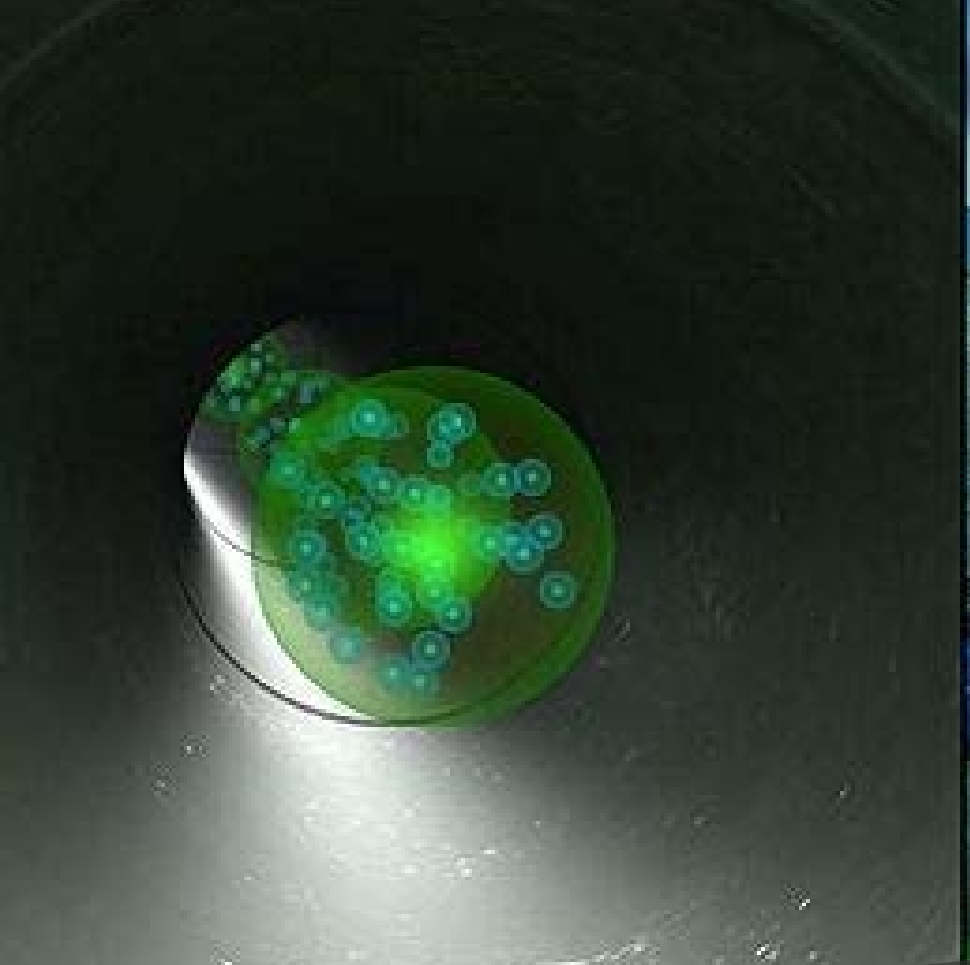

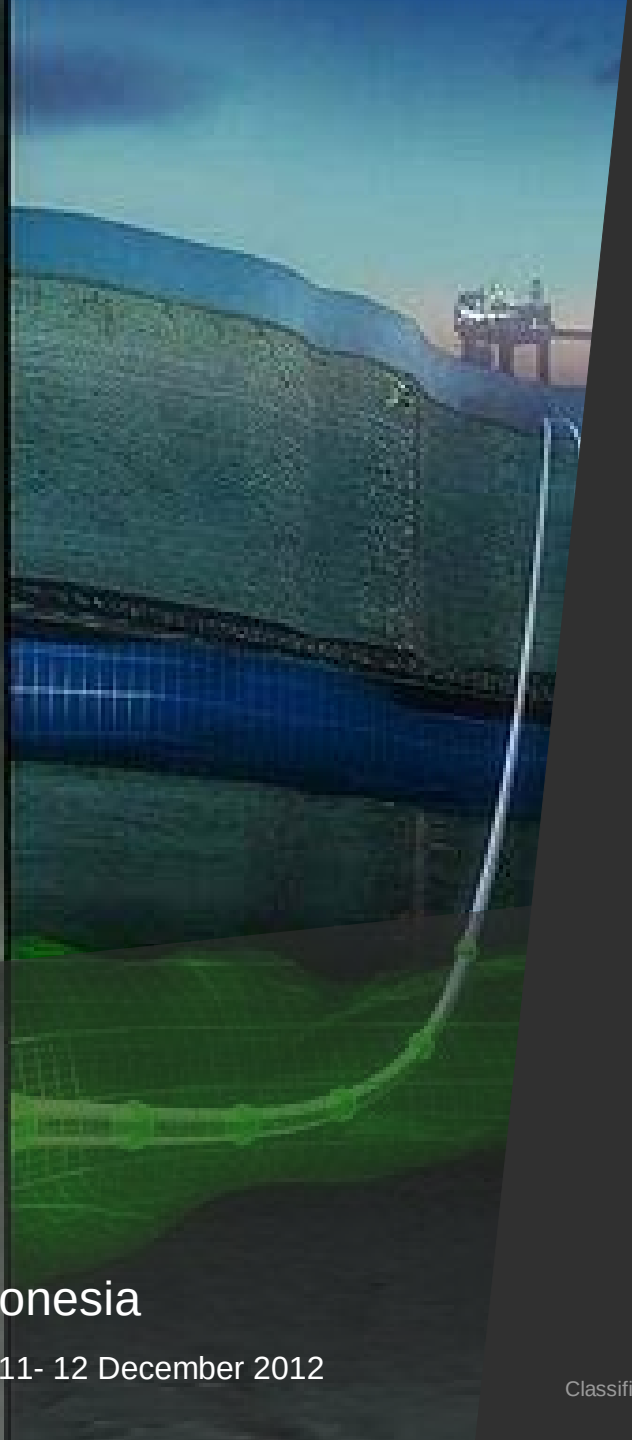

Case Studies of CO_2

Tor Fjæran – President Director Statoil Indonesia

Seminar on Evaluation of CO_2 Storage Potential, ITB Bandung, 11- 12 December 2012

Contents

- CCS Projects - lessons learned
- Acceptance
- CCS commercialization
- How to find solutions?
  - Governments
  - Companies
- Technology development
- Closing remarks

Statoil's CCS projects

An Industrial Approach to the Climate Change Challenge

Sleipner

In Salah

Snøhvit LNG

Test Centre Mongstad

Mongstad Full-scale

1996- 2004- 2008- 2012- ?

