IEA Greenhouse Gas R&D Programme

CCS Current Status
&
Confidence Building

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IEA Greenhouse Gas R&D Programme

Workshop on Confidence Building in the long-term effectiveness of CO_2 Capture and Geological Storage

24th&25th January, 2007, Tokyo

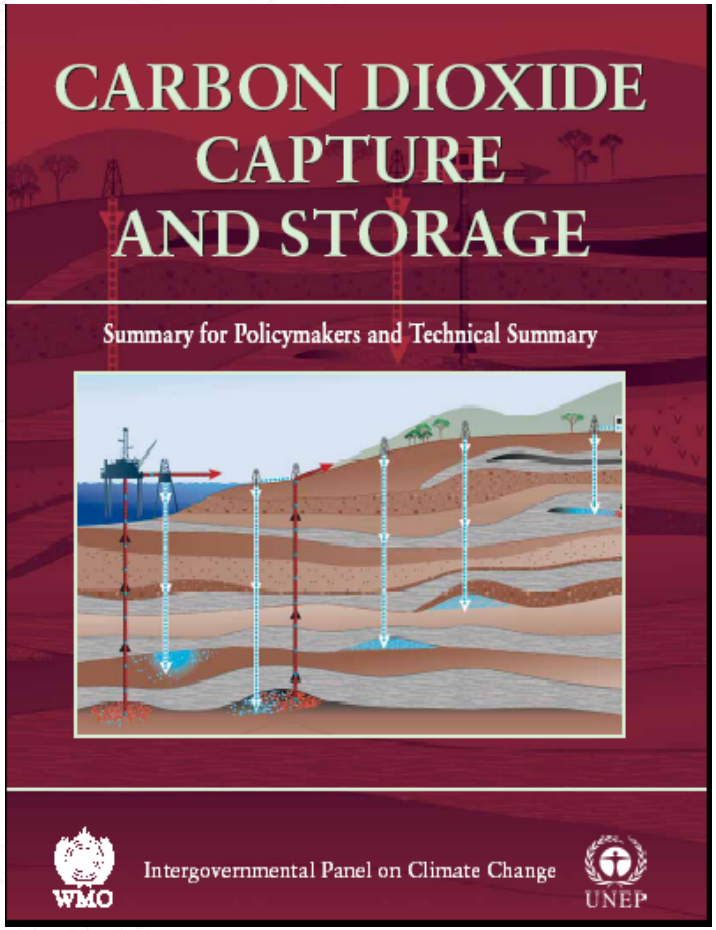
Introduction

- OBJECTIVE: Set the scene for the workshop discussion
- Review the current status of CCS
  - International acceptance
  - Technology status
  - Regulatory issues
- Where we need to get to for wide scale implementation?
  - What are the challenges we face?

International Acceptance

International Acceptance (1)

- Significant progress in this area
- IPCC Special Report on CO_2 capture and storage
  - CCS recognised as a mitigation option
    - National emissions accounting
    - Emissions trading

