CO₂ Storage at In Salah
Iain Wright, CO₂ Project Manager, BP Alternative Energy

2ⁿᵈ International CCS Symposium
Paris, October 4ᵗʰ 2007
Agenda

• CCS Technology
• Why Demonstrate CO2 Storage at Industrial-Scale?
• Objectives of the In Salah CO2 Storage Project
• Progress to Date
• Lessons Learned
• Next Steps
• Questions
BP CCS Technology Program

Research

Industry / Academic Initiatives

Technical Demonstrations

Industrial Scale Projects

Source-sink matching
- CO2CRC, EUGeocapacity, Coach, US Regional partnerships

Public policy support
- CSLF, ECCP, EU-ZEPP, CDM

Assurance framework
- CO2CRC, CSLF, IMCO2, WRI

3rd Party Demonstrations
- Sleipner, Weyburn, CO2Remove

DF1

DF2

DF3, 4, 5 . . .
Technology Options for GHG Stabilization

The Stabilisation Wedge

Emission trajectory BAU

Emission trajectory to achieve 500ppm

1 GtC Slices of the Stabilisation Wedge

<table>
<thead>
<tr>
<th>Examples of Lower Carbon Slices</th>
<th>Scale for 1GtC Reduction by 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased energy efficiency across the economy</td>
<td>'Emissions/$GDP' increased</td>
</tr>
<tr>
<td>Increased energy efficiency (e.g. vehicles only)</td>
<td>2 billion gasoline/diesel cars achieving 60mpg</td>
</tr>
<tr>
<td>Fuel switching natural gas displacing coal for power</td>
<td>1400GW fuelled by gas instead of coal</td>
</tr>
<tr>
<td>Solar PV or wind replaces coal for power</td>
<td>1000x scale up PV; 70x scale up for wind</td>
</tr>
<tr>
<td>Biofuels to replace petroleum based fuels</td>
<td>200x10^6 ha growing area (equals US agricultural land)</td>
</tr>
<tr>
<td>Carbon Capture and Geological Storage</td>
<td>CO₂ captured from 700 1GW coal plants; storage = 3,500x In Salah/Sleipner</td>
</tr>
<tr>
<td>Carbon Free Hydrogen for Transport</td>
<td>1 billion H₂ carbon free cars; H₂ from fossil fuels with CO₂ capture &amp; storage or from renewables or nuclear</td>
</tr>
<tr>
<td>Nuclear displaces coal for power</td>
<td>700 1GW plants (2x current)</td>
</tr>
<tr>
<td>Biosequestration in forests and soil</td>
<td>Increase planted area and/or reduce deforestation</td>
</tr>
</tbody>
</table>
CCS is Now in the Technology “Valley of Death”
EU ZEP Deployment Roadmap

- ZEPs Included in EU ETS
- FP 6 R&D: GRACE, NGCAS, SACS, GESTCO, CASTOR, ENCAP, CACHET, ReMoVe, DYNAMIS

- New Project CO2 Avoidance Cost
- ZEFPFP Business as Usual
- 25 New Policy Projects
- Early Mover Project 10
- Early Mover Project 9
- Early Mover Project 8
- Early Mover Project 7
- Early Mover Project 6
- Early Mover Project 5
- Early Mover Project 4
- RWE Germany
- Mid-Norway
- Peterhead UK
- ZEFPFP CO2 Avoidance Cost

In Salah

Years

ZEFPFP CO2 Avoided (millions tonnes/year)

New Project CO2 Avoidance Cost (€/tonne)
A Business Model for CCS Deployment

Hydro-Carbon

Syngas manufacture

H₂

Combined Cycle
Power Generation

‘Carbon Free’
Electricity

CO₂ Storage

CO₂

e⁻

Transportation

Provides optionality for future to supply H₂ into other sectors

H₂

H₂
How Does In Salah Contribute?