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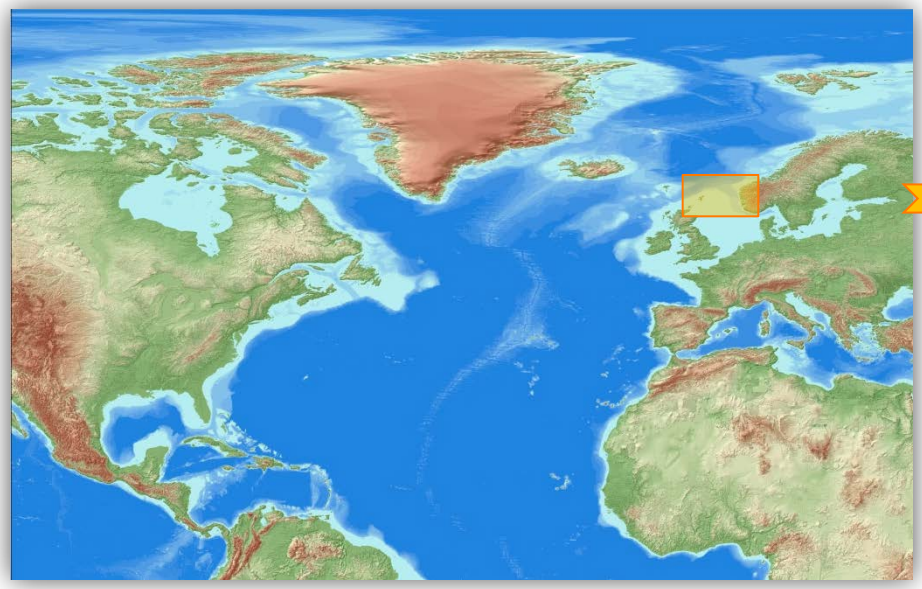
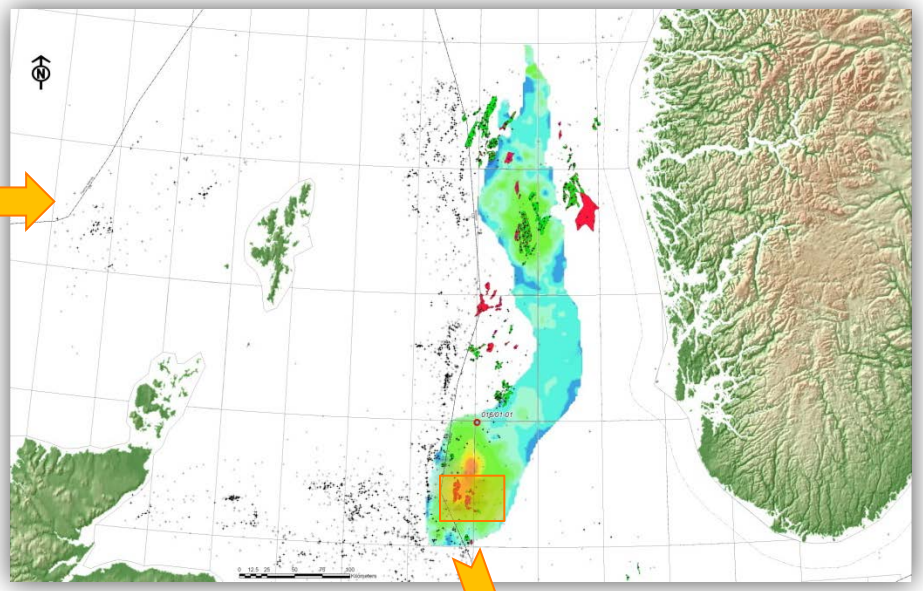
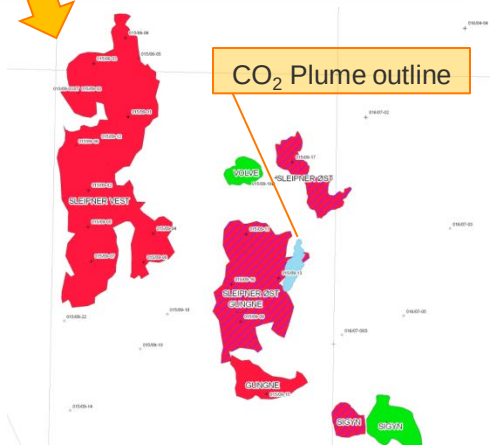
Sleipner, North Sea







- 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

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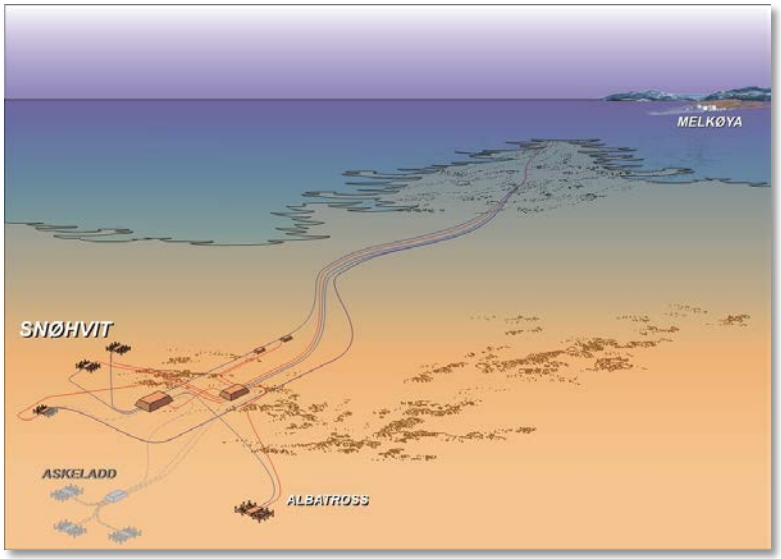
In Salah, Algeria

