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Carbon dioxide Capture & Storage (CCS)

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IEA Greenhouse Gas R&D Programme

IFA Technical Committee Meeting
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Overview of Presentation

- Introduction
- CCS Projects
- CCS Options and Economics
- Is NH_3 an 'early CCS opportunity' ?
- Summary & Conclusions

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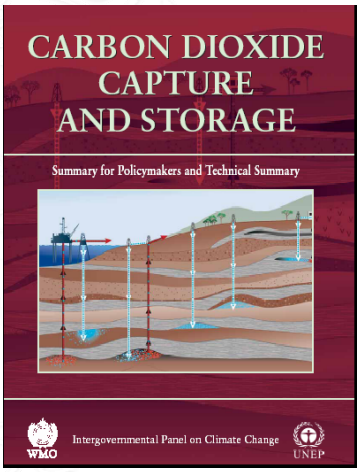
CCS now an option

- 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



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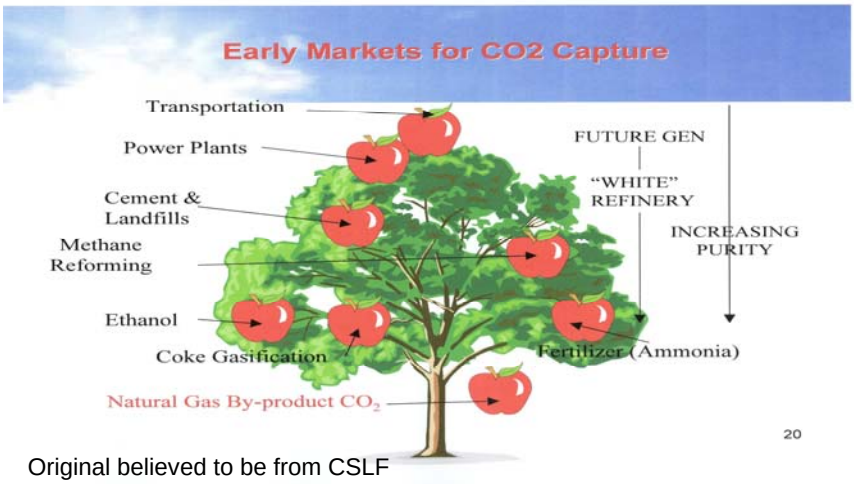
NH_3 quoted as an 'Early-Opportunity'



Original believed to be from CSLF

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CCS Projects
&
Technology Status

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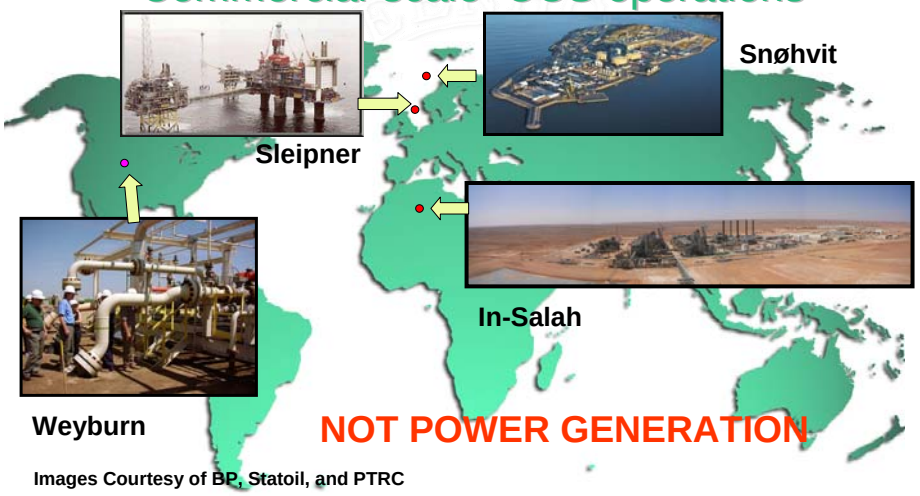
Commercial-scale CCS operations



