



NORWEGIAN PETROLEUM
DIRECTORATE



Developments and prospects in Norway

by

Odd Magne Mathiassen

The Norwegian Petroleum Directorate

EGM on Sustainable Development and Carbon Capture and Storage

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UN Department of Economic and Social Affairs
Division for Sustainable Development

Developments and prospects in Norway (CCS)

- ◆ Policy issues and Government initiatives
- ◆ Norwegian GHG emission and some exsamples of mitigation options
- ◆ Projects
 - ◆ Sleipner (CO₂ removal from produced gas)
 - ◆ Snøhvit (CO₂ removal from produced gas)
 - ◆ Kårstø (CO₂ from gasworks)
 - ◆ Mongstad (CO₂ from combined power and heat plant)
 - ◆ Kårstø/Mongstad transport & storage project
 - ◆ Halten (CO₂ from gasworks and injection for Enhanced Oil Recovery, joint industry project)
- ◆ Concluding remarks

The Norwegian government's white paper on climate policy (Presented 22 June 2007)



Prime Minister Jens Stoltenberg called the plan ambitious and world leading. However, the Government's climate policy has been both welcomed and criticised by the opposition and by environmental organizations

Main goal to:

- ◆ *Cut global emissions of greenhouse gases by the equivalent of 30 per cent of Norway's 1990 emissions by 2020*
- ◆ *Be carbon neutral by 2050*
- ◆ *Improve on Norway's commitment under the Kyoto Protocol by 10 per cent*

The Norwegian government's white paper on climate policy “The role of CCS”



- ◆ It's referred to the Soria Moria declaration and states that the government through economical measures and new technology will provide for that all new licenses for gas fired power plants shall be based on CCS
- ◆ In addition to initiatives through Gassnova and the CLIMIT programme, the Government is participating in two CCS projects:
 - ◆ Mongstad CPH (two-stage development)
 - ◆ Kårstø gasworks