- 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
- CO_2 is captured onshore and transported in a ~140 km subsea pipeline to a subsea template
- The CO_2 is injected at a depth of 2600m into the saline sandstone formations (below the gas reservoir)
- Injection of CO_2 started in 2008, at a rate of ~ 80 t/hr
- Gradual rise in reservoir pressure indicated limited injection rate/capacity
- Well intervention operation successfully completed May 2011
- CO_2 tax the main incentive



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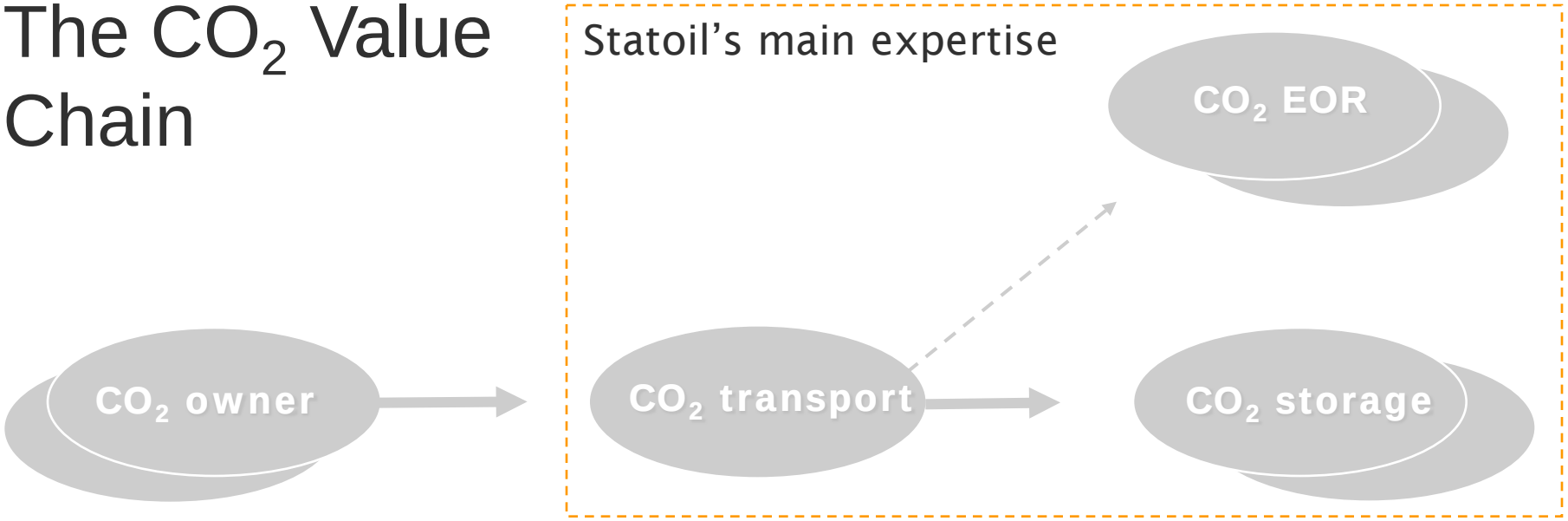
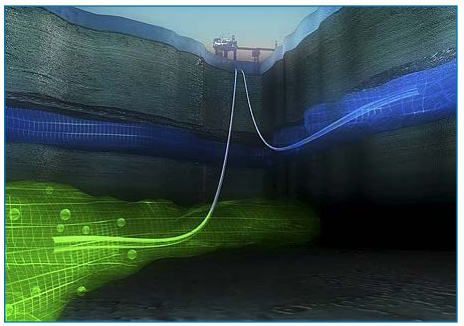
The CO_2 Value Chain