**CO₂**

**In Salah**

**CO₂ Storage**

**Hydro-Carbon**

syngas manufacture

**H₂**

Combined Cycle Power Generation

**e⁻**

‘Carbon Free’ Electricity

**H₂**

Transportation

*Provides optionality for future to supply H₂ into other sectors*
Three Projects at In Salah

• Joint Project of BP, Sonatrach and Statoil

• In Salah Project(s) Overview

  - In Salah Gas Development (1bcf/d $2,000 million)
  - In Salah CO₂ Storage (1mmtpa $ 100 million)
  - In Salah CO₂ Assurance R&D (CSLF & EU $30 million)
    - Part of EU FP-6 CO2ReMoVe ($3mm)
In Salah CO₂ Storage: Project Overview

Climate Change Milestones

- Industrial Scale Demonstration of CO₂ Geological Storage (Conventional Capture)
- Storage Formation is very similar to the North Sea (USA & China)
- Started Storage in August 2004
- 1mmtpa CO₂ Stored (17mm tonnes total)
- $100mm Incremental Cost for Storage: No commercial benefit
- Test-bed for CO₂ Monitoring Technologies $30mm Research Project
In Salah Gas Processing Plant

- Import Gas Pipeline from Teguentour and Reg
- CO2 Storage Pipeline to Krechba
- Export Gas Pipeline to Hassi R’Mel & Europe (1 BCF/d)
CO2 Storage Project

50mmscf/d CO2 (1mmtpa)
Compression
Transportation
Injection
Storage
Objectives (2004-10)

1. Provide assurance that secure geological storage of CO₂ can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring.

2. Demonstrate to stakeholders that industrial-scale geological storage of CO₂ is a viable GHG mitigation option.

3. Set precedents for the regulation and verification of the geological storage of CO₂, allowing eligibility for GHG credits.
Krechba Field

Reservoir

Injectors

Producers

Gas-Water Contact

1330 metres below Mean Sea Level
~1800 metres below Ground Level

Full Gas Column

Kb-1
Kb-2
Kb-4
Kb-5
Kb-8
Kb-9
Kb-10
Kb-11
Kb-12
Kb-13
Kb-14
Kb-501
Kb-502
Kb-503

Surface
Relative Performance - Injectors

Injectors performance to end August 2007:
37.4 bscf

- KB-501 Injection MMscf: 14188, 38%
- KB-502 Injection MMscf: 14080, 38%
- KB-503 Injection MMscf: 9119, 24%
Monitoring Technology: Lessons Learned

JIP Benefit

Low
- Microbiology
- Aquifer studies
- Satellite Imaging
- Dynamic Modelling
- Water Chemistry
- Annulus Sampling
- Trace Geochemistry
- Wellbore monitoring
- Soil gas

Consider

- Flowmeters
- Tiltmeters
- Cement CO2 work
- Surface flux
- Geomechanics
- Tracer
- 4D gravity
- Microseismic
- 4D VSP

Just Do It

- 4D Seismic
- Logging
- Observation Wells
- Park

Key

To be tested

JIP Cost

High
- Microbiology
- Aquifer studies
- Satellite Imaging
- Dynamic Modelling
- Water Chemistry
- Annulus Sampling
- Trace Geochemistry
- Wellbore monitoring
- Soil gas

Low
Monitoring: Oil & Gas vs Saline Formations

<table>
<thead>
<tr>
<th></th>
<th>EOR Project</th>
<th>Depleted O&amp;G</th>
<th>Saline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional/</td>
<td></td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Waterflood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EOR</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CO2 Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Forward Plan: Next 12 Months

• 4Q 2007
  – Soil gas depth testing, lineament analysis, microseismic testing, tiltmeters, surface flux monitoring, hydrogeology, microbiology, gravity test

• Early 2008
  – Full soil gas survey, microseismic array, gravity survey
  – Shallow observation well(s)
  – Further data acquisition from new production wells
  – Hydrogeology/microbiology

• Early to mid 2008
  – 3D seismic survey
  – surface flux
  – gravity measurements
  – logging
Summary

• **BP is Taking Big Steps Towards CCS Deployment**

• What’s required:
  - Regulatory Framework: *Is it Legal?*
  - Policy Framework: *Will Investors be Paid?*
  - How to deal with: *Long-term Liability?*

• In Salah helps to develop answers

• **BP is ready to invest in CCS projects in locations where the three key questions are answered.**
Thank You. Questions?

Useful Links:

• Check your carbon footprint at: www.bp.com
• Princeton Wedges: www.princeton.edu/cmi
• CCS Technology: www.co2captureproject.org
• EU CCS Roadmap: www.zero-emissionplatform.org
• Iain’s email: wrightiw@bp.com