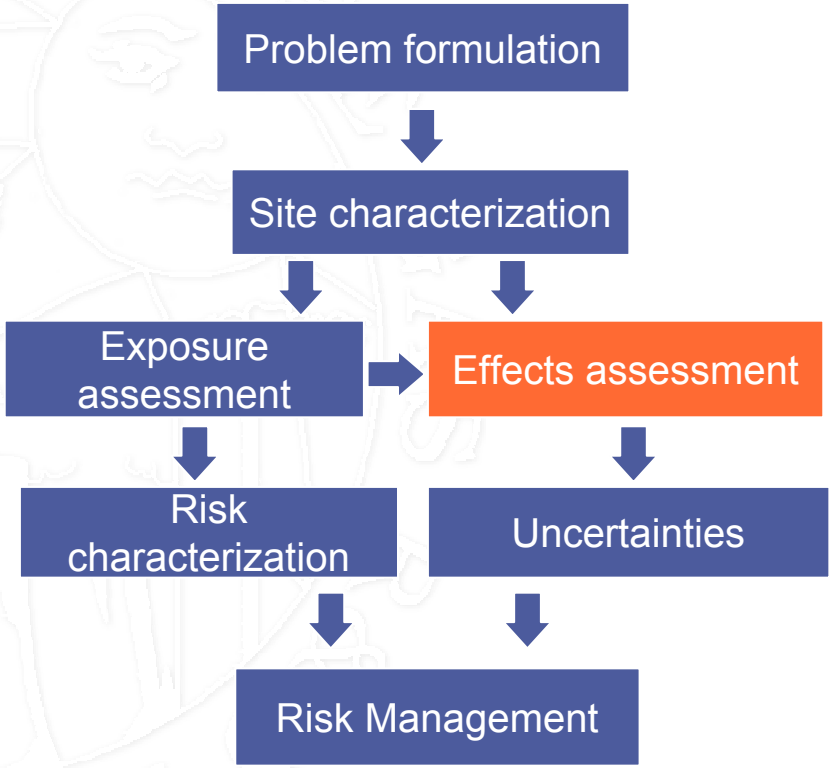


International Acceptance (2)

- Storage <u>under</u> the sea bed
  - Important breakthrough in 2006 – sets precedent
  - Storage under seabed will be legal under terms of London Convention 1996 Protocol
  - Legal Working Group agreed to amend Annex 1 of Protocol to the Convention to allow CO2 to be included under: 'wastes that can be disposed of'
    - Only in sub-sea geological structures,
    - The waste is overwhelmingly of carbon dioxide,
    - No wastes or other matter are added.
  - IEA GHG working with others on guidance for sequestration
    - Example concern – acid gas reaction with storage seal

International Acceptance (3)

- Need agreed outline risk assessment & management framework
- Consistent guidelines needed to be developed
- Initiatives are underway:
  - IEA Legal Issues workshop & Report
  - EU - DG Environment
  - IEAGHG working on 'Sources of Best Practice'
  - Many others



International Acceptance (4): Early 'Best Practice' example

Best Practice Manual

from

SACS - Saline Aquifer CO_2 Storage Project

Statoil

Appendix A.1 BP
ExxonMobil
Norsk Hydro
TotalFinaElf

BGS
BRGM
GEUS
IFP
NITG-TNO
SINTEF

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International Acceptance (5): Developing Countries

- ‘Capture-ready’ concept: must include a ‘feasible’ store

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- International standards for CCS limited
  - ISO 14064 GHG accounting
- Kyoto Protocol route:
  - The Clean Development Mechanism (CDM)
  - CDM option was raised at COP11/MOP1 but a decision was deferred – for 2 years!
  - Outstanding issues from COP/MOP:
    - Permanence
    - Additionality
    - Project boundaries
    - Project leakage (physical, accounting)

Technology Status

Technology Status (1)

- Most actual activity is in the oil and gas sector
  - CO_2 Capture
    - Amine scrubbing demonstrated at 1Mt/y scale in oil and gas field operations
      - Sleipner and In-Salah
    - Not power generation
  - 3,100km pipelines mostly in North America transporting CO_2 for EOR operations
  - Several large projects injecting CO_2 at 1Mt/y scale
    - Sleipner and In-Salah – deep saline aquifers
    - Weyburn – oil field