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

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

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



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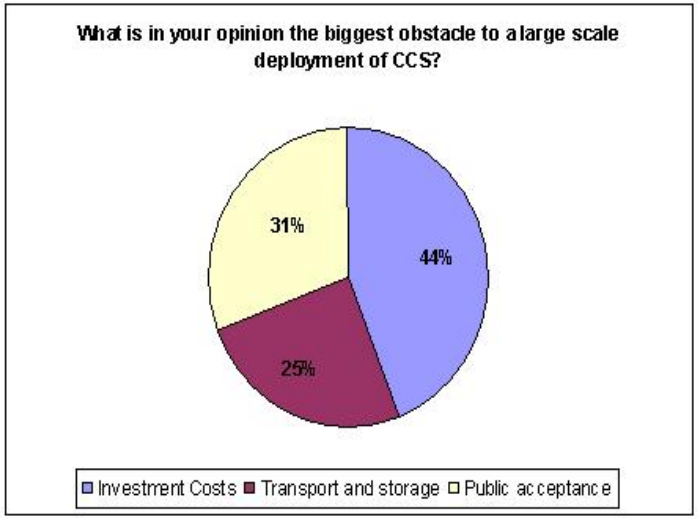
CCS – not fully accepted yet

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

Source: DnV

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



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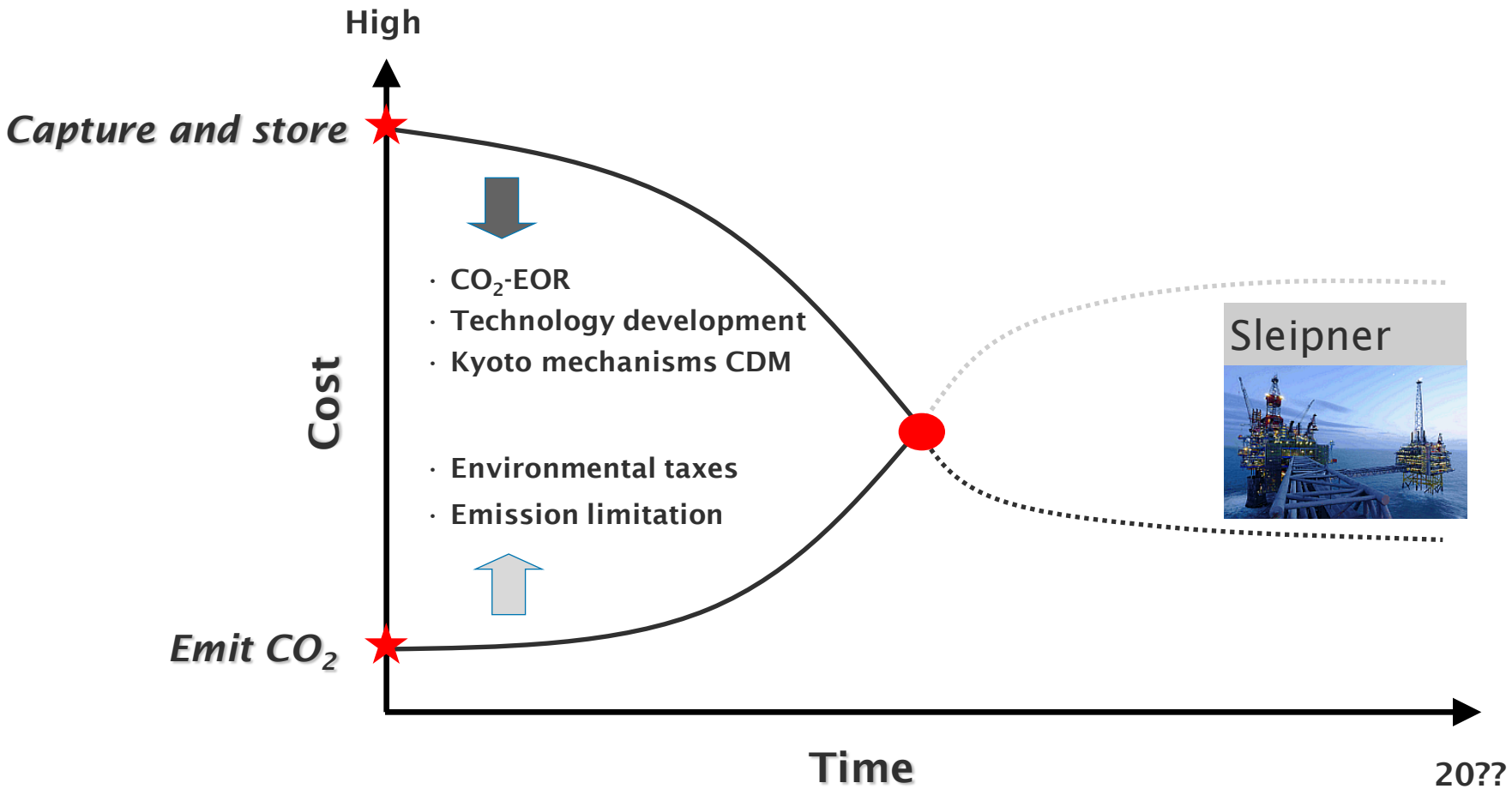
CCS Commercialisation



