CO2 Capture and Storage – Response to Climate Change, Zagreb 27.- 28. February 2007.

10 years of CO2 Storage

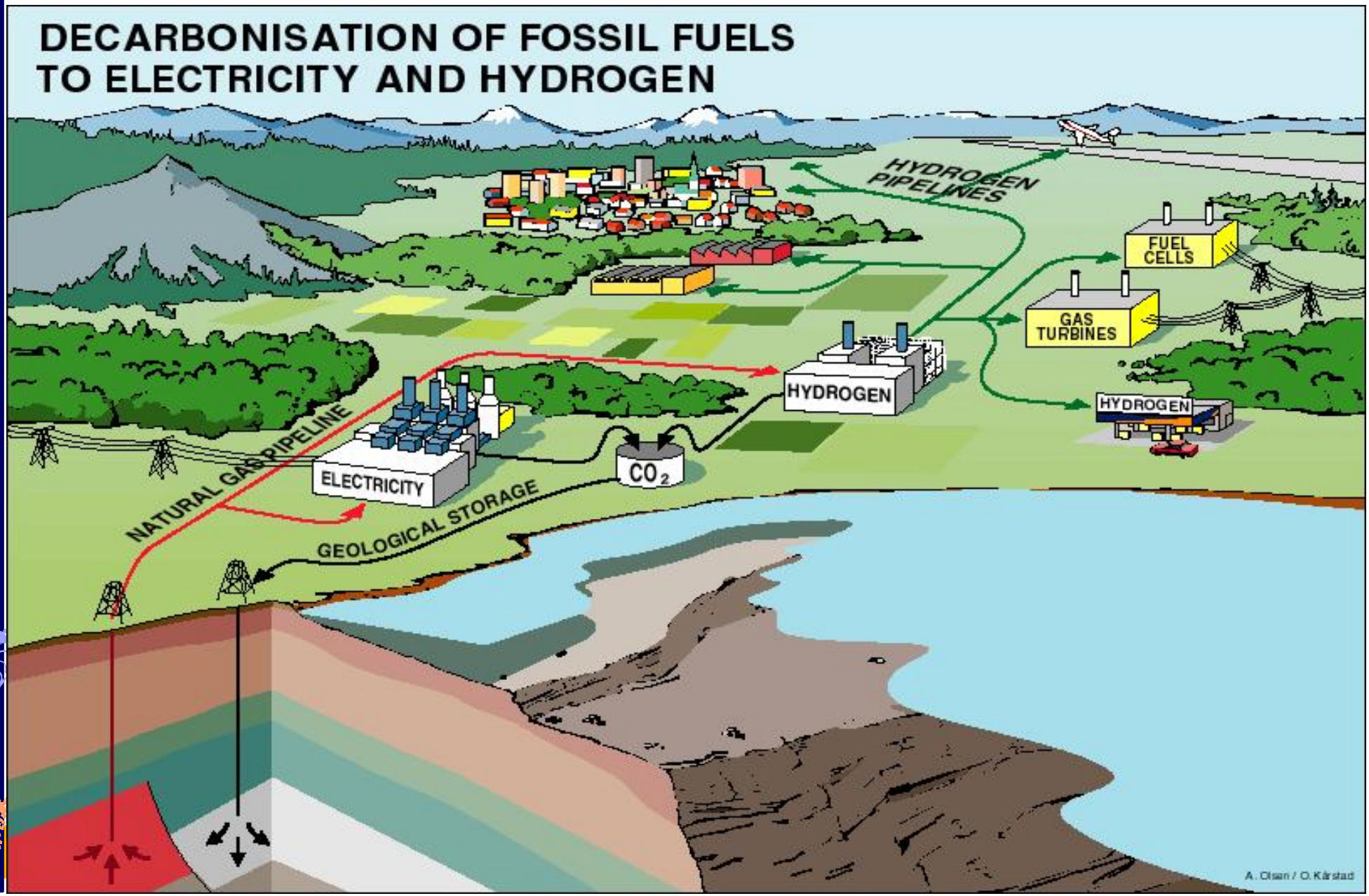
Tore A Torp, Statoil Research Centre, Trondheim, Norway

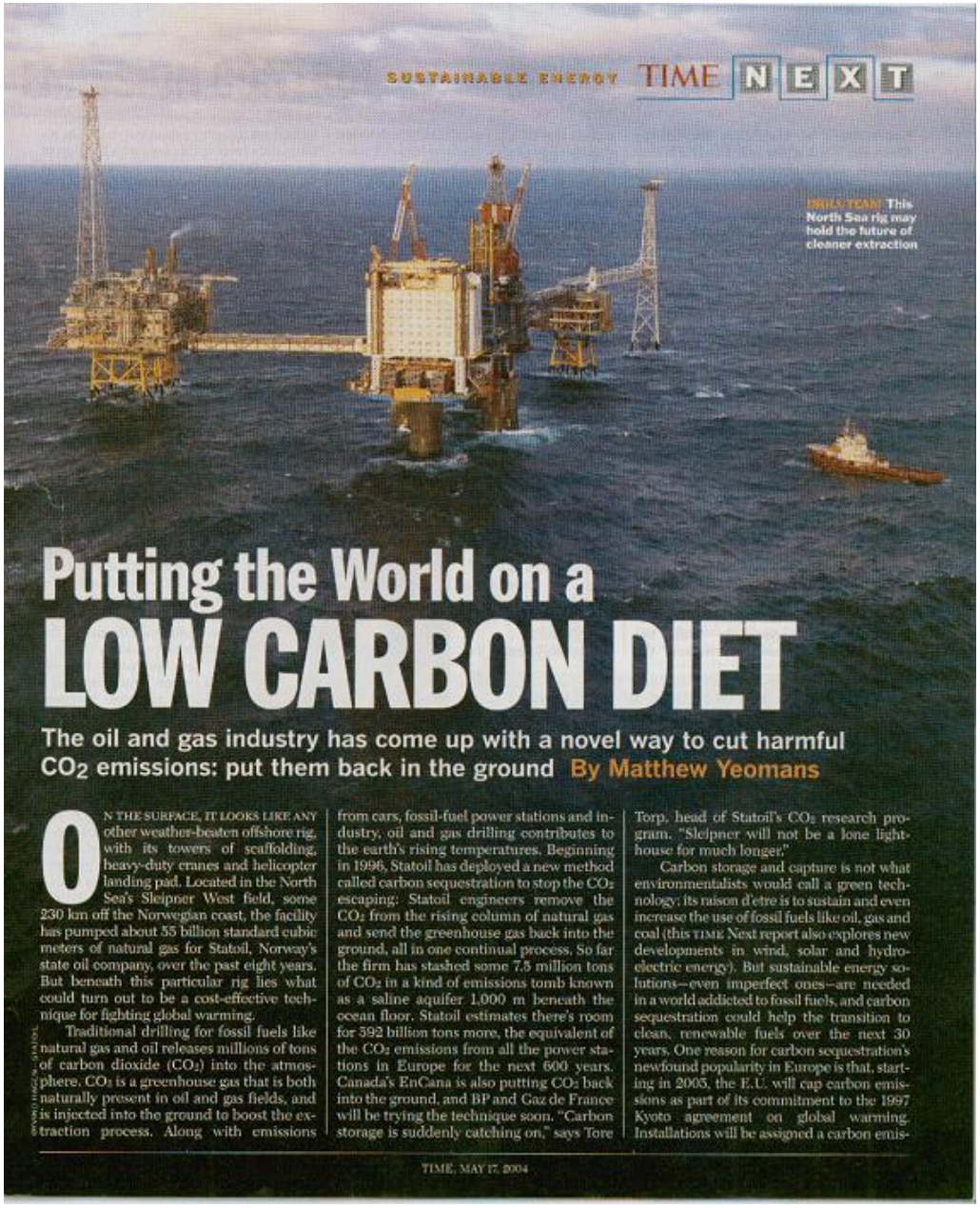
10 years of CO2 Storage

CONTENT:

- "Low Carbon Diet"
- Industrial Experiences with CO2
- Sleipner, In Salah, K12B, Ketzin, Snohvit and ???
- What will Authorities and Public demand?
- Industrial deployment soon?
- VISION and Way forward?