The Soria Moria declaration
13 October 2005



Party leaders

The Labour Party
The Socialist Party
The Centre (Agricultural) Party

Gassnova and CLIMIT

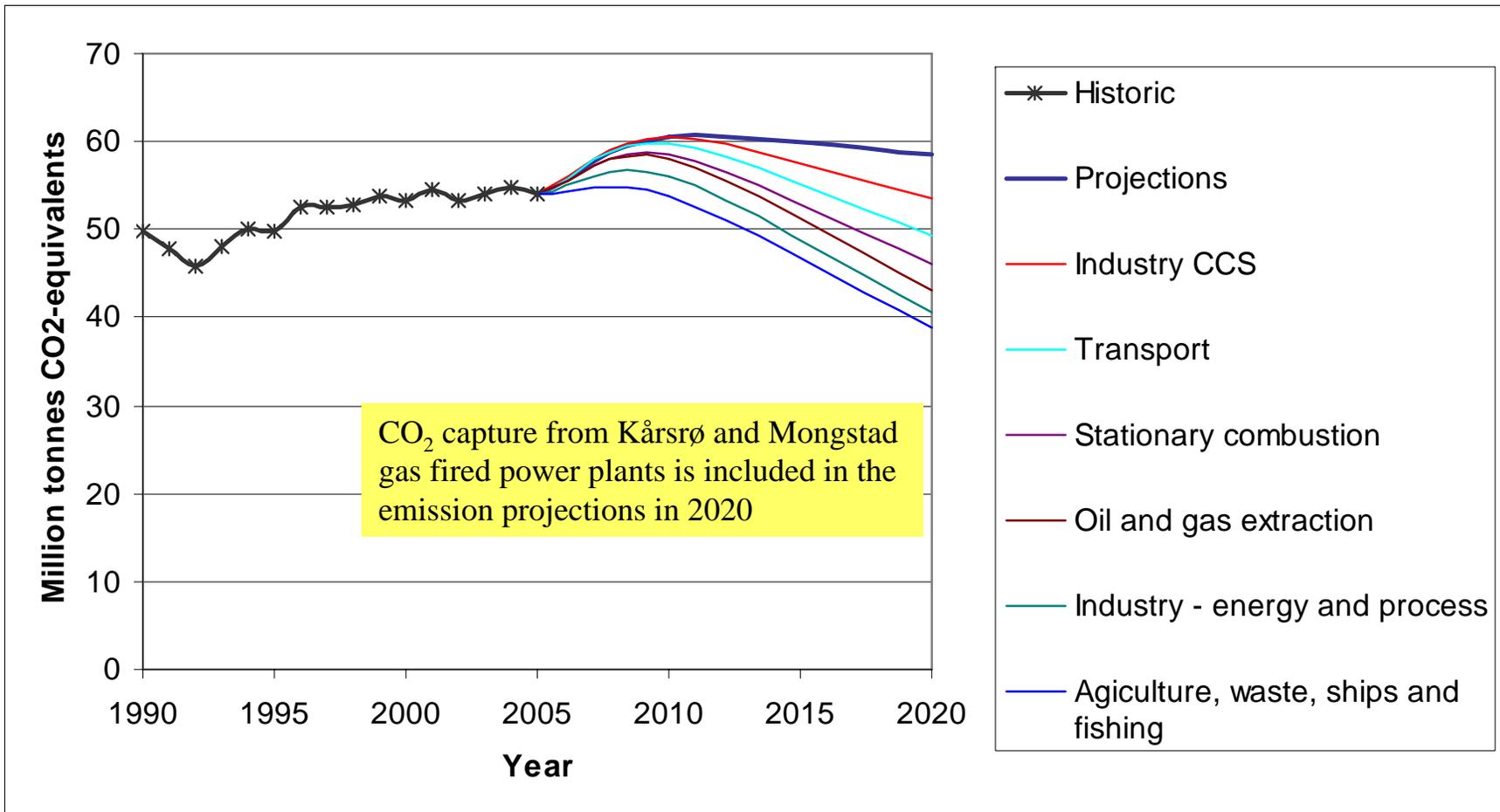


- ◆ **Gassnova** is the Centre for Gas Power Technology. It is a subsidiary of the Norwegian Ministry of Petroleum and Energy. It was established to stimulate the development of technology for natural gas power generation with CCS. The two most important challenges are:
 - ◆ to reduce the costs related to handling of CO₂
 - ◆ and to create public acceptance for geological storage as a climate measure.
- ◆ Gassnova was put into operation on 1 January 2005.

- ◆ **CLIMIT** is the Norwegian national programme for gas power technologies with CCS. Gassnova and the Norwegian Research Council are administering the programme on behalf of the Norwegian state. The programme is designed to promote all phases from research, development and demonstration of technologies