Technology Status (2): Commercial-scale CCS operations

Sleipner

Snøhvit

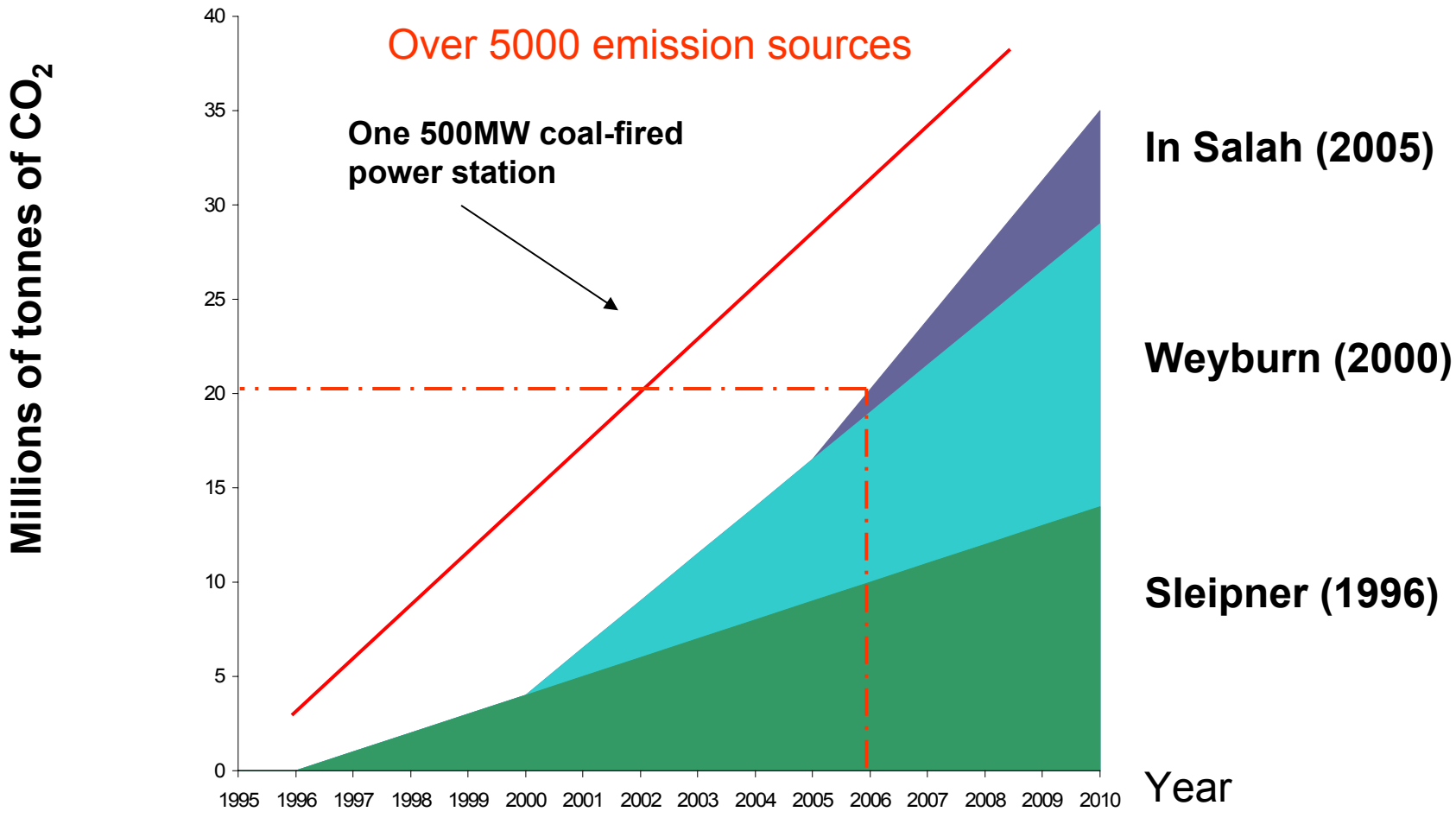
Weyburn

In-Salah

NOT POWER GENERATION

Images Courtesy of BP, Statoil, and PTRC

Technology Status (3): Monitored CO_2 Storage



