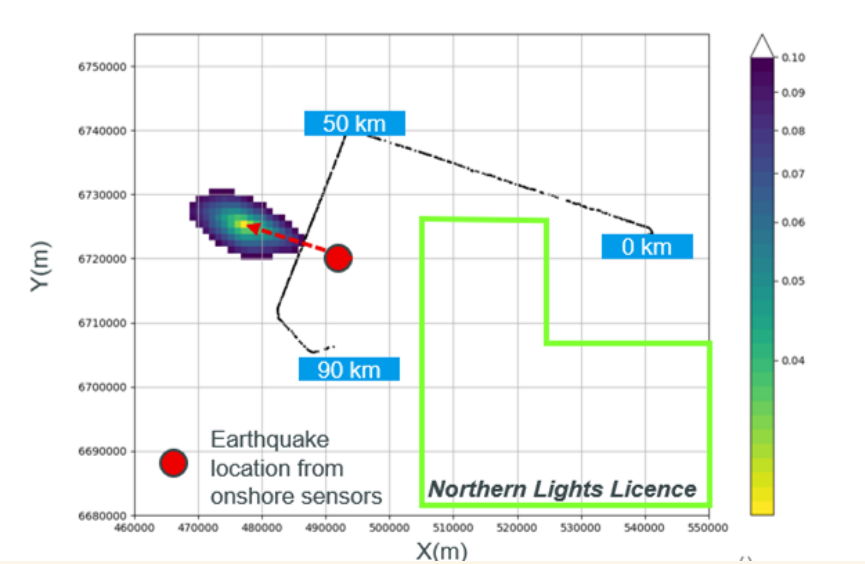
Legend:

- National Seismometers
- Events recorded by NNSN
- Hølsnoy Array HNAR
- Events recorded by HNAR/FO
- Telecom Fiber



Seabed Fiber Optics

Improved sensitivity and measurement of location of Earthquake (seismic event)….



State-of-the-art Monitoring of CO2 storage – Collaboration

PASSIVE / NATURAL SEISMIC MONITORING

Assessment of:

- Natural seismicity
- Potential induced seismicity

Examples of collaboration in the pipeline:

Permanent installation of the HNAR-ARRAY
(Northern Lights JV, NORSAR (,Equinor))

DAS4HNET (project (proposed) to follow previous HNET projects)
(NORSAR, ASN, Equinor, Northern Lights JV, NTNU-CGF, Shearwater, Shell, TotalEnergies, University of Bergen, Viridien)

Focus on maturing novel concepts of integrating fibre optic DAS measurements into microseismic monitoring systems.

Northern Lights – Monitoring of CO2 storage

Summary

- Northern Lights has a world-class subsurface storage complex
- The investments in capture, transport, and storage of CO2 in Northern Lights storage will amount to several 10s of billions NOK
- Demonstrating the success of the CCS investments – i.e., an effective and safe CO2 storage - is crucial; - for the investors/customers, the authorities and the public
- Northern Lights has a state-of-the art monitoring strategy comprising in-well monitoring, active seismic, passive seismic, and the modelling tools to assess the observations
- Collaboration is taking place