STATOIL


DECARBONISATION OF FOSSIL FUELS
TO ELECTRICITY AND HYDROGEN
HYDROGEN PIPELINES
FUEL CELLS
GAS TURBINES
HYDROGEN
HYDROGEN
NATURAL GAS PIPELINE
ELECTRICITY
CO_2
GEOLOGICAL STORAGE
A. Olsen / O. Kårstad



SUSTAINABLE ENERGY TIME NEXT

COLD TEAM This North Sea rig may hold the future of cleaner extraction

Putting the World on a LOW CARBON DIET

The oil and gas industry has come up with a novel way to cut harmful CO_2 emissions: put them back in the ground By Matthew Yeomans

ON THE SURFACE, IT LOOKS LIKE ANY other weather-beaten offshore rig, with its towers of scaffolding, heavy-duty cranes and helicopter landing pad. Located in the North Sea's Sleipner West field, some 230 km off the Norwegian coast, the facility has pumped about 55 billion standard cubic meters of natural gas for Statoil, Norway's state oil company, over the past eight years. But beneath this particular rig lies what could turn out to be a cost-effective technique for fighting global warming.

Traditional drilling for fossil fuels like natural gas and oil releases millions of tons of carbon dioxide (CO_2) into the atmosphere. CO_2 is a greenhouse gas that is both naturally present in oil and gas fields, and is injected into the ground to boost the extraction process. Along with emissions from cars, fossil-fuel power stations and industry, oil and gas drilling contributes to the earth's rising temperatures. Beginning in 1996, Statoil has deployed a new method called carbon sequestration to stop the CO_2 escaping: Statoil engineers remove the CO_2 from the rising column of natural gas and send the greenhouse gas back into the ground, all in one continual process. So far the firm has stashed some 7.5 million tons of CO_2 in a kind of emissions tomb known as a saline aquifer 1,000 m beneath the ocean floor. Statoil estimates there's room for 592 billion tons more, the equivalent of the CO_2 emissions from all the power stations in Europe for the next 600 years. Canada's EnCana is also putting CO_2 back into the ground, and BP and Gaz de France will be trying the technique soon. "Carbon storage is suddenly catching on," says Tore Torp, head of Statoil's CO_2 research program. "Sleipner will not be a lone lighthouse for much longer."

Carbon storage and capture is not what environmentalists would call a green technology; its raison d'etre is to sustain and even increase the use of fossil fuels like oil, gas and coal (this TIME Next report also explores new developments in wind, solar and hydroelectric energy). But sustainable energy solutions—even imperfect ones—are needed in a world addicted to fossil fuels, and carbon sequestration could help the transition to clean, renewable fuels over the next 30 years. One reason for carbon sequestration's newfound popularity in Europe is that, starting in 2005, the E.U. will cap carbon emissions as part of its commitment to the 1997 Kyoto agreement on global warming. Installations will be assigned a carbon emis-

TIME, MAY 17, 2004

Sleipner CO_2-injeksjon:

- Besluttet i 1992
- I drift siden 1996
- 1 million tonn CO_2/år

Time Magazine, 17. Mai 2004

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Previous Experiences with CO2 & Injection

- Enhanced Oil Recovery (Texas, Hungary, Turkey, Brazil,Croatia)
- Natural gas cleaning
- Transport – Pipelines & Ships
- Natural gas re-injection
- Natural gas underground storage