NOT POWER GENERATION

Images Courtesy of BP, Statoil, and PTRC

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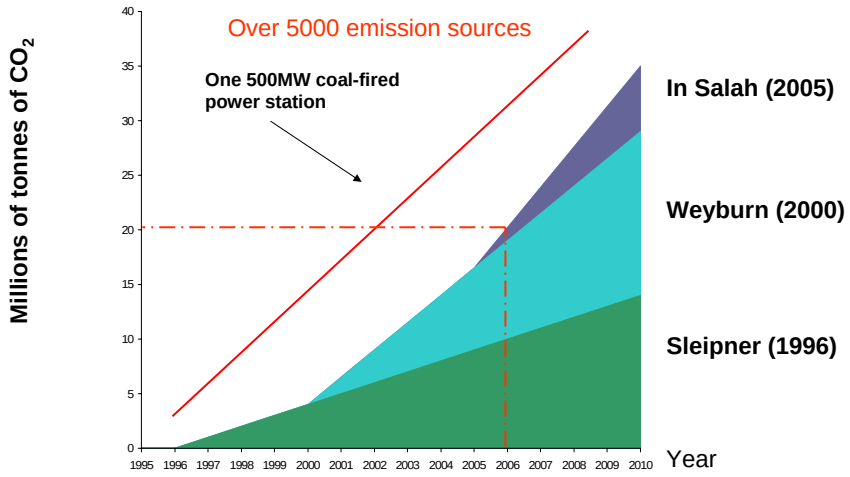
Monitored CO_2 Storage



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Existing activities

- 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
  - 3100km 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

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International Acceptance

- 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
    - Additionally
    - Project boundaries
    - Project leakage
- Storage under the sea bed
  - Important breakthrough in 2006 – sets precedent
  - Storage under seabed will be legal under terms of London Convention 1996 Protocol

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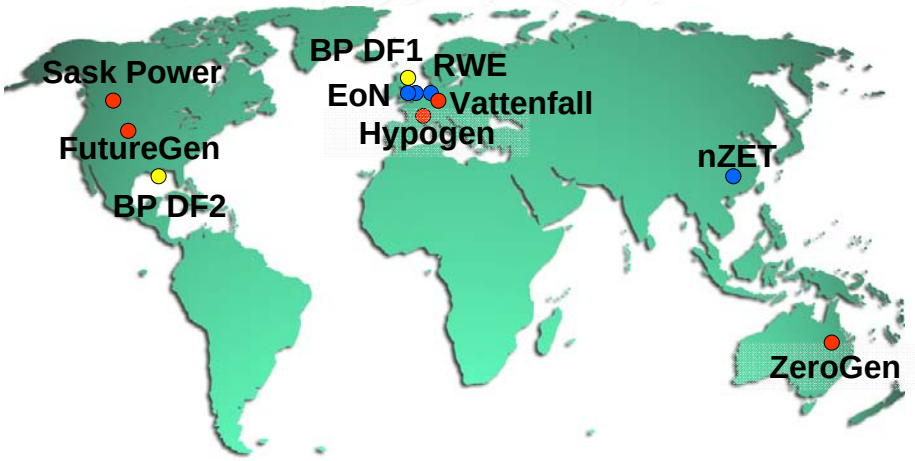
Power Sector CCS Projects