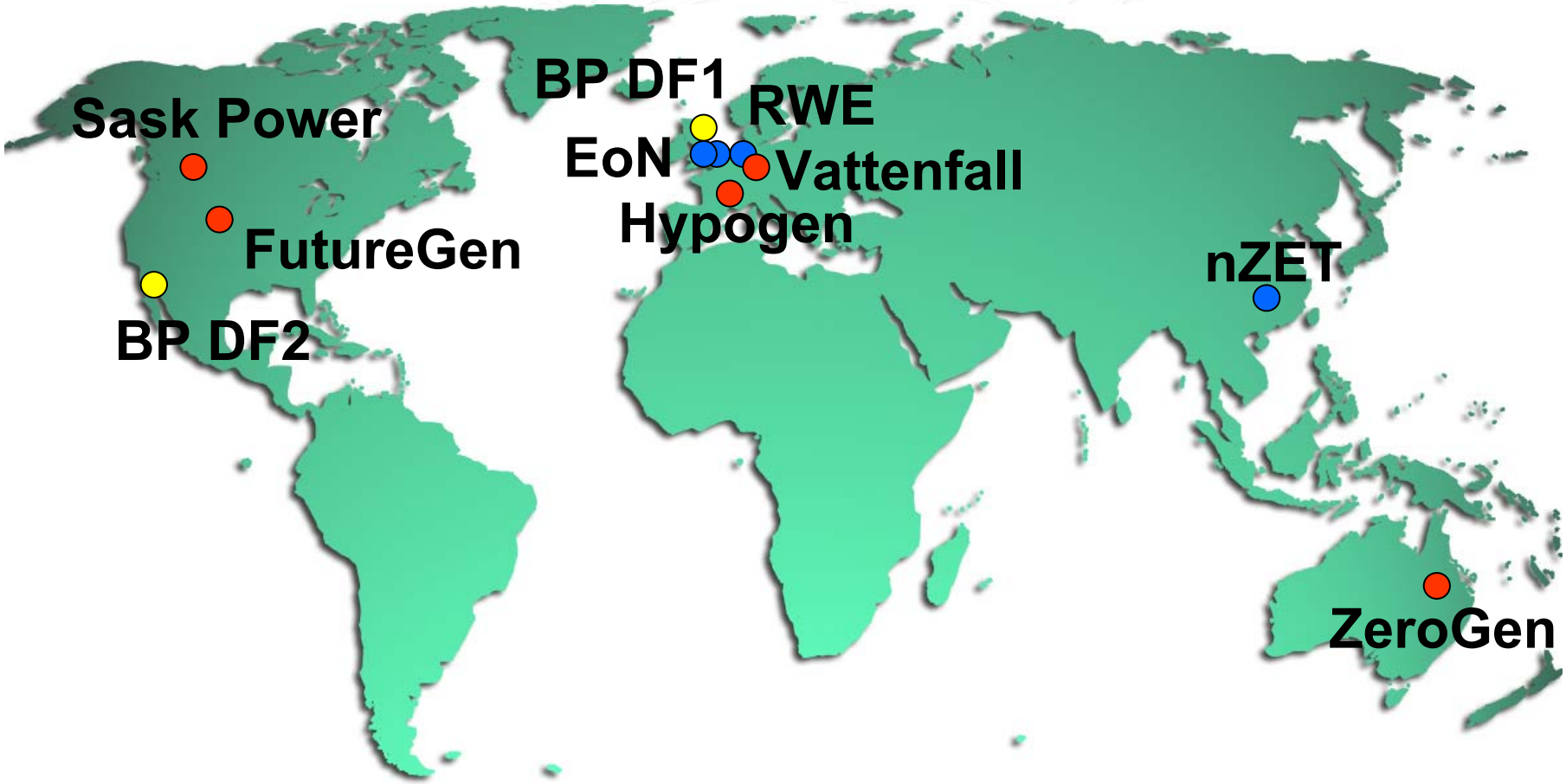
Technology Status (4): Capture Issues

- Capture
  - Represents 75% of cost of CCS chain
  - Need to drive this cost down
    - IEA GHG work indicates 20-40% cost reduction
  - 3 credible options
    - Pre-, post-, oxy-

