CO2 Capture & Storage (CCS) – 14 Years of Storage Experience

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14 Years of Storage Experience

CONTENT:

• Challenge, Vision & History
• Sleipner, In Salah & Snohvit
• Ketzin, Longyear & Svelvik
• Legal Framework
Challenge, Vision & History
Simplified global energy flows 2007

Primary energy (million tonnes of oil equivalent per year)

Coal 3136
to el. + conversion losses
Crude oil 3906
to el. + conversion losses
Natural gas 2654
to el. + conversion losses
Nuclear 622
Hydropower other renewables 709

Final consumption
industrial
Coal
Oil
to mostly transport and industrial
Gas
to industrial and residential commercial
Electricity

16800 TWh/yr
Potential for CCS – Power and Industry

Worst case scenario is business as usual!

Need to get started now!
Vision

DECARBONISATION OF FOSSIL FUELS TO ELECTRICITY AND HYDROGEN
Sleipner, In Salah & Snohvit
– Industrial sites
Sleipner CO$_2$ injection:
- Decided in 1992
- In operation since 1996
- 1 million tonne CO$_2$/år

**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 Yoonans

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Time Magazine, 17. May 2004
**CO₂ Injection well in "Utsira"**

- **Sleipner A**
- **Sleipner T**
- **Heimdal Formation**

`CO₂` Injection Wells

- **Sleipner East**

- Depth range:
  - 0 - 500m
  - 500m - 1000m
  - 1000m - 1500m
  - 1500m - 2000m
  - 2000m - 2500m
  - 2500m - North Sea
The Utsira Formation
**CO₂ Injection**

- 10.2 mill. tons injected as of 2008 seismic data acquisition (May-June)
- 13 mill. tons injected as of New Year 2010
- Wellhead pressure stable at ~ 64 – 65 bar
- Wellhead temperature set at 25 °C

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**Injected CO₂**

![Graph showing the accumulated mass of injected CO₂ over time.](chart1)

**Wellhead pressure**

![Graph showing the wellhead pressure over time.](chart2)
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
CO$_2$ finnes "lagret" naturlig i undergrunnen.

![Diagram showing storage security over time](image)

**Figure 5.9** Storage security depends on a combination of physical and geochemical trapping. Over time, the physical process of residual CO$_2$ trapping and geochemical processes of solubility trapping and mineral trapping increase.
In Salah Gas Project Location, Algeria

<0.3% CO2

5-10% CO2
In Salah in Algeria

Sandstones & Mudstones ~900 metres thick (Regional Aquifer)

Reservoir ~20 metres thick

Mudstones ~950 metres thick

4 Gas Production Wells

3 CO₂ Injection Wells

Amine CO₂ removal

The CO₂ storage scheme at Krechba

Gas

Water
In Salah Satellite Monitoring

First TRE dataset (2003-2007) 
PSInSAR™ revealed ~5mm uplift 
over the CO2 injectors

Vasco et al. 
In Salah 4D seismic amplitude changes at reservoir level
Snøhvit, implement CO₂ storage offshore in North Atlantic
Snøhvit – All subsea

Depth: 330 m

160 km
Snohvit CO$_2$ Injection
Snøhvit CO\textsubscript{2} monitoring

![Graph showing pressure over time and cumulative injected mass.](image)

4D seismic acquisition

![Amplitude changes.](image)

Modelled CO\textsubscript{2} saturation and pressure increase

![Map showing CO\textsubscript{2} injection well locations and pressure increase.](image)
Ketzin, Longyear and Svelvik
- Pilot test sites
CO2SINK - First European On-shore CO$_2$ Storage Project at Ketzin (Germany)

Coordinator: GFZ, Potsdam
Industry: E.ON, RWE, Schlumberger, Shell, Siemens, Statoil, Vattenfall, VNG
Ketzin - Facilities at Wintertime

Source: GFZ, Potsdam
Regular Operations (3)
Rates & Pressures

Source: GFZ, Potsdam
LONGYEAR CO₂ - Storage on Svalbard
CO2 Storage on Svalbard

Drill hole target – 900 m

Longyearbyen

Source: UNIS, Svalbard
Longyear CO2 – Drill rig at winter

Courtesy: UNIS, Svalbard
CO2 Field Lab

Objectives:

1. Determine requirements for monitoring of industrial CO2 storage
2. Quantify unforeseen migration and leakage into the atmosphere or ocean

Courtesy SINTEF Petroleum
CO2 Field Lab – Svelvik site
Legal Framework — Present status

- **Ownership to site** – Ground owner
  **Ownership to subsurface** – State*

- **Petroleum law** – Injection of fluids
- **Environmental Protection law** - Emissions to air and sea

- **EU Water Directive** – CO2 excluded
- **EU Landfill Directive** – CO2 excluded
- **EU CCS Directive** – Regulates “from birth to grave”
  Under implementation in Member States and Associated Norway

* USA special – Subsurface owned by ground owner
THANKS for your attention!

QUESTIONS?