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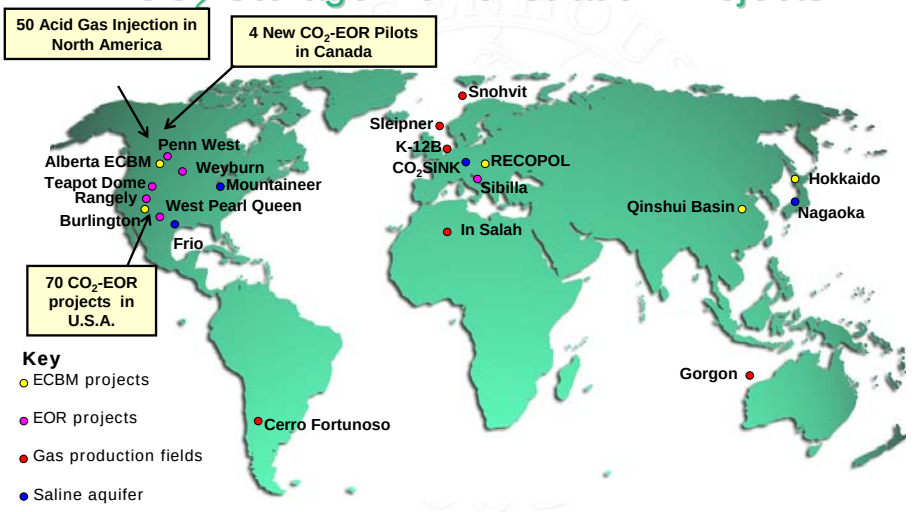
CO_2 Storage Demonstration Projects



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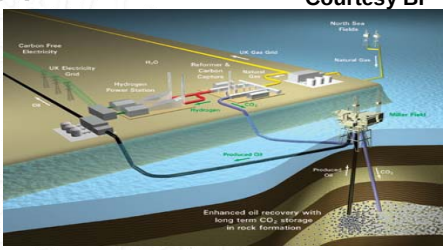
Near-term Implementation

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

CO_2-EOR opportunities

- North Sea seen as an opportunity for CO_2-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

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CCS Options & Economics

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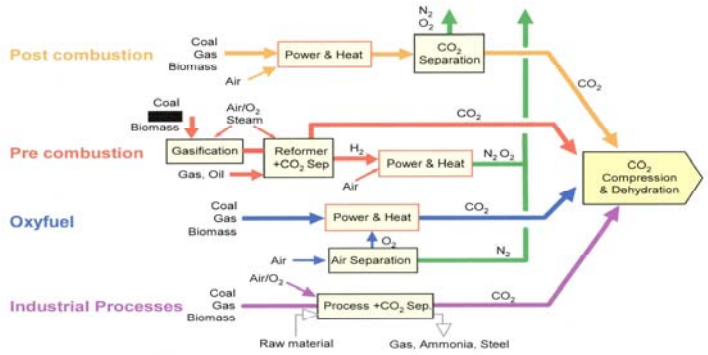
IPCC view of CO_2 Capture Opportunities

CO2 Capture



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

WMO UNEP

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IPCC view of CCS costs

CCS component costs

CCS component	*Cost range*
Capture from a power plant	15 - 75 US$/$tCO_2$ net captured
Capture from gas processing or ammonia production	5 - 55 US$/$tCO_2$ net captured
Capture from other industrial sources	25 - 115 US$/$tCO_2$ net captured
Transportation	1 - 8 US$/$tCO_2$ transported per 250km
Geological storage	0.5 - 8 US$/$tCO_2$ injected
Ocean storage	5 - 30 US$/$tCO_2$ injected
Mineral carbonation	50 - 100 US$/$tCO_2$ net mineralized

20-30% cost reduction over next 10 yrs

Monitoring/ verification: 0.1-0.3 US$/t CO2

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COST OF CO_2 SUPPLY

	US$/tonne CO_2
Capture	25-35
Transmission	5-10
Storage	5-10

Overall Cost of CO_2 from CCS is about 35 - 55 US$/tonne CO_2. Cost of 'early opportunity' CO_2 could be about 10-20 US$/tonne

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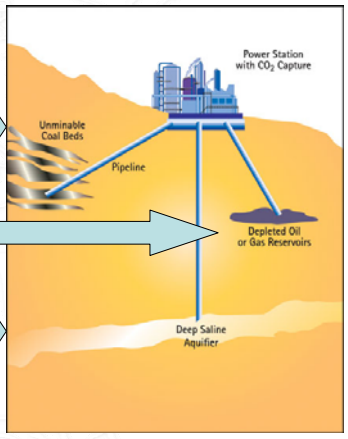
Geological storage: Options