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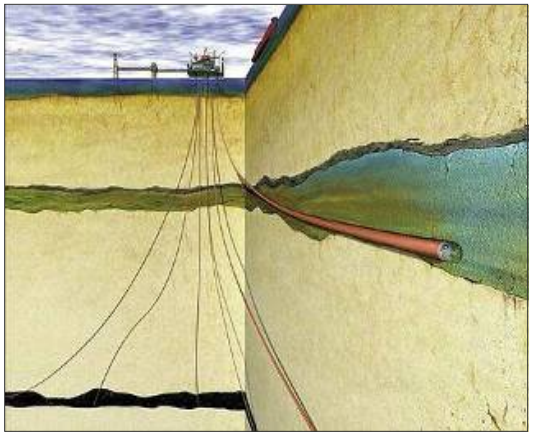
Making business out of CO_2

- **CO_2 capture, transport and storage**
  - Developing business storing 3rd party CO_2
  - Use of CO_2 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,

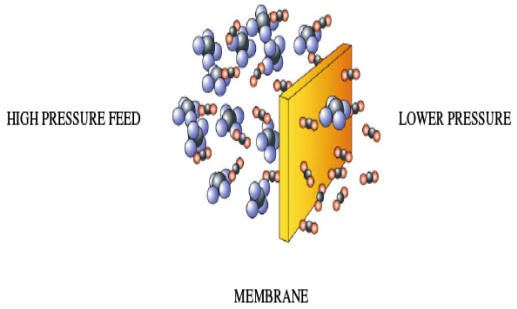
Industry

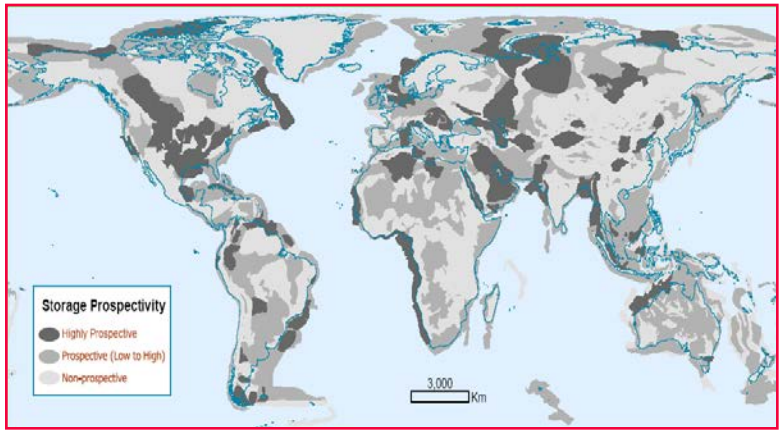
- Accept the global climate challenge
- Establish clear industrial positions
- Technology development
  - Cost reduction
  - Qualification and scaling
- Risk taking – market positioning
- Cooperation vs competition
- Industry – academia - government