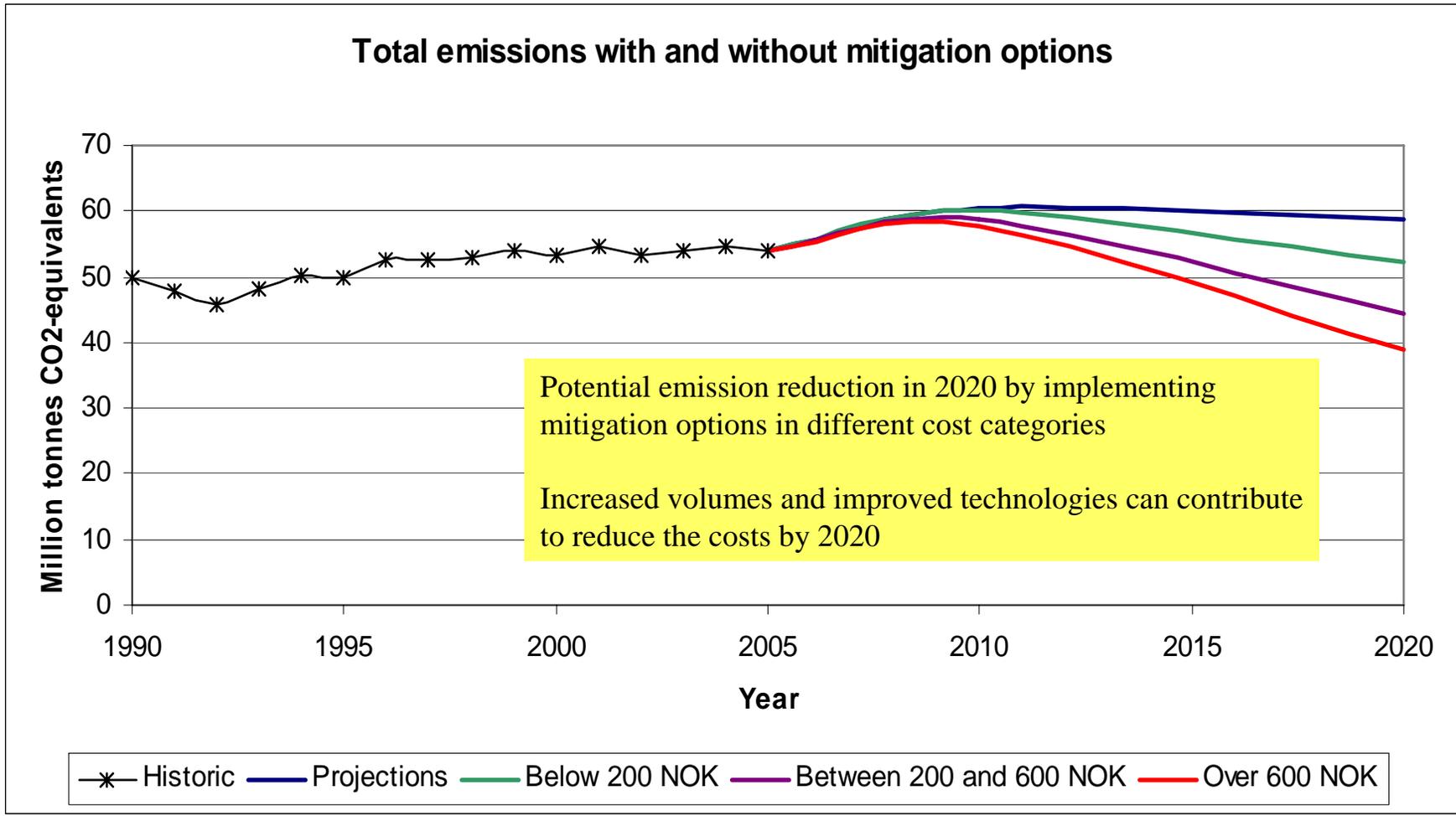


Potential for emission reductions up to 2020 in various sectors (SFT study June 2007)



Source: Norwegian Pollution Control Authority

Mitigation costs (SFT study June 2007)



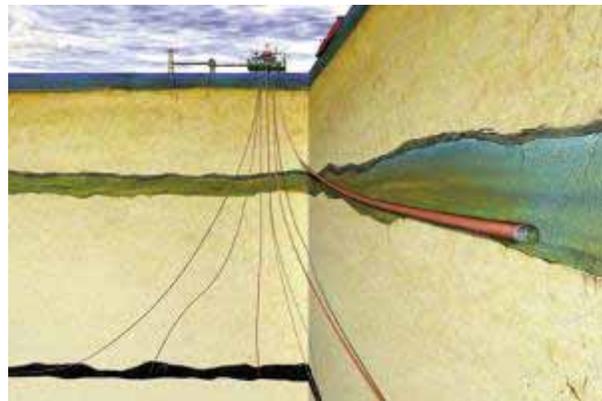
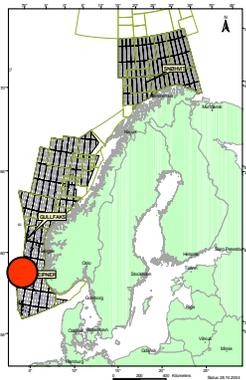
Source: Norwegian Pollution Control Authority

Sleipner CO₂ project



Since 1996, 1 million tonnes CO₂ per year is injected into the Utsira formation, an aquifer about 1000 meters below the sea bed.

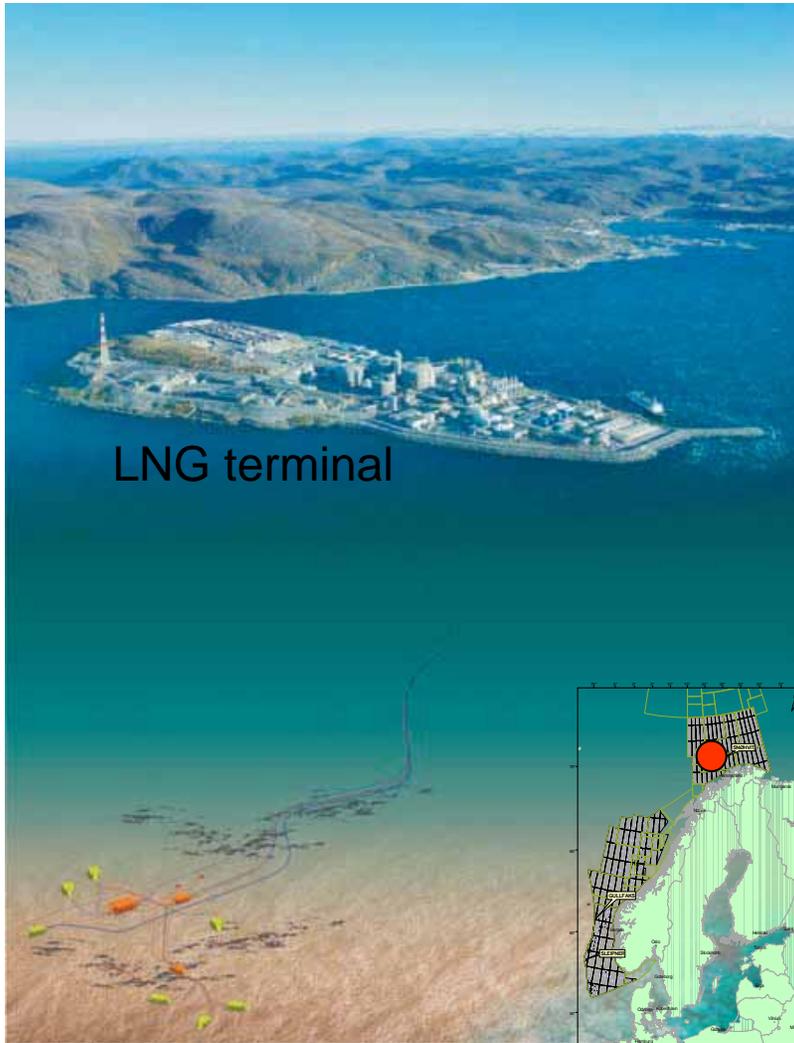
The CO₂ content in the Sleipner gas is about 9%, and has to be removed in order to meet the sales gas specifications at max 2,5% CO₂.