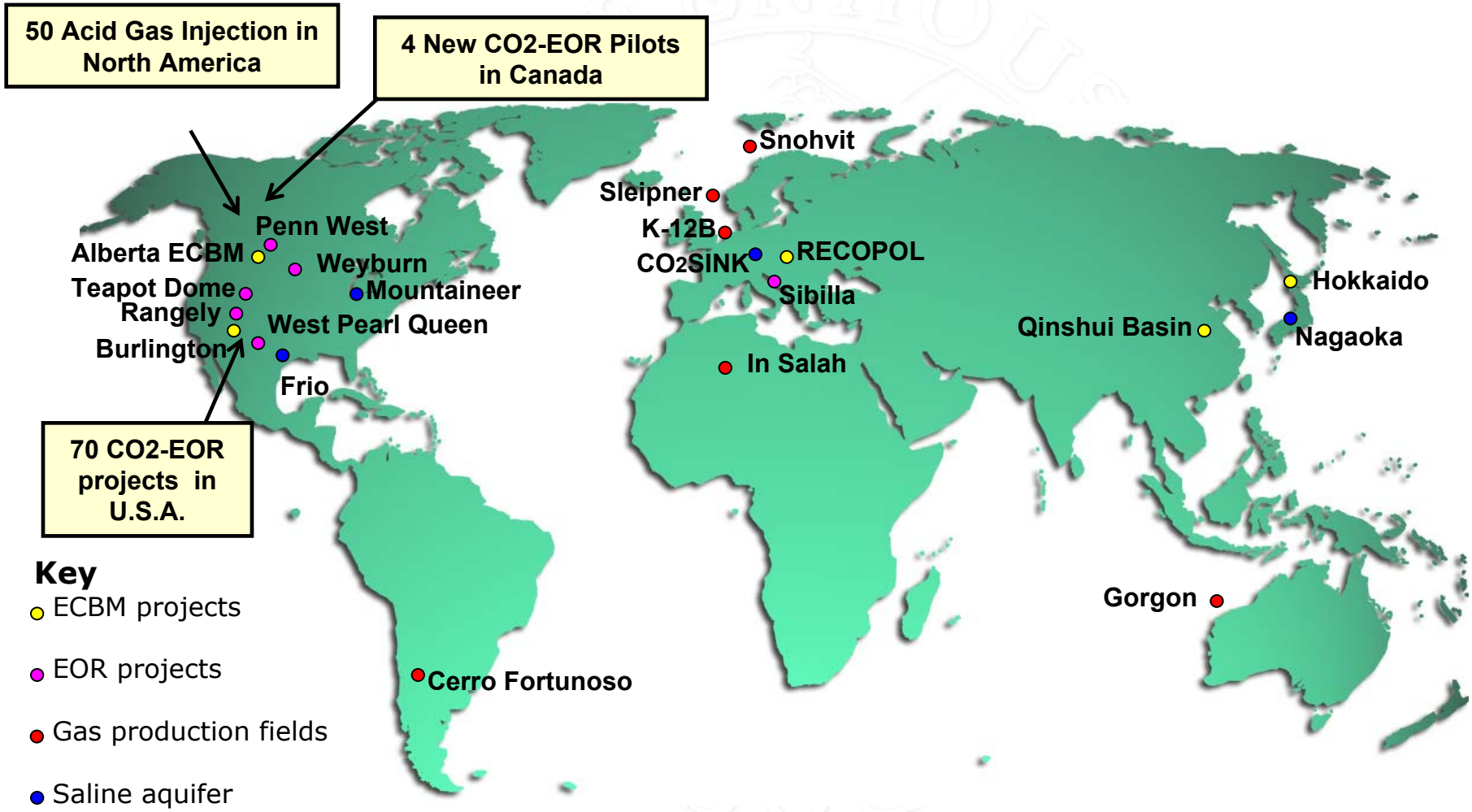
Technology Status (5): Capture Scale-up

- Bench scale (simulated flue gas)
- Pilot scale activity (on flue gas slip-stream)
  - EU Castor – 25 tCO_2/d, Denmark
  - MHI -10 tCO_2/d, Nagasaki, Japan
  - ITC – 8 tCO_2/d, Boundary Dam, 8 tpd
- NEXT STEP: Demonstration – with integrated operation

Technology Status (6): Power Sector CCS Projects



Technology Status (7): CO_2 Storage Demonstration Projects



Technology Status (8): Geological Storage

- It is believed sufficient capacity available
  - Oil and gas fields provide significant global storage capacity
  - Saline formation capacity large but not well documented
  - Can capacity of a store be defined?
- CCS will need to rely heavily on deep saline aquifers
  - Aquifer injection demonstrated at Sleipner and In-Sala
- Need additional effort to quantify both the storage capacity and storage integrity of deep saline aquifers
  - Need to demonstrate effective containment
  - Maintain integrity in future alongside continued oil and gas exploration

Technology Status (9): CO2ReMoVe

- Will study and compare results from:
  - Sleipner
  - Snohvit
  - In Salah
  - CO_2 SINK (Ketzin)
- Best practice guidelines
  - Identification of suitable sites
  - Protocols and tools for monitoring and verification

Technology Status (10): Safety/Permanence

- For a CCS operation we cannot say there will be never be leakage
- There will be fugitive emissions from pipelines and surface facilities ('handling')
  - Low level and intermittent
  - Can quantify such emissions
- Emissions from the storage formation
  - If they occur, will be very low level (seepage) and persist over long time periods
  - Could cause local environmental impacts
  - Remediation

Technology Status (10): Safety/Permanence

- Need to engineer for zero leakage from the storage formation
- 5 component plan:
  - Detailed site characterisation
  - Reservoir simulation
  - Risk assessment
  - Monitoring programme
  - Remediation programme