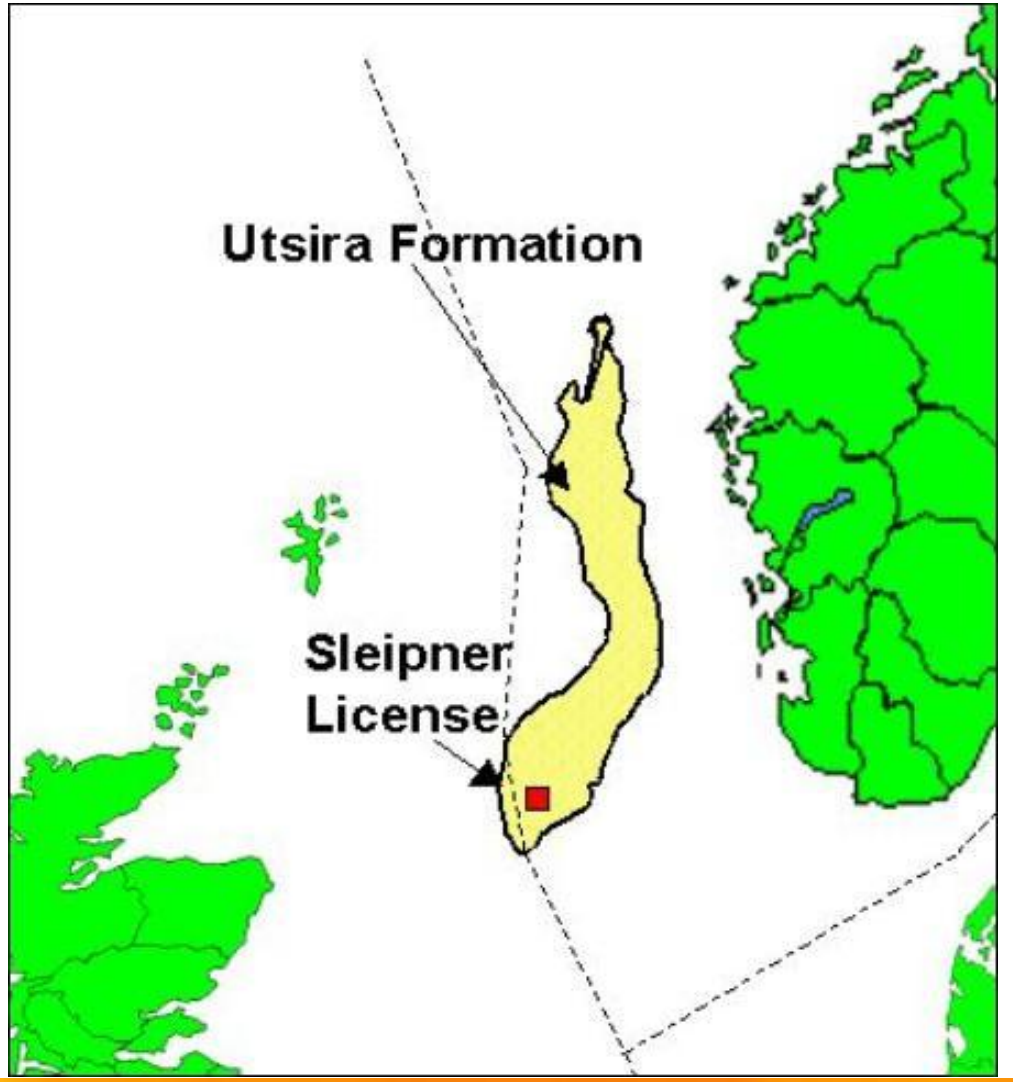
and

- Beer & soft drinks, dry cleaning, food packaging – Every day life

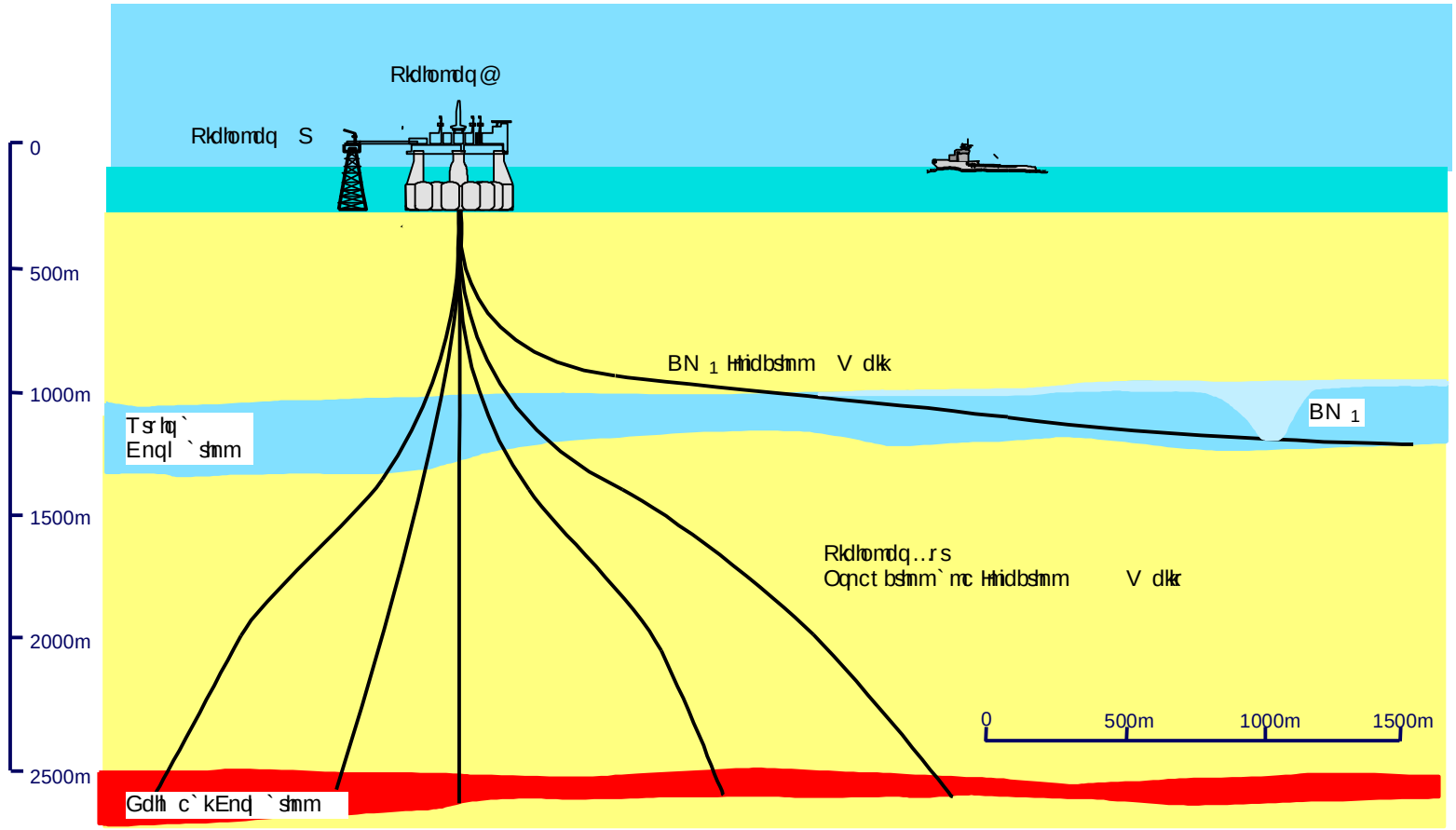
Yara CO_2-tankers, 1500 m^3 capacity

The Sleipner field – CO2 Treatment and Injection

The Utsira Formation



CO2 Injection Well in "Utsira"



SALINE AQUIFER CO_2 STORAGE PROJECT

Statoil
BP
ExxonMobil
TotalFinaElf
Norsk Hydro
Vattenfall

BGS
BRGM
GEUS
IFP
NITG-TNO
SINTEF

IEA Greenhouse Gas R&D Programme
Schlumberger Research
NO, DK, NL, FR & UK Authorities

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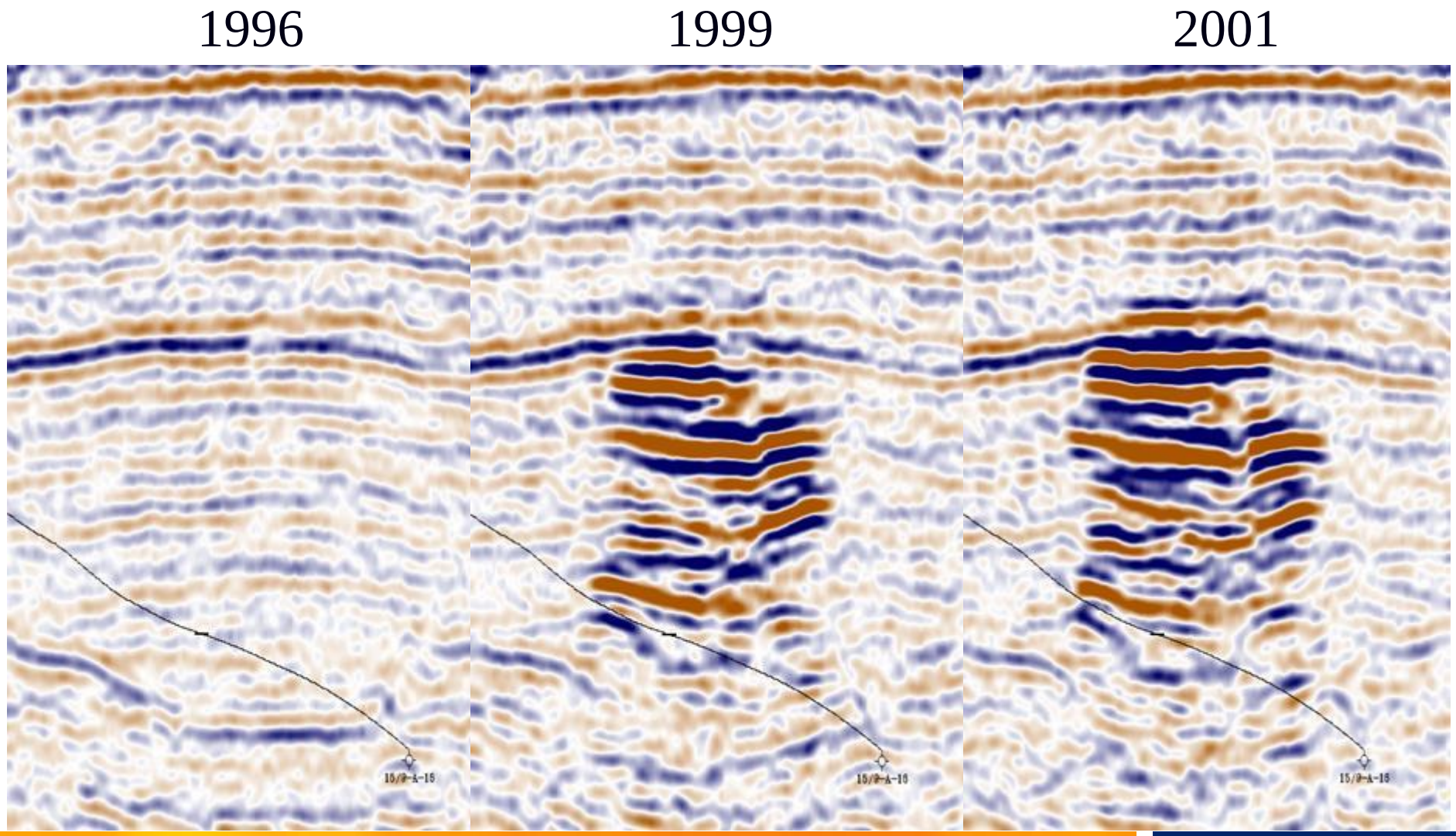
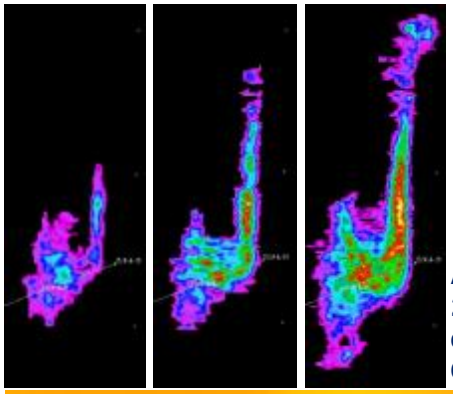
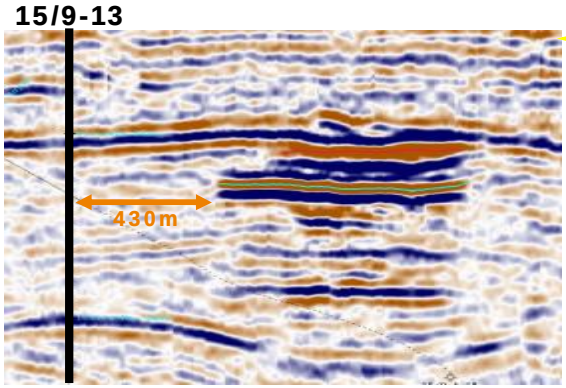
3D Seismic surveys at Sleipner