The injection is a result of the Norwegian policy.

Due to the CO₂ tax, injection is a better option than emitting the CO₂ to the atmosphere and pay CO₂ tax, approximately 300 NOK (50 \$) per tonnes CO₂.

Snøhvit CO₂ project



LNG terminal

The Snøhvit field in the Barents Sea is located 150 km from shore.

The CO₂ content in the Snøhvit gas is about 8 % and has to be removed before cooling the gas to LNG.

The production is just started and 0.7 million tonnes CO₂ per year will be injected into the Tubåen formation, an aquifer about 2500 meters below the sea bed.

CO₂ capture from power generation is not included.

Snøhvit is the first development in the Barents Sea. Several reasons lead to the decision to inject and store the CO₂ in a geological formation instead of emitting it to the atmosphere.

Kårstø CO₂ project

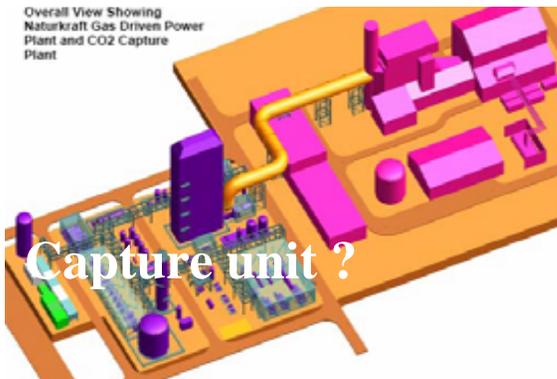


Gas terminal



Power station

Overall View Showing
Naturkraft Gas Driven Power
Plant and CO₂ Capture
Plant



Capture unit ?

420 MW Power Plant

- ◆ Most advanced technology available
- ◆ First of its kind in Europe with a filtering system for NO_x emissions.
- ◆ Expected to start electricity production fall 2007
- ◆ Constructed for possible later installation of gas scrubbing facility for CCS

CO₂ Capture Plant

- ◆ Project team in place
- ◆ Main target to start CO₂ capture early 2012
- ◆ Up to 1.1 mill tonnes CO₂ per year from flue gas
- ◆ Possible CO₂ capture from other point sources at Kårstø gas terminal

Kåtsf CCS cost estimates



Total estimated costs (cheapest storage alternative)			
	CAPEX	OPEX	
Capture	3460	344	million NOK
Transport and storage	1560	25	million NOK
Sum	5020	369	million NOK
Sum	837	62	million USD

CO₂ abatement cost for different annual hours of operation				
Operation hours	2000	5000	8000	hours
Abatement cost	2200	1000	700	NOK/tonne
Abatement cost	367	167	117	USD/tonne

Mongstad CO₂ project



Mongstad refinery

Combined heat and power plant:

- ◆ 350 MW heat
- ◆ 280 MW electric power

Planned CCS

- ◆ 100.000 tonnes CO₂/year from 2010
- ◆ Up to 2,2 million tonnes CO₂/year from 2014