Unminable Coal Seams
30 Gt CO_2
Able to store <2 Years of 2030 Emissions

Depleted Oil & Gas Fields
930 Gt CO_2
Able to Store 50 Years of 2030 Emissions

Deep Saline Aquifers
400-10 000 Gt CO_2
Able to store 20 - 530 Years of 2030 Emissions



Note: CO_2 Storage capacity at cost of 20 US $ per tonne of CO_2

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Is Ammonia Production an Early Opportunity ?

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CO_2 Capture an integral part of NH_3 production

MITSUBISHI CO_2 Recovery Technology from Flue Gas

Commercial Scale Plants

1. CO2 Recovery Plant in Malaysia

Plant Outline

CO2 recovery capacity	200 ton/day
Solvent	KS-1
Use of CO2	Urea production
Start of operation	October, 1999
Client	Petoronas Fertilizer (Kedah) Sdn Bhd
Location	Kedah Darul Aman, Malaysia
Flue gas source	Stream reformer flue gas

Process Description

CO_2 is recovered from flue gas of steam reformer of ammonia plant and delivered to CO_2 compressor for urea synthesis. Recovered CO_2 is used to increase urea production. The first commercial plant for flue gas CO_2 recovery using this advance technology has been operating in Malaysia since October 1999 for Urea production. Performance of process is excellent in terms of low steam consumption, very low solvent degradation and low solvent loss.

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IPCC emission factors

- tCO_2/tNH_3
  - 1.7 for modern plant - natural gas feedstock
    - 1.2 process & 0.5 heat & power
  - 2.8 for modern partial oxidation
  - 2.1 average for existing plant – natural gas
  - 3.3 average for existing plant – partial oxidation
- tCO_2/t urea
  - 0.73

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CO_2 balance on ammonia/urea complex

- Global figures (year 2000)
  - 155 million tonnes CO_2 surplus to urea requirements
- Modern complex (private communication)
  - 2000mtpd NH_3 and 3200mtpd urea
  - Excess CO_2 1064mtpd
  - Most of excess is flue gas not process gas

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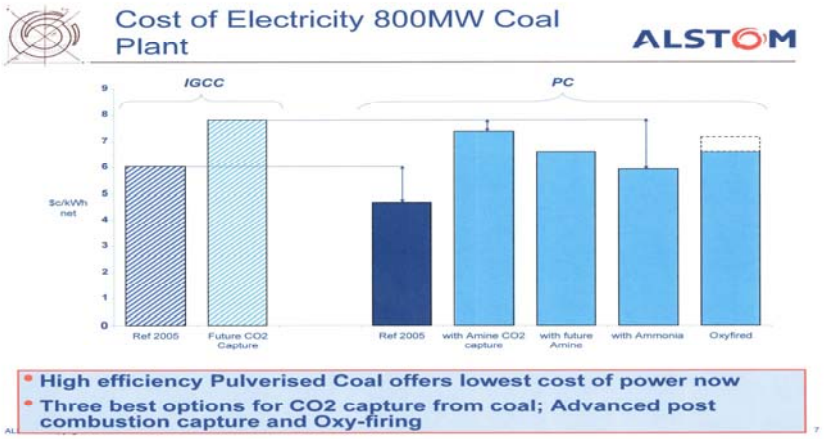
Ammonia is potentially a capture solvent



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Summary and Conclusions

- CCS is now a firm policy option for CO_2 emission reduction
- Commercial-scale activities are in progress and CCS is gaining credibility
- The financial incentives are not in place
- Early opportunities could help establish CCS
- Further work would be useful to examine ways & means by which NH_3 production could be established as an early opportunity

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