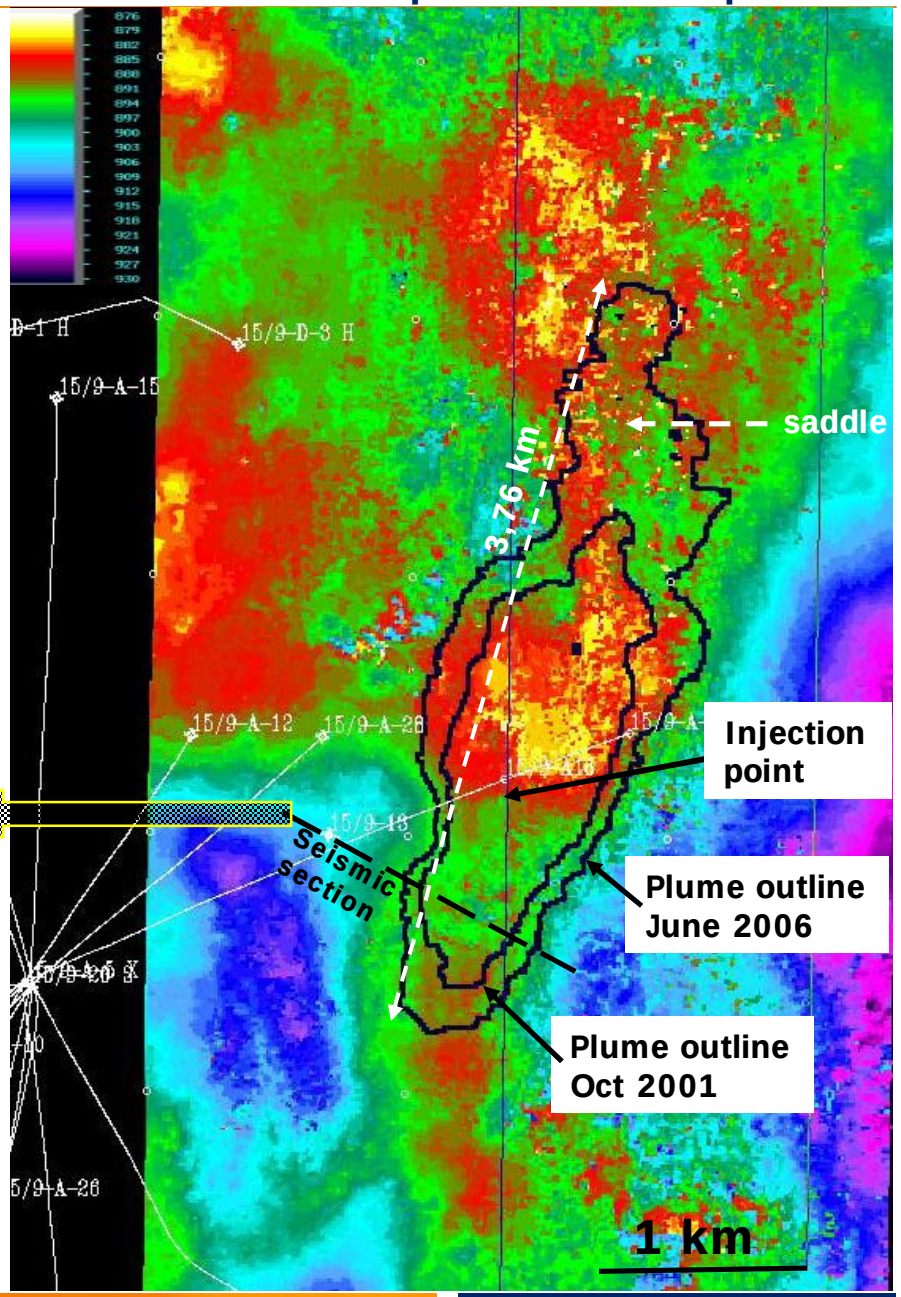
CO_2 distribution June 2006

- 8,4 million tonnes had at the time of seismic data acquisition been injected over 10 years
- Plume area: *2,8 km²* (*1,3 km²* in 2001)
- Plume long axis: *3760 m*
- Maximum distance from injection point: *2560m*
- Plume limitation:
  - UTM E: 437950 – 439550
  - UTM N: 6470000 - 6473660
- The plume reached a northern saddle point between 2002 and 2004
- Maximum speed of front since 2004: *250 m/year*, in a NNE direction
- Distance from CO_2 to wells:
  - Exploration well 15/9-13: *430m*, decreasing about 12 m/year
  - D-template: about 2 km straight west of northern plume
  - 15/9-19 wells: about 4,5 km north of plume





Amplitude maps of the uppermost horizon, in 2001 (left), 2004 (middle) and 2006 (right). Hot colors represent higher amplitudes and thicker CO_2 accumulation.



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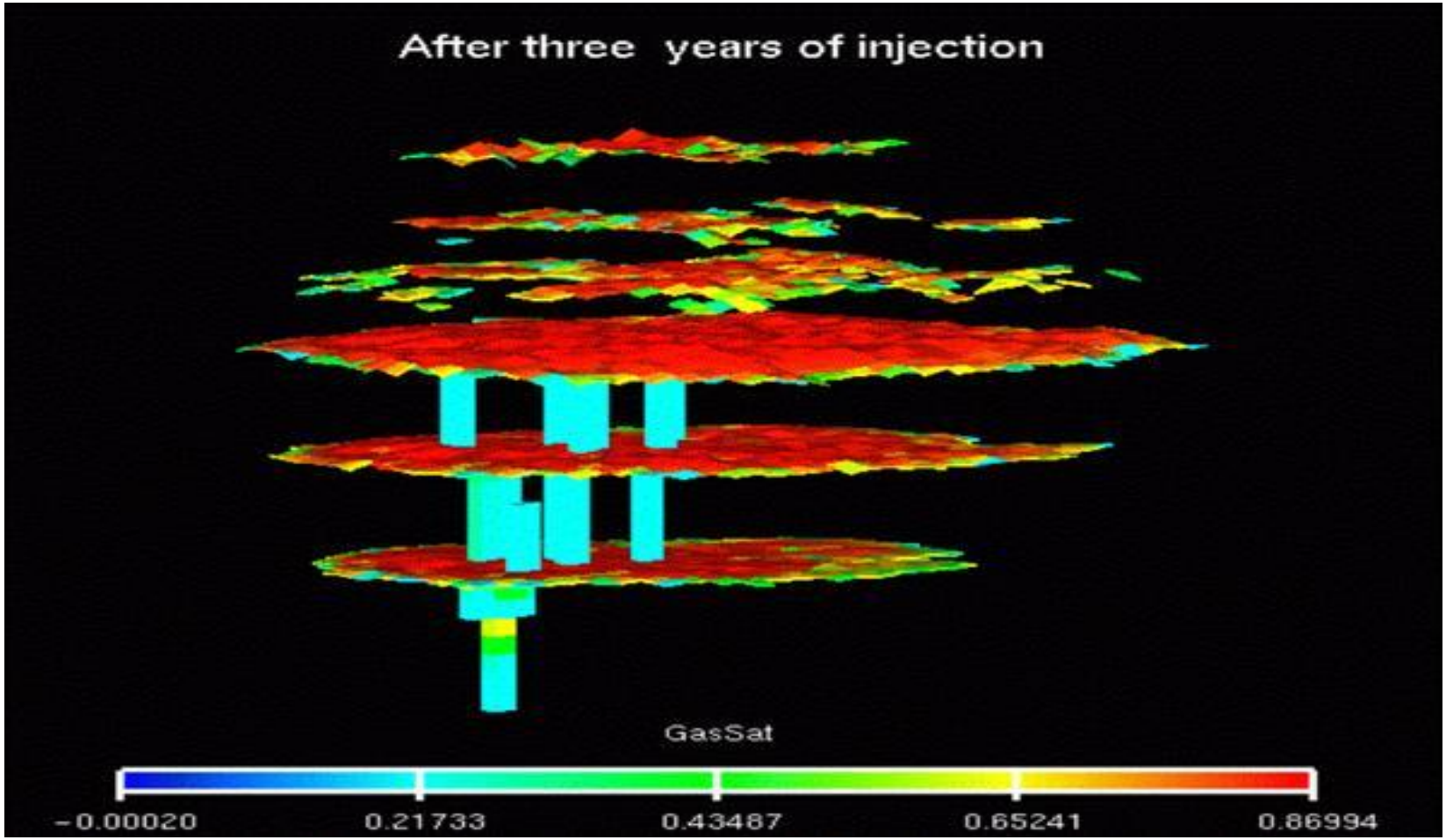


Simulated picture of the distribution of CO_2 after three years. Radius of largest bubble 800 m and the total plume 200 m high.