Mongstad CO₂ Project

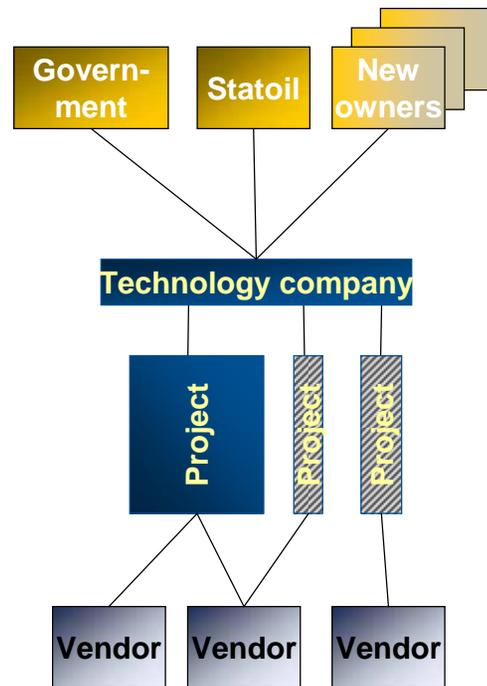


October 2006. The Norwegian government and Statoil undertook an agreement to establish the world's largest full-scale CCS project in conjunction with the projected combined heat and power plant at Mongstad. The project is to be fully operational by the end of 2014. The first stage of the project will be in place at the start-up of the proposed cogeneration facility in 2010.

21 June 2007. The Ministry of Petroleum and Energy signed an agreement with DONG Energy, Hydro, Shell, Statoil and Vattenfall on co-operating towards a test centre for CO₂ capture and storage at the combined power and heating station at Mongstad, Norway.

The co-operation agreement will regulate the planning and preparation for a test centre (European CO₂ Test Centre Mongstad), and will be running until the investment decision for the test centre will take place 1. quarter 2008.

European CO₂ Test Centre Mongstad

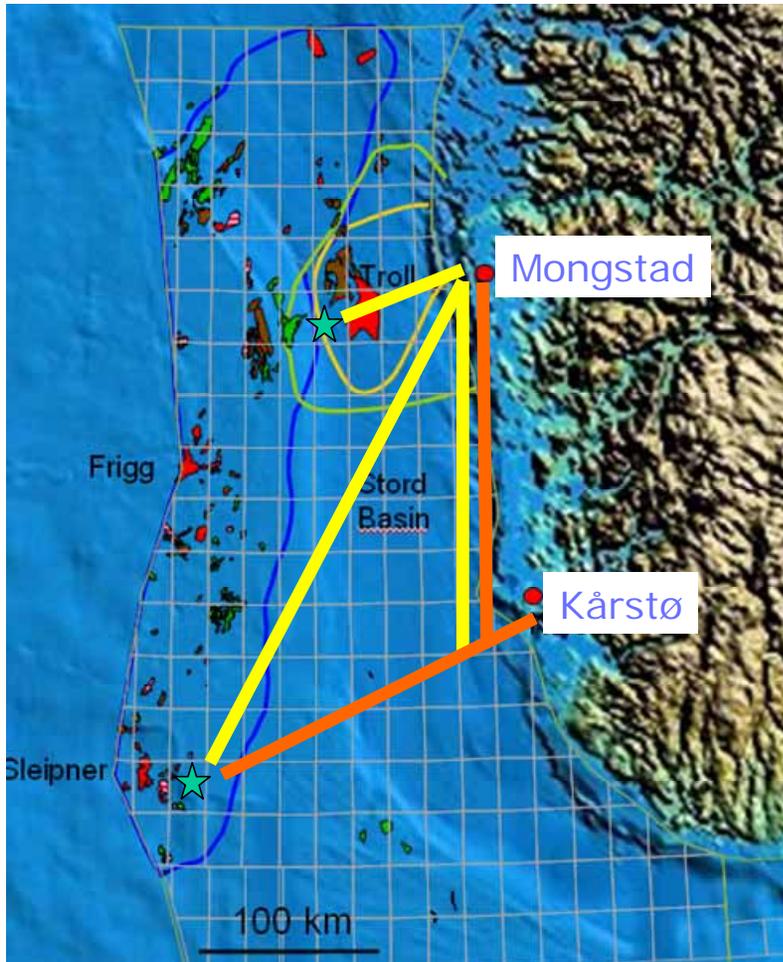


Statoil has signed a joint development contract with Alstom for development of carbon capture using chilled ammonia.
(pilot test period 2009-2011, cooperation with Electrical Power Research Institute EPRI)

- ◆ Agreement 12 October 06
- ◆ Government and industry
- ◆ Owners contribute with know-how, resources and capital
- ◆ Arena for technology development
- ◆ Development contracts
- ◆ Vendors participate based on competition

