European Perspective on CCS through Norwegian Commercial Projects



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2007 RITE International Symposium: Technologies for mitigating global warming and the role of Japan



This is Statoil

- World's third largest net seller of crude oil
- Markets two-thirds of all Norwegian gas to European customers
- Largest retailer of oil products in Scandinavia
- A highly competent technology company
- A leader in application of CO₂technologies





The Norway - Japan climate heritage Sebastian Oberthür Hermann E. Ott PROTOC The **Kyoto Protocol** International Climate Policy for the 21st Century KRAN THAI Foreword by Ernst Ulrich von Weizsäcker ARICAT The Kyoto **Protocol** ratified, ecologic Springer 2005 The Kyoto **Protocol**, 1997 **Norway's Prime** THE WORLD COMMISSION **Minister ON ENVIRONMENT Gro Harlem** AND DEVELOPMENT Brundtland in 迹 "The Brundtland about 45 US\$/ton **Rio in 1992***

Report", 1987

* Gro Harlem Brundtland introduced a CO2-tax of in Norway in 1992



The background → IEA Baseline scenario: Primary energy use will more than double to 2050



Primary energy use more than doubles between 2003 and 2050, with a very high reliance on coal.

Source: IEA Energy Technology Perspectives 2006



We are not running out of fossil fuels...

we are running out of atmosphere





ENERGY EFFICIENCY

- REDUCE
 CONSUMPTION
- MORE EFFICIENT
 ENERGY USE
- MORE EFFICIENT ENERGY CONVERSION









6

CCS = CO₂-Capture and -Storage

Statoil's climate policy – cleaning up our operations

Statoil's strategy to reduce greenhouse gas emissions:

- Energy efficiency in own operations
- Emissions trading
- Carbon capture and storage
- Renewables





Economic potential of CCS: Typical modelling result (orange = CCS)





Modelling indicates that CCS will play an important part in climate change mitigation

Source: International Panel on Climate Change - SRCCS (2005)



Background:

CO₂ for enhanced oil recovery well known on land



•70 fields on going
•For more than 30 years
•About 30 Mt injected pr year, mostly from naturally occuring CO₂-fields
•Large long CO₂-pipelines

•But not focus on climate

•Very profitable at to-days oil prices



Is there enough underground CO₂ storage capacity?

.....the answer is yes for all practical purposes

.....but it is not equally divided between regions and countries



.....but acceptance and regulatory regimes are needed

- Legal
 - London Convention & OSPAR
- Scientific
 - IPCC-report on CCS
 - Large scale demonstration plants needed
- Political support
 - EU Research Framework Programme
 - Carbon Sequestration Leadership Forum
 - Norwegian experience government very active
- Public
 - NGO support



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

N THE SUBFACE, IT LOOK LIEF, AN other weather-beaten offshore rig, with its towers of scatfolding heary-duty emnes and helicopter landing pad. Located in the North Sol's Sleipner West field, some 30 km off the Norwegian coast, the facility as pumped about 55 billion standard cubic neters of natural gas for Statoil, Norway's ate oil company, over the past eight years, ate oil company, over the gast eight years, but beneath this particular rig lies what oild turn out to be a cost-effective techique for fighting global warming. Taditional drillong for fossi fuels like

Traditional drilling for fossil fuels like tanni gas and of releases millions of tons f carbon dioxide (CO.) into the atmostere. CO: is a greenhouse gas that is both turally present in oil and gas fields, and injected into the ground to boost the exside on precess. Along with emissions torng is suddenly cutching on "sws Torng torng is sugars and the state of the secwill be trying the technique scon." Carbon storage is suddenly cutching on "sws Torng torng is sugars and the storage is subtoring in the storage is subtoring is subtoring in the storage is subtoring is

er stations and industry, oil and gas drilling contributes to on to ston the CO CO: from the rising column of natural ga and send the gree ground, all in one continual he firm has stashed some 75 mil of CO₂ in a kind of emissions tomb known as a saline aquifer 1.000 m beneath the ocean floor. Statoil estimates there's roon for 592 billion tons more the CO2 emissions from all the power sta-Europe for the next 600 years Canada's EnCana is also putt into the ground, and BP and Gaz de France will be trying the te nique soon, "Carbon

Torp, head of Statoil's 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 naison d'etre is to sustain and even increase the use of fossi fuels like onl gas and ceal (this TIME Neat rappert take explores new developments in wind, solar and hydroelectric energy). Bull sustainable energy so lutions—even imperfect outs—are needed in a world additected to fossil fuels, and carbon sequestration cauda help the transition to clean, renewable fuels cover the next 30 years. One reason for carbon sequestration's newfound popularity in Europe is that starting in 2005, 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-

TIME, MAY 17, 2004

11

Source: TIME Magazine, May 2004

STATOIL

Sedimentary basins and CO₂-storage prospectivity





Source: IPCC Report on CCS, 2005

Some current CO₂-projects



Norway as a "CO₂-laboratory"



The Sleipner experience – Statoils starting point



- Started in 1996 10 year of CO₂-injection in October 2006
- Separating and injecting nearly 1 mill. tons CO₂ annually
- Storing in saline aquifer above natural gas reservoir
- Driver: Since 1992 a CO₂-tax of approximately 40€/tonne



Confidence building: Sleipner CO₂-monitoring

Time-lapse seismic datasets of CO₂ stored in Utsira formation







In Salah CO₂-injection, Algeria (BP, Statoil and Sonatrac)







Snøhvit LNG – the next milestone

- Barents Sea
- Piped CO₂ separated from natural gas from onshore LNG plant
- Storing 700.000 tons CO₂ annually from 2007
- Injecting below natural gas reservoir







Need for integrated CCS value chains: Here the Statoil – Shell "Halten CO₂ Project"







The next step: Mongstad CHP* with CO₂-plant



* CHP – Combined Heat and Power



CO₂-capture at Naturkraft's gas fired power plant at Kårstø



- Naturkraft 430 MW
- Electricity 2007

Halten CO2

årsto – Naturkraft

longstad

- 1 mill tonnes/year
- CO₂-capture from 2011/2012
- •Possibly CO2 for the Volve field

CO₂-storage alternatives





Can CCS be a profitable investment?

