Offshore CCS-projects in Norway
20 years of experience and 20 million tonnes CO₂ stored

CCS workshop at ISO/TC 265 plenary meeting – September 10th 2015

Sveinung Hagen and colleagues – Statoil
- Gas/condensate field in the North Sea (1996)
- Discovered 1974
- Statoil (operator), ExxonMobil and Total
- High CO$_2$ content (4-9%) - export quality specification allows (2.5%)
- Almost 16 Million ton CO$_2$ stored

- Gas/condensate field in the Barents Sea (2007)
- Discovered 1984
- Statoil (operator), Petoro, Total, GDF Suez, DEA
- All subsea installation, - gas processing (LNG) at Melkøya
- About 150 km gas (and CO$_2$) transport pipe
- Approaching 4 million ton CO$_2$ stored

Decision to store geologically the captured CO$_2$ was based on willingness to try out new technology, CO$_2$ tax incentive and state requirements
Sleipner

Snøhvit

~150 km offshore CO₂ pipeline

TCM

Sleipner

Brevik
Outline Sleipner CO$_2$ injection project

- CO$_2$ from the Sleipner field is stored in the Utsira Formation, North Sea
- Reservoir unit at 800-1100 m depth
- One CO$_2$ injector - 36 meter perforation at ~1012 meter (TVD)
- Injected gas is ~98% CO$_2$
CO₂ plume monitoring and permanence

- Plume distribution controlled by gravity (buoyancy) and top Utsira/ base sealing formation topography
- About 4500 meter long (2013)
- No pressure increase detected/measured at wellhead
- No observation of CO₂ leakage above the Utsira Fm.

Accumulated seismic amplitude difference


Chadwick et al (2005)
Operating the Sleipner CO₂ project

Operational Performance

- Stable wellhead pressure ~65bar
- Wellhead temperature held at 25°C

Monitoring Data

- Wellhead pressure and flow rate is monitored continuously
- Gas composition samples are taken intermittently
- Seven time-lapse (4D) seismic surveys
- Three repeat gravimetric surveys
- Electromagnetic survey
- Sea bottom surveys - Side scan sonar and multi beam echo-sounding 2006 & Synthetic Aperture sonar 2011

Subsurface questions

- Role of internal Utsira shale layers, plume propagation
- Reservoir and wellbore processes
- Maximum injection capacity/rate (large volume beyond Sleipner)
Snøhvit
Outline Snøhvit CO$_2$ injection project

- CO$_2$ from the LNG processing facility at Melkøya stored in the Tubåen and Stø Formation, Barents sea
- Reservoir unit at 2000 - 2500 m depth
- CO$_2$ stored initially in the Tubåen Fm. (2008-11) and then in the Stø Fm. (2011-)
- Stable injection of ~1800 ton/day
**Snøhvit - subsurface setting**

**Stø**
- Shallow-marine environment
- Good lateral and vertical communication

**Tubåen**
- Densely stacked fluvial channels
- Poor lateral and vertical communication

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**Well F-2H**

**Seismic survey - 2003**

**Structural depth map – top reservoir**
CO$_2$ pressure development - Snøhvit
Snøhvit CO₂ 4D seismic (2011 & 2012)

Base

Base-2011
2 months, 121kton

Base-2012
13 months, 550kton

Amplitude change maps
Concluding remarks

• Both Snøhvit and Sleipner inject CO₂ as planned and predicted
• No leakage are observed
• Geophysical, non-invasive monitoring has proven essential for site management and used to address most of the operational questions
• Sharing experience is important for building confidence in CCS

• Need/require international regulation, political courage and public acceptance to move forward!
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