- ◆ 6 Participants:
The Norwegian state, Statoil, Hydro, Shell, Vattenfall, Dong

Kårstø/Mongstad transport & storage project

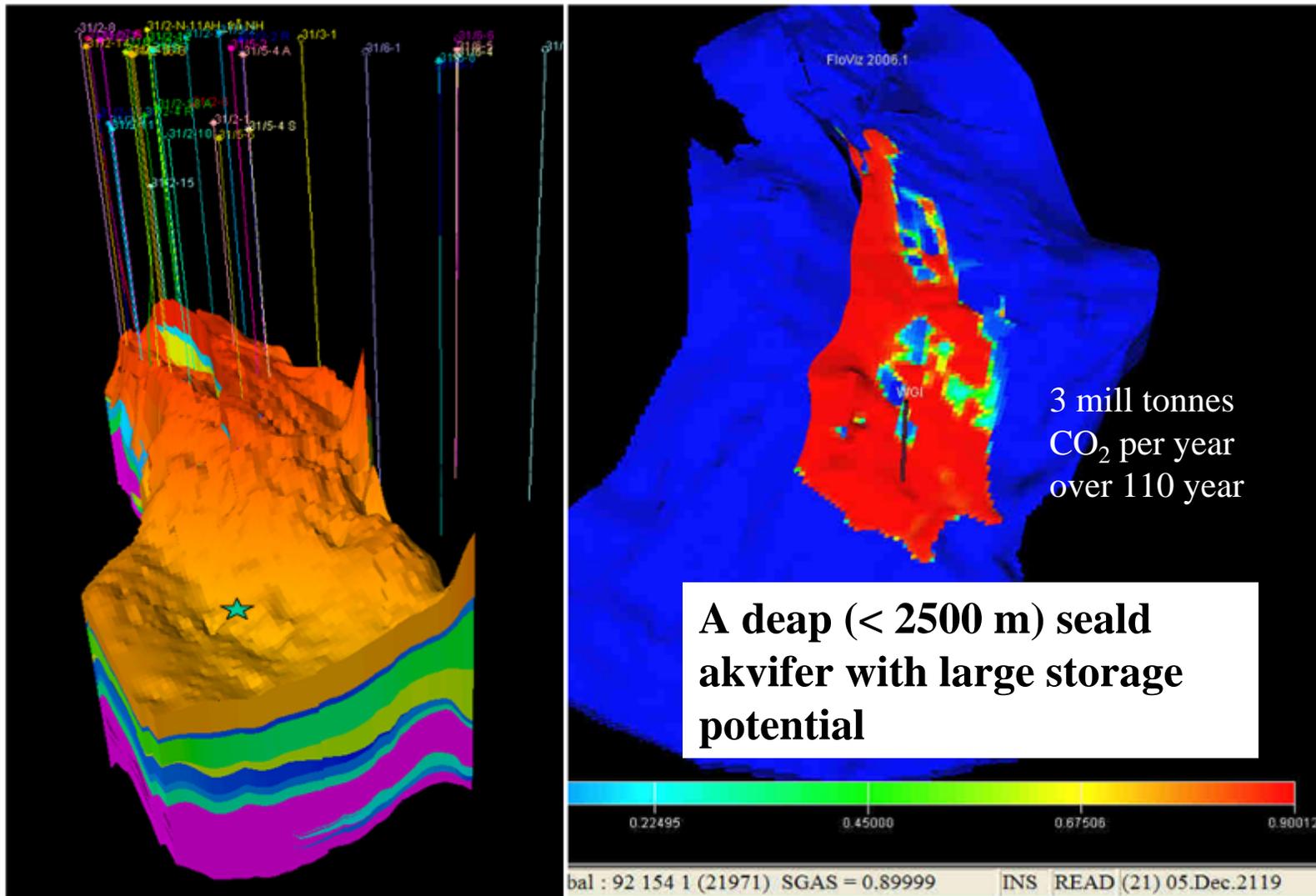


Project team:

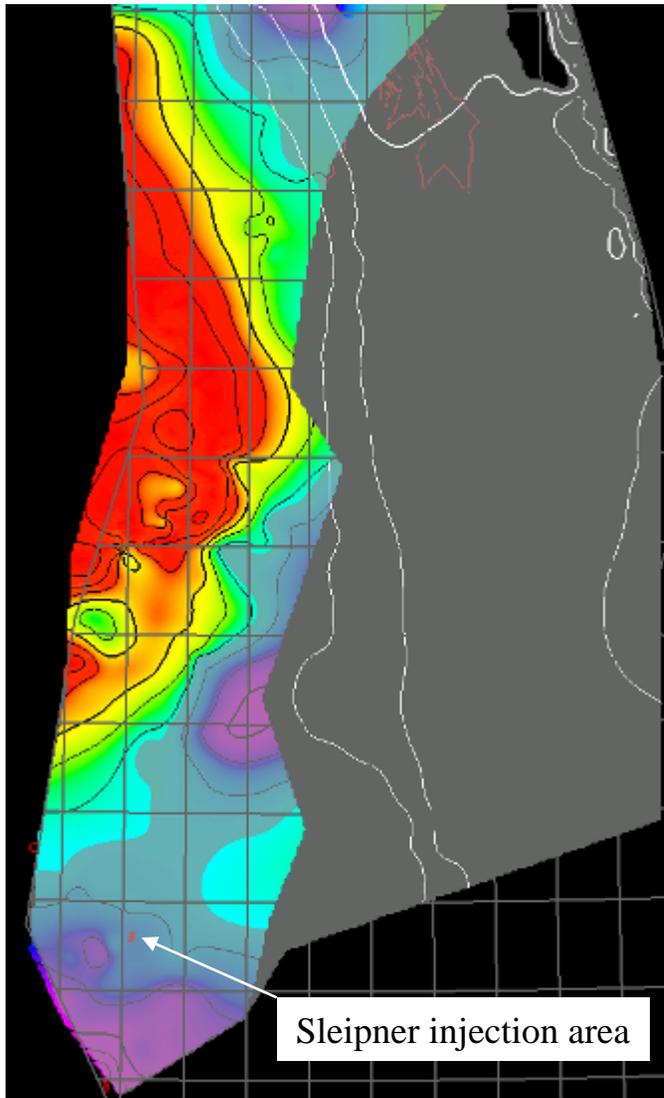
- ◆ Gassnova
- ◆ The Norwegian Petroleum Directorate
- ◆ Gassco
- ◆ The Norwegian Water Resources and Energy Directorate

- ◆ Several possible storage sites identified
- ◆ Pipe transport
- ◆ Injection via existing infrastructure or new sub sea installation
- ◆ Possible future link to oilfields for EOR