Ref: SINTEF Petroleum 2001

SACS Project 1998-2002

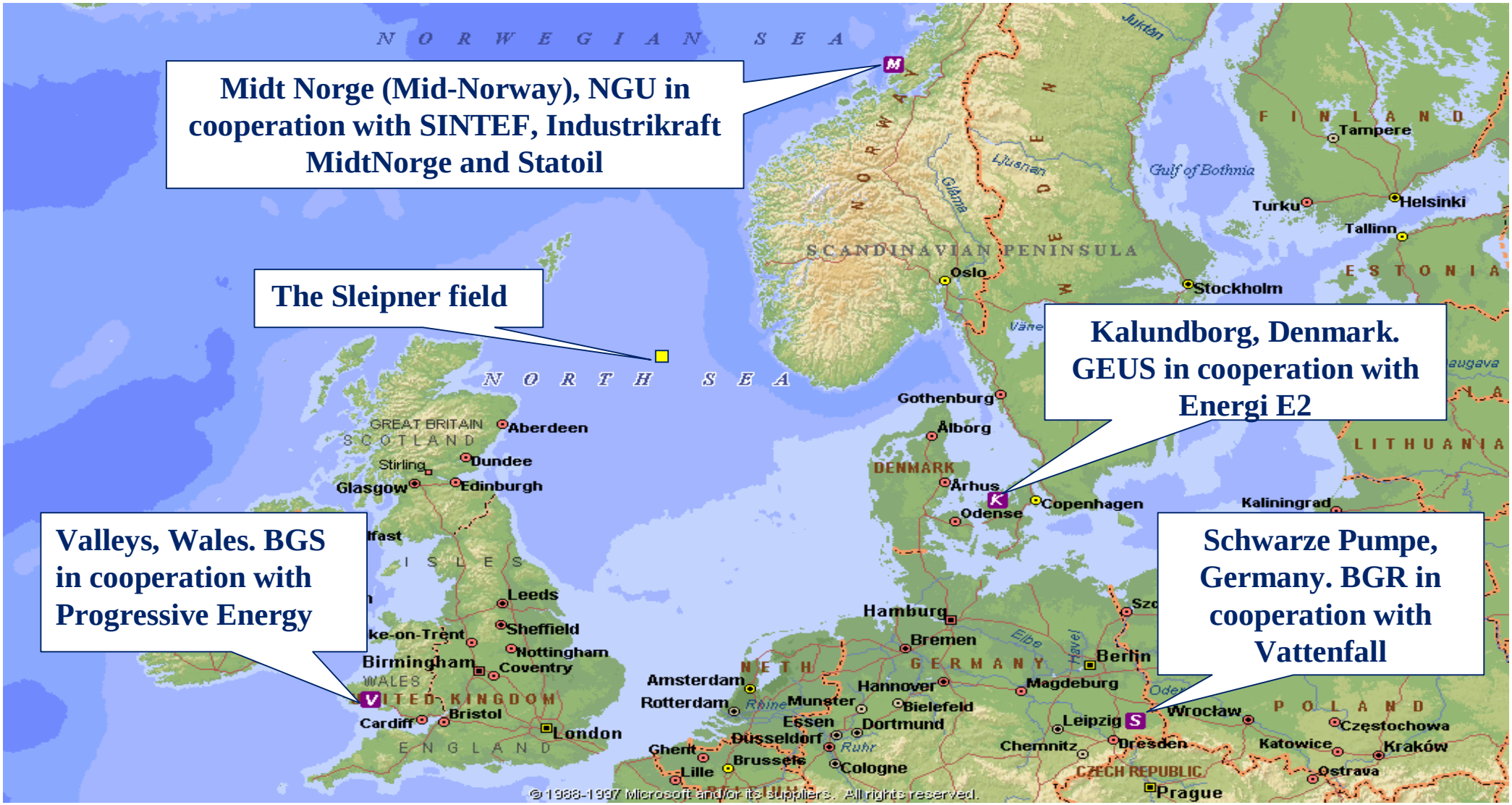
WHAT WE DID ACHIEVE:

- 3D Seismic proven, Gravimetry tested
- Reservoir simulation tools partly proven
- Geology and Geochemistry of “Utsira” mapped
- Reason to expect the CO2 to stay for thousands of years

DOCUMENTATION

- “SACS Best Practice Manual, 1.version.”
- Download from www.co2store.org, see page “SACS”.

CO2STORE – the case studies



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Demonstration
K12-B

Injection of CO_2

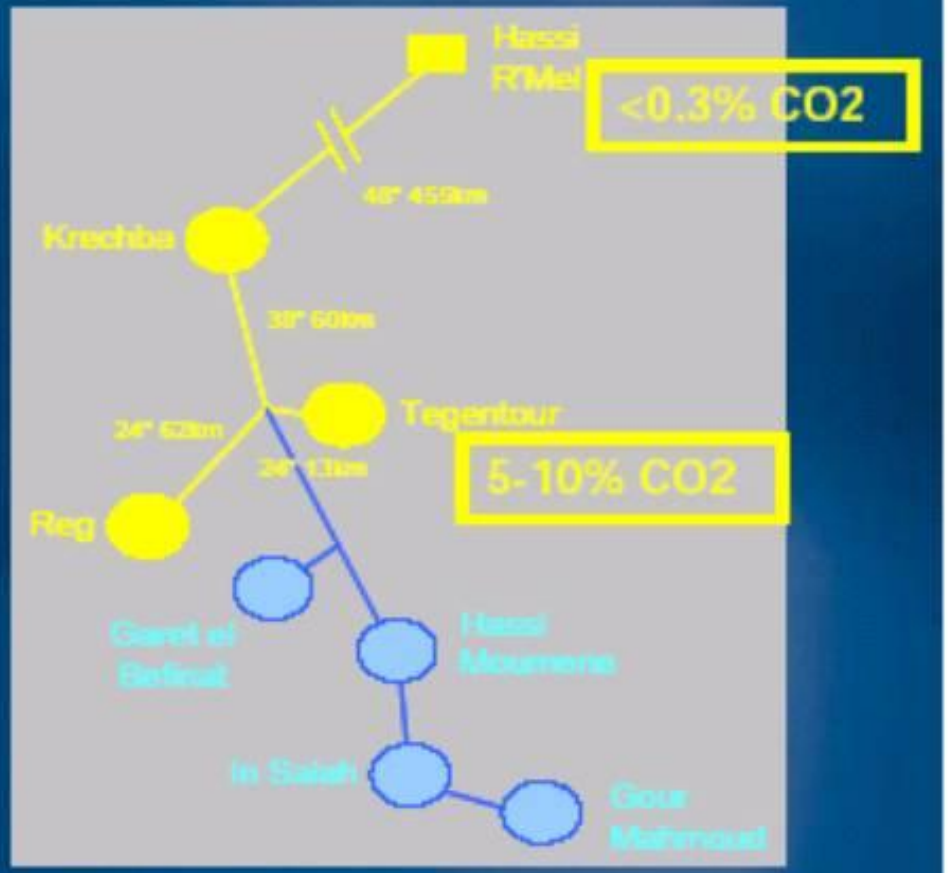
In a depleted gas field

Operator:

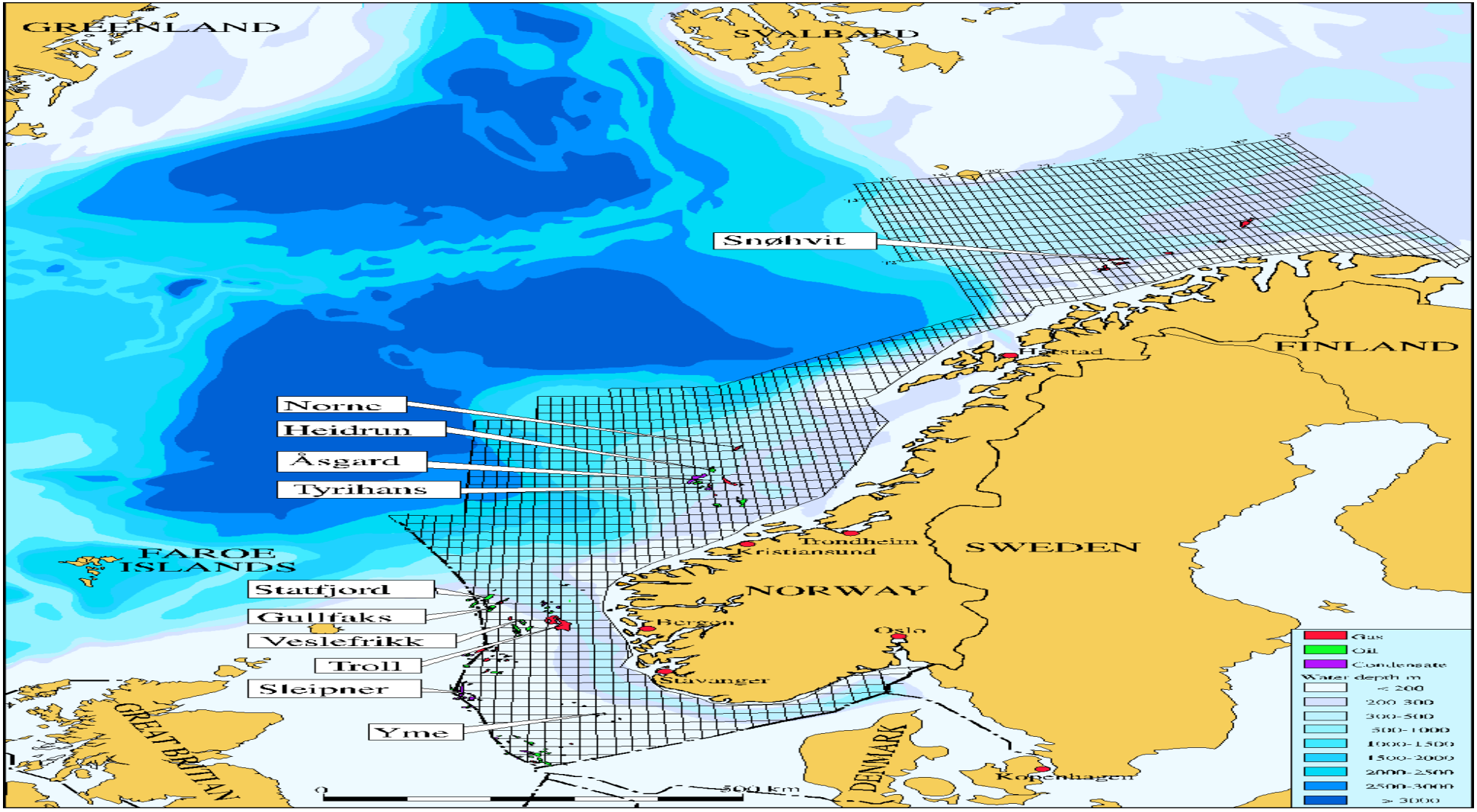
Gaz de France PRODUCTION NEDERLAND B.V.