• The income sources can be:

- Increased oil recovery (in some cases)



 Emission trading credits from European Union Emission Trading System or perhaps CDM*, JI*

• Some of the problems:

- The cost of CO_2 -capture is high, but sometimes inexpensive CO_2 is available
- Redeveloping onshore oil fields to use CO₂ for enhanced oil recovery is much better known (and less expensive) than for an offshore platform/reservoir



Other large CCS-projects internationally*

- Projects not mentioned earlier in this presentation

Power plants with CO2-capture: Proposed full-scale projects CO2-storage projects: Commercial and demonstration



15 projects



* Based on list compiled by IEA Greenhouse Gas R&D Programme



Research focus for CCS internationally

Power plants with CO2-capture:

- Focus on coal-fired plants
- In Norway → gas fired plants
- Better processes
 - Lower energy consumption
 - Lower cost
 - Environmentally friendly chemicals



CO2-storage projects:

- Focus on public acceptability
- How to select good storage sites
- Safety of long term storage
- Monitoring
- Long term liability





* Based on list compiled by IEA Greenhouse Gas R&D Programme

Conclusions



- Geological storage technically proven with very large storage capacity worldwide
- Regulations for CCS are slowly coming in place
- CO2-enhanced oil recovery expected to spread to many oil-regions of the world
- CCS expected to become an important element in meeting the global climate challenge

Thank you for listening!



Back-up material



Other large CCS-projects internationally* (1)

Proposed full-scale (~100 MWe and above) CCS projects in the <u>electricity sector</u>

Company/Project Name	Fuel	Plant output/cost	Technology	Start
BP/SSE DF1, Peterhead/Miller, Scotland	Natural gas	350 MW, (\$600M)	Autothermal reformer + precombustion, storage in the oilfield – EOR	2010
BP DF2, Carson, USA	Petcoke	500 MW, (\$1bn)	IGCC + shift + precombustion, storage in the oilfield – EOR	2011
Nuon, Eemshaven, Netherlands	Coal / natural gas	1200MW	IGCC with option to capture	2011
China Huaneng Group (CHNG), GreenGen, China	Coal	100 MW	IGCC + shift + precombustion	2015
E.ON, Killingholme, Lincolnshire coast, UK	Coal (+petcoke?)	450 MW (£1bn)	IGCC+shift+precombustion? (may be capture read)	2011
Ferrybridge, Scottish & Southern Energy, UK	Coal	500 MW	PC (supercritical retrofit) + post- combustion capture	2011
FutureGen, USA	Coal	275 MW (US\$1 bn)	IGCC + shift + precombustion	2012
GE / Polish utility	Coal	1000 MW	IGCC + shift + precombustion	

* Based on list compiled by IEA GHG



Other large CCS-projects internationally* (2)

Proposed full-scale (~100 MWe and above) CCS projects in the <u>electricity sector</u>

Company/Project Name	Fuel	Plant output/cost	Technology	Start
Powerfuel, Hatfield Colliery, UK	Coal	~900 MW	IGCC + shift + precombustion	2010
Centrica, Progressive Energy, Teeside, UK	Coal (petcoke)	800 MW (+H2 to grid) (\$1.5bn)	IGCC + shift + precombustion	2009
SaskPower, Saskatchewan, Canada	Lignite coal	300 MW	PC+Post-combustion or oxyfuel, storage in the oilfield – EOR	2011
Siemens, Germany	Coal	1000 MW 1.7 bn EUR	IGCC + shift + precombustion	2011
Stanwell, Queensland, Australia	Coal	100 MW	IGCC + shift + precombustion, storage in saline reservoir	2012
RWE, Germany	Coal	450 MW (€1bn)	IGCC + shift + precombustion, storage in saline reservoir	2014
RWE, Tilbury, UK	Coal	1000 MW (£800m)	PC (supercriticial retrofit) + post- combustion (may be capture ready)	2016

* Based on list compiled by IEA GHG



Other large CCS-projects internationally* (3)

Major commercial and R&D storage projects

Project name and location	Source of CO ₂	Type of geological formation	CO ₂ stored
K12b (Netherlands)	Stripped from natural gas	Gas field -EGR	Over 0.1 Mt/year since 2004
Gorgon (Australia –offshore)	Stripped from natural gas	Saline reservoir	129 Mt over the life of the project, starting between 2008- 2010
Weyburn (Canada/USA)	Coal	Oil field –EOR	1 Mt/year since 2000
Permian Basin, US	Natural reservoirs and industry	EOR	500 Mt stored since 1972
Frio Brine, USA		Saline reservoir	3 Kt injected in 2005-2006
Nagaoka, Japan		Saline reservoir	10.4 Kt in 2004-2005
Ketzin, Germany		Saline reservoir	60Kt total, starting 2006

* Based on list compiled by IEA GHG