Technology Status (11): Monitoring Experience

- No firm evidence from any of the large scale projects that leakage is occurring
  - Weyburn (3 years), Sleipner (10 years), Rangeley (20 years)
- Surface seepage at Rangely has been suggested but there are doubts about the data
- Monitoring lifetimes are short
- Cannot quantify seepage
  - Nor determine/specify a generic leakage rate

Regulatory Issues

Regulatory Issues (1): Status

- Several countries have amended/are amending existing laws to allow CCS
  - USA – US EPA looking at adapting UIC Programme rules
  - Netherlands, adapted it Mining Law for K-12B
  - Australia adapted it regulations for Gorgon
- One major issue that needs to be resolved is that of long term liability
  - Who is liable for leakage after abandonment?
  - Insurance bonds or similar funds required?

Regulatory Issues(2): Developments

- Need for regulatory systems essential to implement projects in near term
- Quicker to amend existing regulations than develop new ones
  - Europe
    - Netherlands - adapted existing laws
    - UK - regulatory task force established
    - Norway - permitting CCS under existing laws
  - USA
    - Adapting legislation
  - Australia
    - State and Federal Governments involved
    - Gorgon review under way

Challenges

Challenges (1): Implementation

- How do we get from where we are now:
  - Several storage demonstrations but not based on power generation
  - Plans for CCS demonstrations but major funding required
- To wide scale implementation with thousands of commercial scale CCS projects?

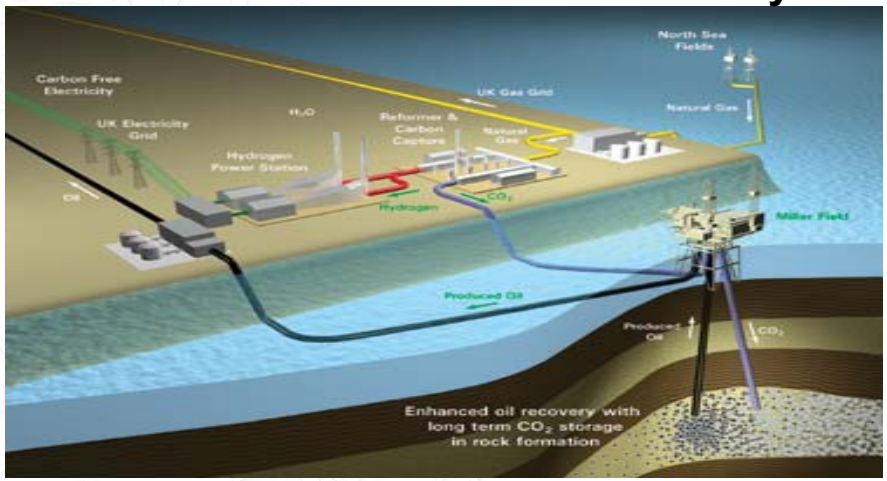
Challenges (2): Near-term Implementation

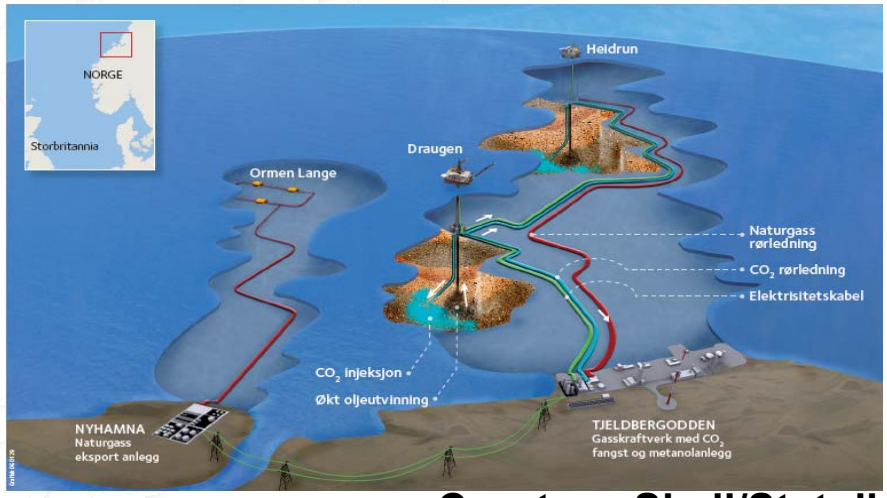
- Currently we are seeing developments in the gas sector
  - CO_2 removal required to meet gas pipeline standards
  - Low incremental cost for CCS
- CO2-EOR projects not developing as could have been expected worldwide
  - High oil prices could be expected to stimulate development of EOR projects