What can we afford - cost and/or consequences

Technology development needed

- To reduce cost - Mainly capture
- To upscale & increase capacity - CCS value chain
- To test & implement - CCS value chain
- To build trust & comptence - Storage





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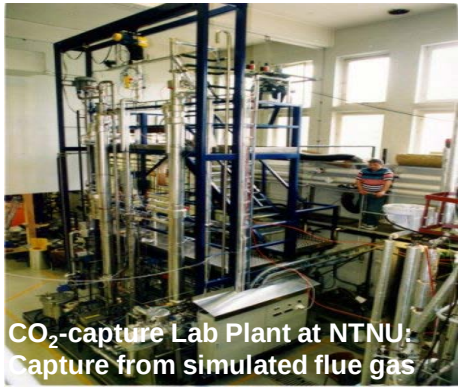
CO_2 Value Chain Research & Development

- Some CO_2 value chain research projects:
  - Amine technology
  - Carbonate technology
  - Combustion processes
  - Mass transfer equipment
  - Pre combustion technology
  - Ceramic material technology and oxyfuel
  - CO_2 transport and injection
  - CO_2 storage accept
  - CO_2 subsurface
  - CO_2 fundamental properties



CO_2-capture Lab Plant at NTNU: Capture from simulated flue gas

CO_2-capture Pilot Plant at Kårstø: Capture from flue gas

CO_2 transportation test loop at Statoil R&D centre in Trondheim

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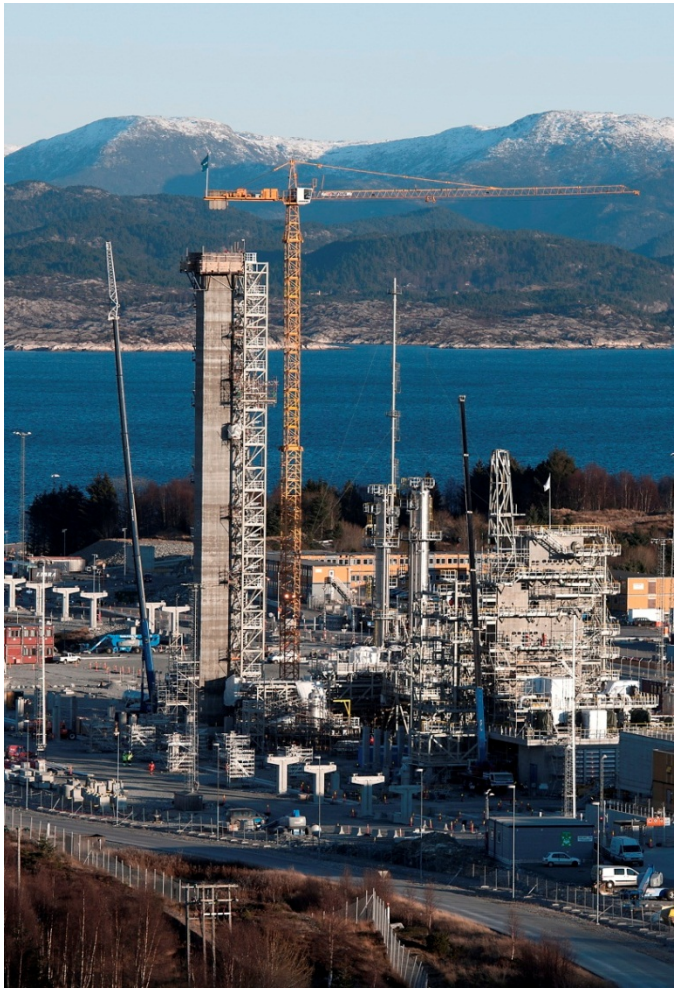
Tecnology Center Mongstad - Ambitions

- 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	Statoil		sasol reaching new frontiers
75.12%	20%	2.44%	2.44%

Other potential partners to be invited

“Need high price on CO_2”

- 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 CO_2”

  - 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 CO_2*

Thank you

Tor Fjaeran
President Director, Statoil Indonesia

tof@statoil.com
www.statoil.com

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