Johansen fm storage capacity

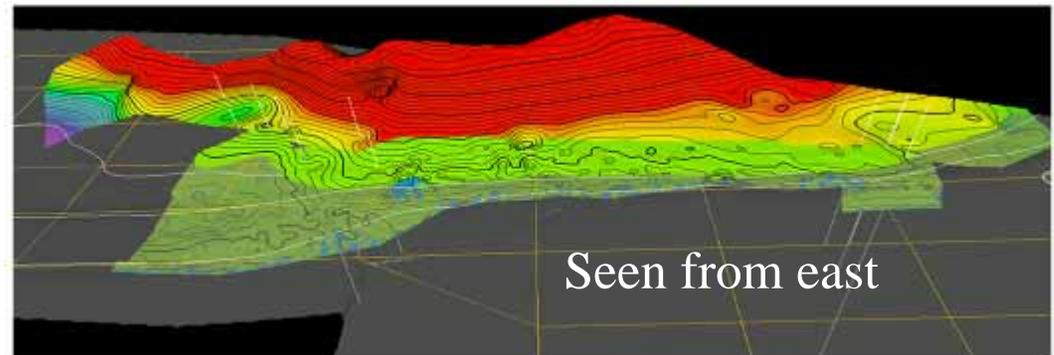


Utsira fm storage capacity



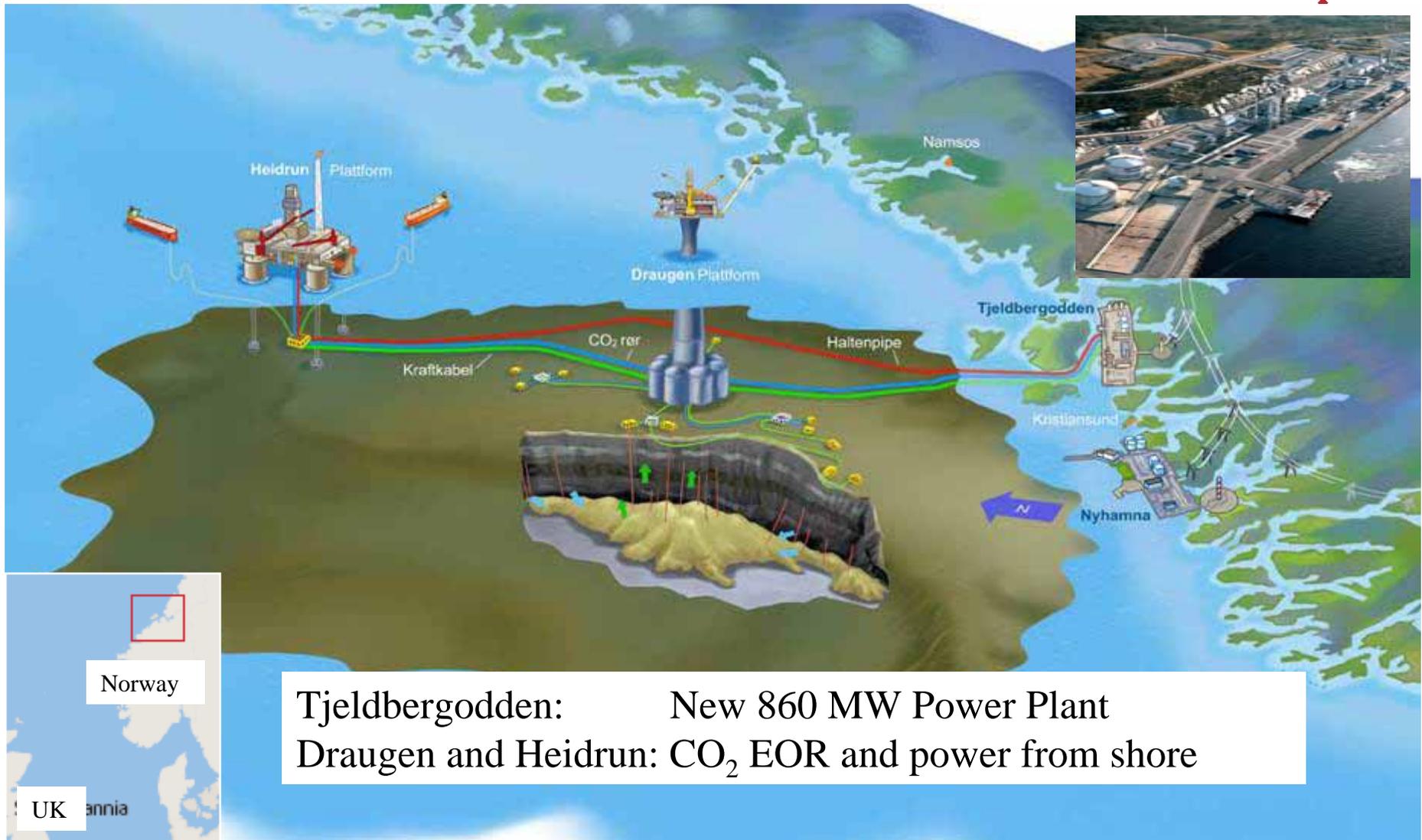
Sleipner injection area

- The Utsira fm is a huge aquifer (26000 km²) with large storage potential
- A large part of the Utsira fm lies above the CO₂ vapour/liquid transition line (not exactly, and dependent on temperature gradient etc).
- Worst case (figure), depth shallower than 750 m
- Best case , depth shallower than 630 m



Seen from east

Halten CO₂ project



Tjeldbergodden: New 860 MW Power Plant
Draugen and Heidrun: CO₂ EOR and power from shore

Halten CO₂ project - Background/history



- ◆ 8 March 2006; announcement of joint effort (Statoil and Shell) to evaluate CO₂ value chain at Haltenbanken
- ◆ A successful development requires a.o. substantial economic contribution by the government and contribution by industrial players onshore and offshore
- ◆ Schedule driver; window of opportunity for EOR at Draugen

- ◆ Established organisation with experts from both companies
 - ◆ **manpower 80 -90 people**
- ◆ Considerable effort put into the project last 14 months
 - ◆ **400 million NOK (65 million USD)**

Halten CO₂ project - Way forward



- ◆ Due to negative EOR value, project has to be redefined or terminated
- ◆ Commercial model without EOR is more complex
- ◆ Project organisation in place, power plant with CCS progressing according to plan
- ◆ A ground-breaking project that needs involvement and commitment from several parties in order to proceed
- ◆ No technical show stoppers identified for the value chain

Work to be continued until end October:

- ◆ Complete technology qualifications
- ◆ Explore further economic models together with, and secure commitment from potential investors/industrial players
- ◆ Clarification of frame conditions with the Government

Concluding remarks on CCS



- ◆ On the positive side:
 - ◆ Political engagement
 - ◆ High level joint projects/studies with other countries
 - ◆ Projects in progress
- ◆ On the negative side.
 - ◆ Large capex/opex
 - ◆ No business drivers (yet)
- ◆ Outstanding issues:
 - ◆ Legal
 - ◆ Public awareness
 - ◆ Mature storage sites for large CO₂ volumes