Challenges (3): CO2-EOR opportunities

- North Sea seen as an opportunity for CO2-EOR
- Studies by NPD and UK DTI said that it is uneconomic
  - CO_2 supply and infrastructure requirements
- New commercial projects now being planned
  - BP DF1 development at the Miller field
  - Statoil/Shell 'Halten' development

Courtesy BP





Courtesy Shell/Statoil

Challenges (4):CO2-EOR Continued

- New initiative in Norway to create a CO_2 supply infrastructure
  - Part public sector/part private sector enterprise
  - Establish a CO_2 supply infrastructure for Norway to realise its CO2-EOR potential
  - Leave behind a supply infrastructure that can then be used for CO_2 storage
  - Announced in Autumn 2006

Challenges (5): Power Sector

- Largest sources of CO_2 emissions
  - 10.9Gt/y in 2000
  - 5009 emission sources
- For power generation applications need to scale up capture plant to 3 to 5Mt/y scale
  - Replicate several thousand times
- Need to expand pipeline infrastructure to be comparable to that of natural gas in regions
    - 150,000 km pipelines in North America and Europe
      - Not a major technical barrier
      - Routeing issues to be resolved
    - How will we finance that infrastructure development?

Challenges (6): Power Sector continued

- Power sector happy to sell electricity over the fence to the market
- May prefer to act in the same way for CO_2
  - Pipelines and geological activities not traditional skills in power sector
- How do we establish a storage industry to work with the power sector?
- Will emissions trading be sufficient to establish such an industry?
- Early market volatility in ETS may not stimulate investment at present

Challenges (7): Perception

- One of the key questions usually asked is:
  - Is it safe?
    - Will the storage formations leak?
    - What are the environmental impacts if it leaks?
- This is a question we must answer satisfactorily
- Important issue to resolve to get general acceptance for this technology
  - Governmental acceptance building
  - Public awareness is low and could be a barrier to wide scale implementation

Challenges (8): Public Awareness

- Public awareness on CCS is limited
- Need to build public awareness to ensure projects do not meet public resistance
- Need urgently start to an education programme
  - Open and transparent
  - Happening at pilot project scale in some countries
    - Australia, Europe, Canada and USA
  - Need more concerted engagement programmes
    - Netherlands - CATO programme
    - Japan
  - Need more demonstration projects with public engagement
    - In-Salah
  - Need to be aware that local issues could dominate in planning reviews

Challenges(9) : CO_2 Containment

- For a CCS operation we cannot say there will be never be leakage
- Industry statistics show there will be fugitive emissions from pipelines and surface facilities
  - Low level and intermittent
  - Can quantify such emissions
- These emissions are distinct from the storage formation events
  - Is a leak from a well a fugitive emission or leakage from the storage formation?

Challenges (10): CO_2 Containment continued

- Need to build a strong case for zero leakage from the storage formation
  - Limited data to support the case to date
    - Only a few monitoring projects
    - Performance assessment work at an early stage of development
  - Can refer to natural and industrial analogues

Finally, Some relevant IEAGHG activities: Studies (1)

Published in 2006:

- Safe storage – analogies with the natural gas industry
- Permitting issues for CCS
- Storage monitoring decision support tool
- Environmental impact of solvent scrubbing

Some relevant IEAGHG activities: Studies (2)

- Some of the studies in progress:
  - CO_2 Capture-ready plant
  - Remediation of leakage from geological stores
  - Sub-sea ecosystem impacts
  - Regional storage capacity – India
  - Risk assessment and regulatory needs
  - Environmental impact frameworks
  - Terrestrial ecosystem impacts of CO_2 leakage

Summary

- Given a perspective on the current status of CCS
- The big challenge that lies ahead is wide scale global implementation
- Current key barriers to implementation
  - Convincing people storage is safe and secure
  - Creating a value chain for CCS
    - More CO2-EOR projects in near term
    - Power sector in medium term
  - Establishing CCS projects in developing countries
- Hopefully I've set the scene for the discussion.

THANK YOU

ANY QUESTIONS?

Further details on projects listed can be found at:

www.Co2captureandstorage.info