STATOIL

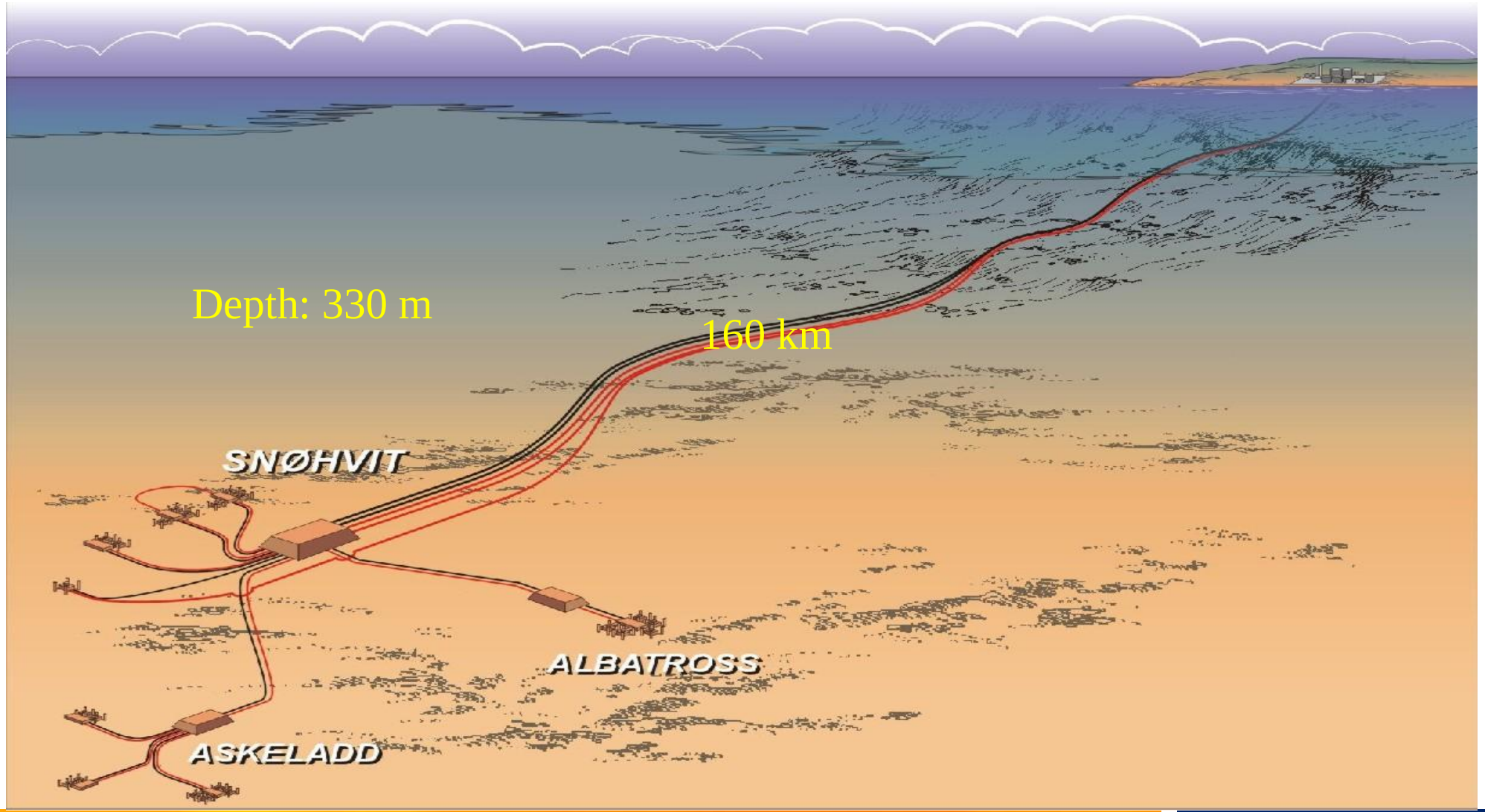
In Salah Gas Project Location, Algeria



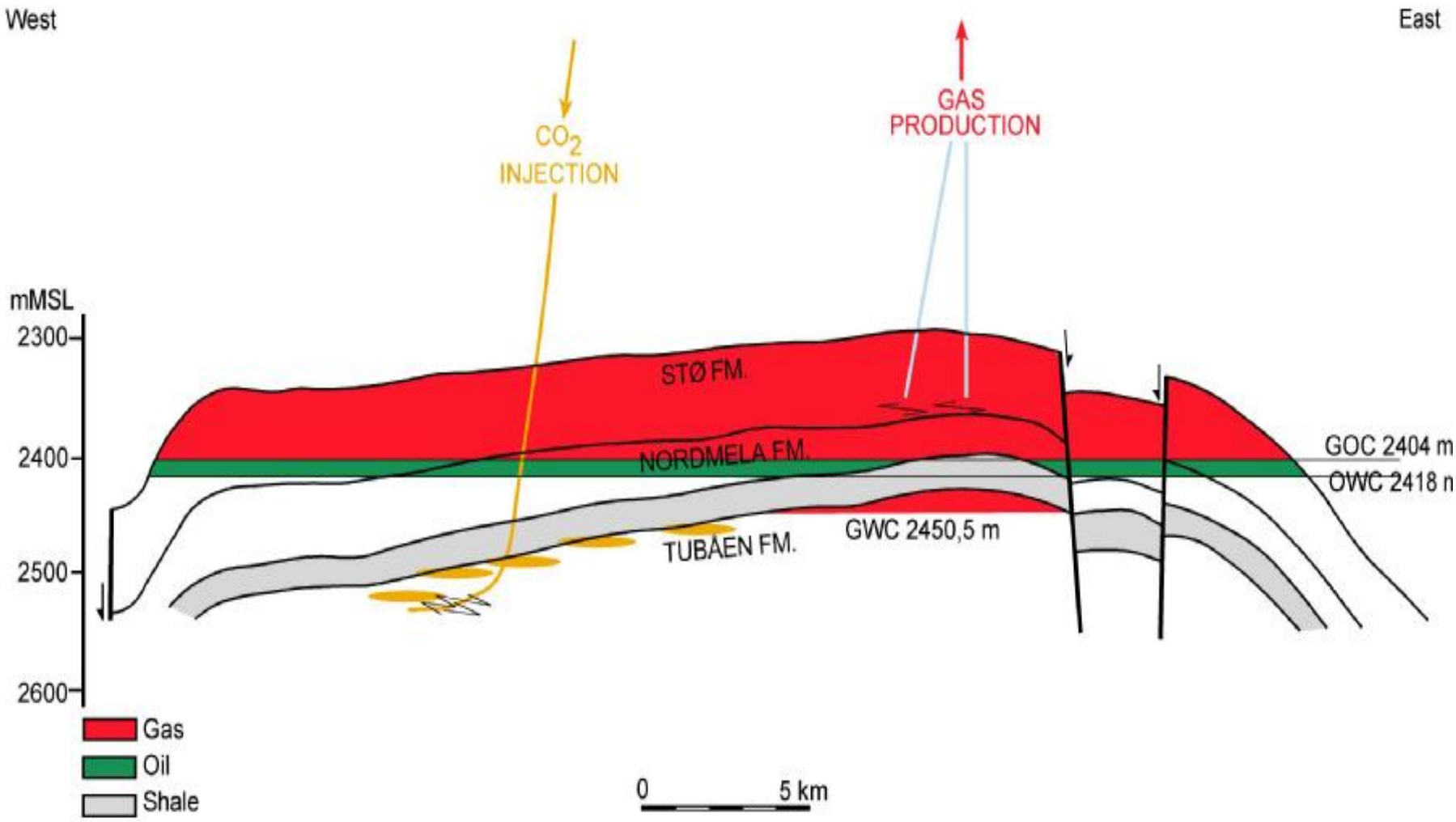
Snøhvit, the next field to implement CO2 storage



