Case Studies of CO$_2$

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Contents

• CCS Projects - lessons learned
• Acceptance
• CCS commercialization
• How to find solutions?
  − Governments
  − Companies
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Statoil’s CCS projects
An Industrial Approach to the Climate Change Challenge

1996-
2004-
2008-
2012-
?
Sleipner, North Sea

- CO$_2$ from the Sleipner field is stored in a saline sandstone aquifer
- Storage formation at 800-1100m depth, gas reservoir at ~3000m
- One CO$_2$ injector - 36 meter perforation at ~1012 meter (TVD)
- Injected gas is ~98% CO$_2$
- >13.5Mt CO$_2$ have been injected since 1996 (~0.9M per annum)
- CO$_2$ tax (from 1992) the main incentive
In Salah, Algeria

- In Salah is multiple gas field development project in central Algeria (JV with Sonatrach and BP)
- CO$_2$ contents in the gas fields ranges between 1% and 9%
- CO$_2$ is separated from the gas and injected into the down-dip aquifer of the Carboniferous sandstone at Krechba (1900m)
- CO$_2$ Injection started in 2004 and since then over 3.8 million tonnes of CO$_2$ have been stored
- A comprehensive monitoring programme has been developed - In Salah JIP
- Pipeline specifications and climate awareness
Snøhvit, Barents Sea

- Snøhvit LNG project, in the Barents Sea offshore Norway
- \( \text{CO}_2 \) is captured onshore and transported in a \( \sim 140 \) km subsea pipeline to a subsea template
- The \( \text{CO}_2 \) is injected at a depth of 2600m into the saline sandstone formations (below the gas reservoir)
- Injection of \( \text{CO}_2 \) started in 2008, at a rate of \( \sim 80 \) t/hr
- Gradual rise in reservoir pressure indicated limited injection rate/capacity
- Well intervention operation successfully completed May 2011
- \( \text{CO}_2 \) tax the main incentive
The CO₂ Value Chain

Statoil’s main expertise

CO₂ EOR

Multiple storage sites possible for large volumes
• Abandoned fields
• Saline formations

CO₂ transport

Transport facilities dedicated or dimensioned for additional volumes
• Pipeline
• Vessel

CO₂ storage

Multiple source but two main clusters;
• Emitter (coal)
• Capture facility

CO₂ owner

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CO₂ owner
# CCS – not fully accepted yet

<table>
<thead>
<tr>
<th>Potential barriers or enablers</th>
<th>International (I), Regional (R), National (N)</th>
<th>Expected time until solved</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNFCC-IPCC National Inventories</td>
<td>N, I</td>
<td>&lt; 2 years</td>
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<tr>
<td>Kyoto Protocol (CDM and Ji)</td>
<td>I</td>
<td>2-5 years</td>
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<tr>
<td>UNCLOS</td>
<td>I</td>
<td></td>
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<td>London Convention and Protocol</td>
<td>I</td>
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<tr>
<td>OSPAR</td>
<td>R</td>
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<td>Trans-boundary movement and/or damage</td>
<td>I</td>
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<tr>
<td>The Aarhus Convention</td>
<td>I</td>
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<tr>
<td>EU ETS</td>
<td>R</td>
<td></td>
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<tr>
<td>EU enabling legal framework</td>
<td>R</td>
<td></td>
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<tr>
<td>UK regulations and CCS</td>
<td>N</td>
<td></td>
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<tr>
<td>Norway regulations and CCS</td>
<td>N</td>
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<tr>
<td>Long-term liability</td>
<td>N, R, I</td>
<td></td>
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<tr>
<td>Risk assessment methods</td>
<td>I</td>
<td></td>
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<tr>
<td>Risk acceptance, including site approval criteria</td>
<td>I</td>
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<tr>
<td>Monitoring and verification</td>
<td>I</td>
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<td>Public support</td>
<td>I</td>
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<tr>
<td>Accounting and certification of credits</td>
<td>I</td>
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<td>Costs and economics</td>
<td>I</td>
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<tr>
<td>Incentives</td>
<td>I/R/N</td>
<td></td>
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<tr>
<td>Technology maturity</td>
<td>I</td>
<td></td>
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</tbody>
</table>

- Political issues
- Legal issues
- Scientific issues
- Technology and cost issues
- Public acceptance

Source: DnV
CCS Commercialisation

Capture and store

Cost

 Emit CO₂

High

- CO₂-EOR
- Technology development
- Kyoto mechanisms CDM
- Environmental taxes
- Emission limitation

Time

20??

Sleipner

Classification: Internal     2012-12-04
Making business out of CO₂

• CO₂ capture, transport and storage
  - Developing business storing 3rd party CO₂
  - Use of CO₂ for enhancing oil recovery – EOR

• Kyoto Mechanisms – business development
  - Capturing business opportunities through Kyoto mechanisms
  - Contribute to sustainable, climate friendly industry practices – flaring reduction
## How do find solutions?

### Governments

- Accept the global climate challenge
- Global agreements
  - New Kyoto Agreement?
  - Cap and Trade
  - International policies (storage)
- National incentives
  - Cost recovery/ tax incentives
  - Emission quotas
- National penalties
  - Taxes, emission caps,

### Industry

- Accept the global climate challenge
- Establish clear industrial positions
- Technology development
  - Cost reduction
  - Qualification and scaling
- Risk taking – market positioning
- Cooperation vs competition
- Industry – academia - government

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**What can we afford - cost and/or consequences**
Technology development needed

- To reduce cost
- To upscale & increase capacity
- To test & implement
- To build trust & competence

- Mainly capture
- CCS value chain
- CCS value chain
- Storage
CO₂ Value Chain Research & Development

• Some CO₂ value chain research projects:
  - Amine technology
  - Carbonate technology
  - Combustion processes
  - Mass transfer equipment
  - Pre combustion technology
  - Ceramic material technology and oxyfuel
  - CO₂ transport and injection
  - CO₂ storage accept
  - CO₂ subsurface
  - CO₂ fundamental properties
Tecnology Center Mongstad - Ambitions

- Test, verify and demonstrate CO$_2$ capture technology owned and marketed by vendors
  - verify safe and stable continuous operation
  - identify and assess critical equipment

- Reduce cost, technical, environmental and financial risks
  - develop and validate modelling tools
  - minimise energy demand and other operating costs
  - reduce capital costs

- Encourage the development of market for CO$_2$ capture technology
TCM Owners

GASSNOVA  75.12%

Statoil    20%

Shell      2.44%

Sasol      2.44%

Other potential partners to be invited
“Need high price on CO₂”

• Helge Lund to UN Climate Summit:

  “As an industry leader, I am aware of only one solution which can yield results quickly enough

  - placing a high price on CO₂”

  - Will speed up development of new carbon emissions reducing technologies
  - The challenges are complex and demanding. Finding sustainable solutions is a matter of urgency
  - Would bring about sufficient results because production would become more efficient

  and energy forms releasing less carbon dioxide would become more competitive

• A new global framework must take into account the fact that contribution opportunities vary

  from country to country
Concluding Remarks

• Incentives necessary to make CCS happen
• Both governments and industry have a role to play
• Binding global agreements and joint industry positions awaited
• Can we afford the consequences?
• Place a high price on CO₂
Thank you

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