Future of CCS Technology – Moving Ahead

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• Crystal ball
• Trends
• New drive?
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Conclusion
1. Slow progress – Do storage pilots!
2. Power expensive – Do industry!
Crystal ball
This is it!
Simplified global energy flows 2007

Primary energy (million tonnes of oil equivalent per year)

- Coal 3136
- Crude oil 3906
- Natural gas 2654
- Nuclear 622
- Hydropower and other renewables 709

Final consumption

- Coal
- Oil
- Gas
- Electricity

To energy: industrial, mostly transport and industrial, residential and commercial, and conversion losses.
Worst case scenario is business as usual!

Need to get started now!
Vision

DECARBONISATION OF FOSSIL FUELS TO ELECTRICITY AND HYDROGEN
Machiavelli «Il Principe» 1513:

There is no more dangerous act than trying to implement a new way

because

…the old way has formidable and numerous defenders and the new way only feeble and few supporters.
Arthur Schopenhauer:

“All new truths pass through 3 stages:

1. Ridicule,
2. Violent opposition and
3. Accepted as obvious.
Trends
Putting the World on a LOW CARBON DIET

The oil and gas industry has come up with a novel way to cut harmful CO₂ emissions: put them back in the ground

By Matthew Yeomans

TIME NEXT

Put to Bed Statoil’s full CO₂ research program. “Sleipner will not be a lone lighthouse for much longer.”

Carbon storage and capture is not what environmentalists would call a green technology, its raison d’être is to sustain and even increase the output of fossil fuel. Disposal, gas and coal this rate. Next reportage explores new developments in more, sore and hydroelectric energy. But sustainable energy solutions—ever imperfect ones—are needed in a world addicted to fossil fuels, and carbon sequestration could help the transition to clean, renewable fuels over the next 50 years. One reason for carbon sequestration’s newfound popularity in Europe is that, starting in 2008, the E.U. will cap carbon emissions as part of its commitment to the 1997 Kyoto agreement on global warming. Installations will be assigned a carbon emis-

Sleipner CO₂ injection:
- Decided in 1992
- In operation since 1996
- 1 million tonne CO₂/år

Time Magazine, 17. May 2004
In Salah in Algeria

Carboniferous Reservoir ~20 metres thick
Carboniferous Mudstones ~950 metres thick
Cretaceous Sandstones & Mudstones ~900 metres thick (Regional Aquifer)

Gas Production Wells
CO₂ Injection Wells
Processing Facilities
Amine CO₂ Removal

The CO₂ storage scheme at Krechba
Snøhvit, implement CO₂ storage offshore in North Atlantic
Snøhvit – All subsea

Depth: 330 m

160 km
CO2SINK - First European On-shore CO₂ Storage Project at Ketzin (Germany)

Coordinator: GFZ, Potsdam
Industry: E.ON, RWE, Schlumberger, Shell, Siemens, Statoil, Vattenfall, VNG
Test Centre Mongstad – inaugurated June 2012

Amine and chilled ammonia CO2 capture demos,
100,000 t CO2/a combined capacity – “Catch and release”
Legal Framework

**OSPAR & London Protocol**
- since February 2007:
  - CO2 storage permitted sub-seabed, if:
    1) Content as captured, no additions
    2) Sea bottom monitored – HOW?
    3) EIA - Environmental Impact Assessment – WHICH?

- since 2010?

- CO2 trans-border (over or under), if:
  1) Both states agree
  2) Both states follow OSPAR & London standards
Research on Environmental Impact

PAST:

• NASCENT – Natural Analoges for geological CO2 Storage. Terrestrial and sea-bottom impacts of volcanic seepages

ONGOING:

• RISCS – ”Research into Impacts and Safety in CO2 Storage”. Terrestrial and sea-bottom impacts of possible seepage

• ECO2 – “Sub-seabed CO2 Storage; Impact on Marine Ecosystems“.  
  1) CO2 appearance (if seeping)  
  2) Detection  
  3) Sensitivities of marine species

• QUICS – Controlled release of CO2 in the sub-seabed in Scotland
Pressure vessel 25 bar at SINTEF Sealab, Trondheim
SAFETY STRATEGY

- Prepare
- Monitor
- Remediate
CO2QualStore – Site selection

CO2QUALSTORE – Guideline for Selection and Qualification of Sites and Projects for Geological Storage of CO₂
Licensing – Start and End

START – Site Selection and Characterisation:

• SITECHAR – "Characterisation of European CO2 Storage"
  Characterise European cases and show
  How Guidelines work in Practice

END – Closing and Handover:

• CO2CARE – "CO2 Site Closure Assessment Research"
  1) Wells closure for long-term,
  2) CO2 behaviour prediction and
  3) Handover procedures drafted.
Public Communication – Local!

"Europe needs 10 – 12 Demonstration sites to verify…”

- Geology

and

- Geography

➤ PILOTS:

1 well, 30 kt CO2 over 3 years, Monitoring = 15-10 M€ ?

+ OPENNESS
New drive?
Why delays?

1. New technology & underground – Hesitate?
2. Governmental crisis in GR, IT, ES, PT, IR – No public money?
Decisive factors:

1. IPCC 4.assessment Report 2013 -2014 – Climate change?

2. Financial crisis hits bottom – New optimism?
Critical path?

1. Site characterisation – “Long lead item” - 3 – 10 years?
2. Injectivity and capacity – Critical factors for full CCS chain
3. Underground storage – Public uncertainty
4. Drill one well, inject 10-50 kT CO2 - Low costs

⇒ Storage pilots!
Conclusion
1. Slow progress – Do storage pilots!
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THANKS for your attention!

QUESTIONS?
Norway as a CO₂ laboratory

- Halten CO₂ in aquifer storage - 2015?

- North Sea CO₂ storage in aquifer - 2014?

- Sleipner - CO₂ capture and storage - 1996

- CO₂ Transport
  - Yara CO₂ tankers, 1500 m³ capacity
  - Laying a new pipeline in the ocean

- Snøhvit - all subsea

- Snøhvit, 2007

- Melkøya LNG plant with CO₂ capture
  - Melkøya LNG - 0.7 million tonn/y from 2007

- Mongstad 1,3 to 2,1 million tonn/y, 2014

- Kårstø – 1 million tonn/y, 2011/2012?

- Johansen – 1 million tonn/y from 1996

- Mongstad combined heat and power (CHP) station with CO₂ capture plant
  - European Test Center Mongstad & Full scale capture

- Methanol plant at Tjeldbergodden - future capture site?

- Halten

- Tjeldbergodden - 2,5 million tonn/y, 2012?

- Melkøya LNG plant with CO₂ capture

- Kårstø gas power station – with CO₂ capture

- North Sea CO₂ storage in aquifer

- Sleipner - CO₂ capture and storage - 1996
Sedimentary basins of the world.
Onshore - Green. Offshore - Lavender.
Point sources of CO2 (green dots)