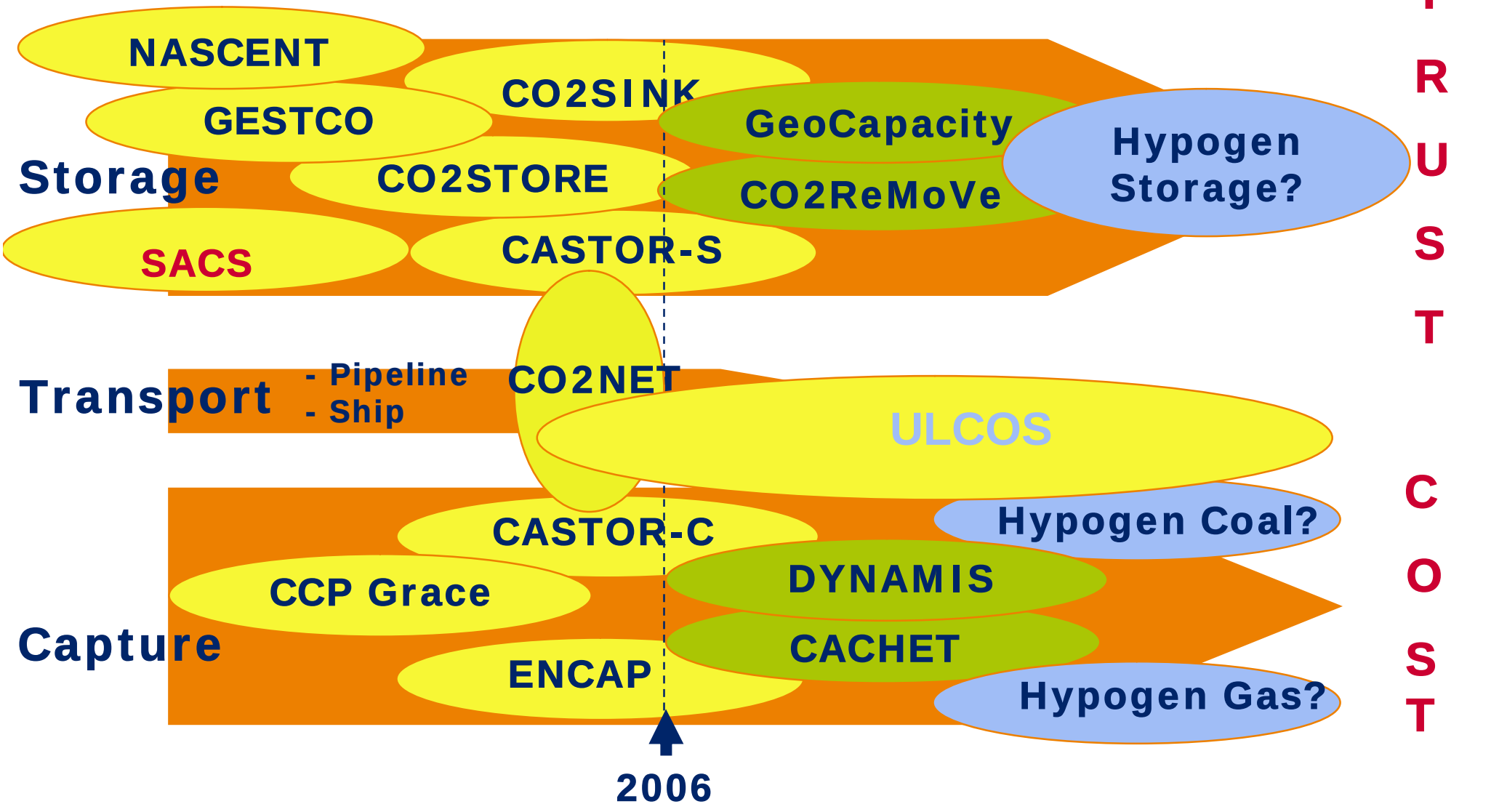
Snøhvit – All subsea



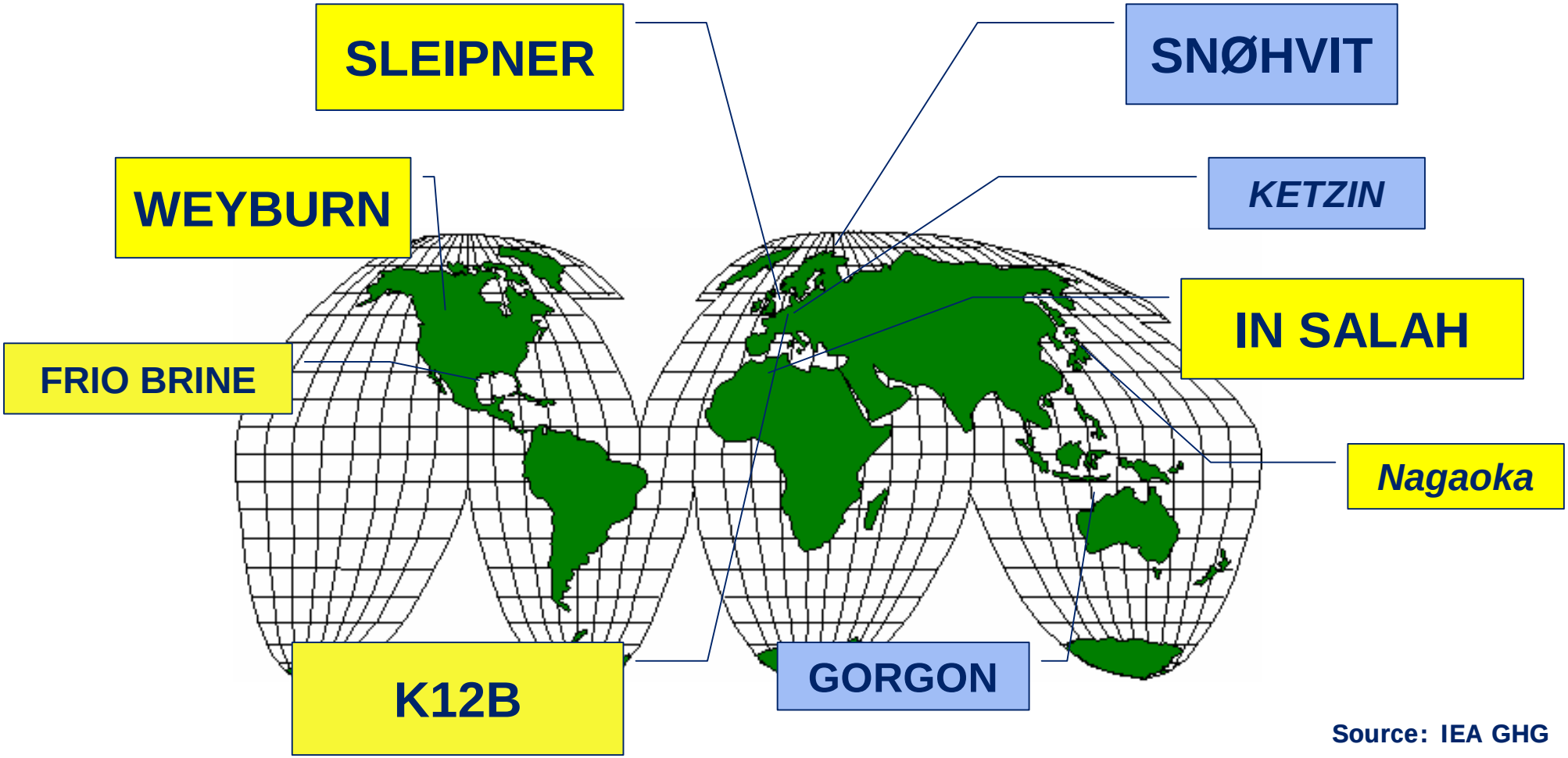
The Snøhvit CO_2 Injection



Towards Large Scale Implementation?



Demonstrations of CO_2 storage



Source: IEA GHG

Trapping and Leakage

Trapping Mechanisms

- Containment
- Micro-pore trapping
- Dissolution in water
- Mineral binding

Leakage ways?

- WELLS
- Faults/Cracks
- Underground mobility

Environmental impacts

Main potential LOCAL impacts:

- **Humans and animals – if concentrated**
- **Plants – if in root systems**
- **Soil**
- **Sea bottom – More R&D!**

Natural analogues:

- **Natural CO2 seeps (vulcanoes)**
- **Under sea vents**

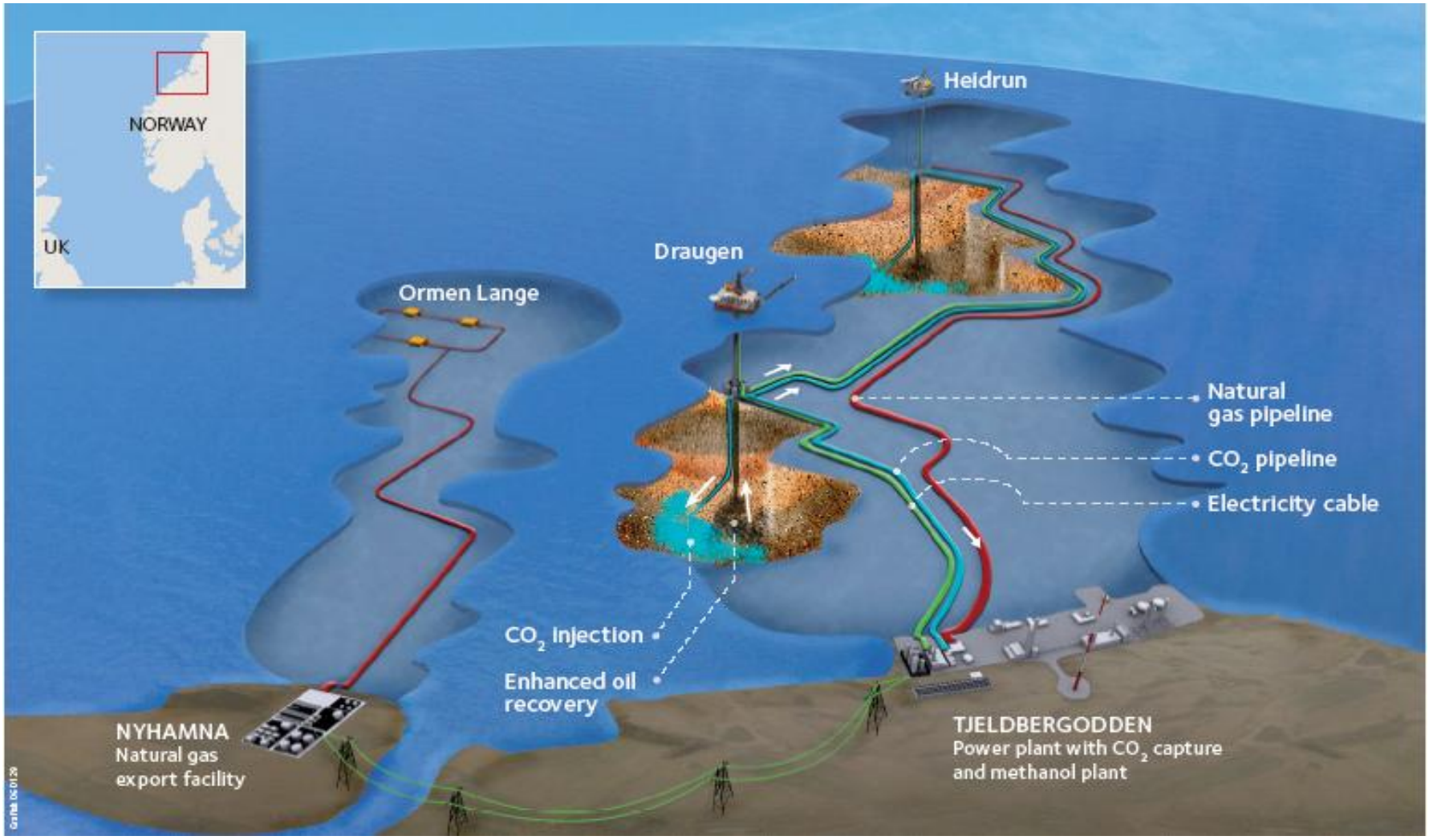
What will the Authorities demand?

- Access rights and Licence
- Site characterisation and Plan
- Monitoring & Verification
- Reporting to UNFCC and ETS
- Remediation?
- Decommissioning and ”Hand shake”
- Monitoring until “stability”?

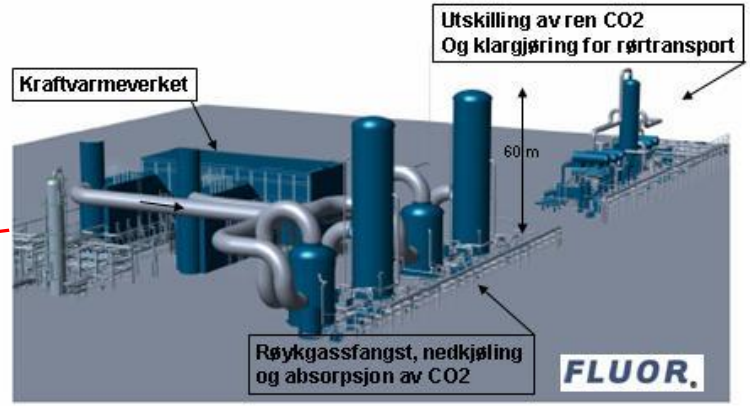
What will the Public demand?

- Safe operation
- No leakage
- Monitoring & Verification in full openness
- Acceptance from UNFCC and ETS
- Long term stability

HALTEN CO2 Project
- Statoil & Shell industrial realization



Mongstad CHP
w/CO2-plant



Plant for CO2-capture

Need two legs to walk !

Reduce capture COST:

- Technologies exists
- Another chemical factory
- Extra investment and energy consumption
- Costs too high for industry

è NEED NEW TECHNOLOGY

Build TRUST in storage:

- Is it staying there long enough?
- Experience and large scale demo
- Experience from EOR and storage
- Oil&gas methods and tools works
- Geology varies from site to site

è MORE DEMO SITES