The innovation challenge of carbon capture and storage technologies

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Outline of this presentation

- Climate change and energy – the challenges
- Energy technology pathways to reduce emissions - role of CO_2 capture and storage (CCS) technologies
- Status, cost and the global economic potential of CCS
- Challenges and opportunities for CCS
- Conclusion

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IEA –GHG current membership

Centre for low emission technology - cLET

The State of Queensland through the Department of State Development, Trade and Innovation

Australian Coal Association Research Limited

Stanwell Corporation Limited

CSIRO through CSIRO Energy Technology and its Energy Transformed Flagship Program

Tarong Energy Corporation Limited

The University of Queensland

"….progressing the development of enabling technologies for the low emission production of electricity and hydrogen from coal…."

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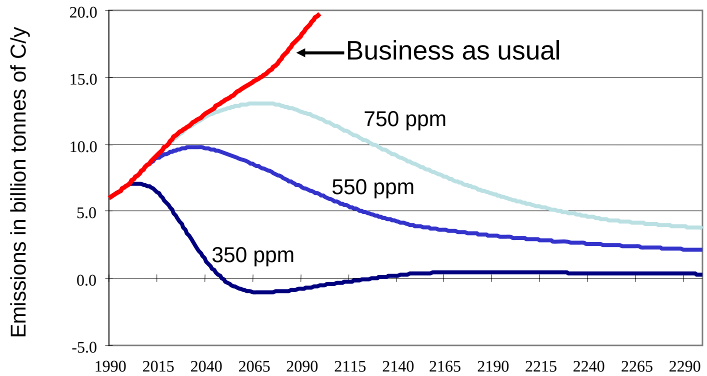
IPCC projections of CO_2 emissions



- Pre-industrial concentrations in the atmosphere 275 ppm
- Today's concentration in the atmosphere ~380 ppm
- A 550 ppm stabilisation scenario would require the removal of over 100 years of the current energy related CO_2 emissions into the atmosphere

Source IPCC TAR

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The main influences on CO_2 emissions

$$CO_2 = \frac{Emissions}{Energy} \cdot \frac{Energy}{GDP} \cdot \frac{GDP}{Popn.} \cdot Population$$

Technology *Energy use* *Wealth*

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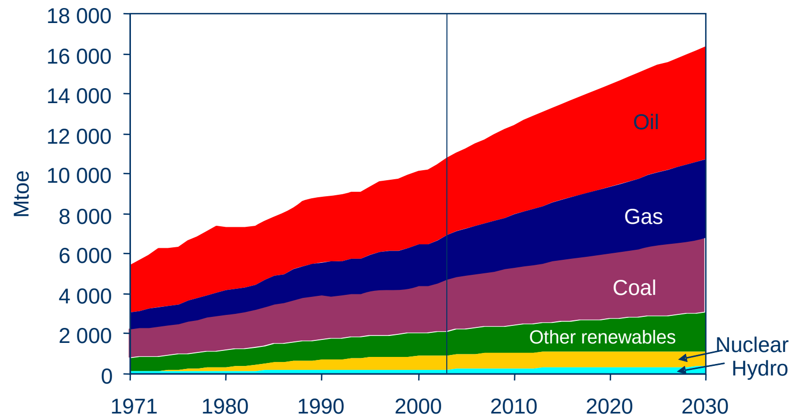
World primary energy demand, IEA 2005



Oil, gas and coal together account for 83 % of the growth in energy demand between now and 2030 in the Reference Scenario

Source IEA world energy outlook, 2005

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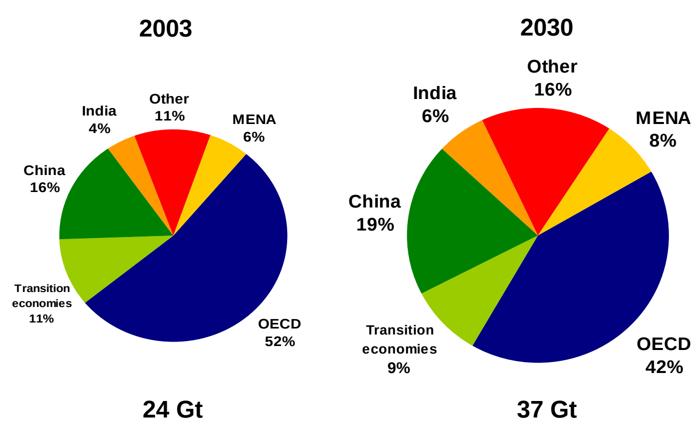
Energy-related CO_2 emissions by region



Global emissions grow by just over half between now and 2030, with the bulk of the increase coming from developing countries

Source IEA world energy outlook, 2005

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The carbon – lock in

New and replacement fossil fuel power generation capacity (GWe)

	2010	2020	2030
World	520	967	1205
OECD	160	309	363
Developing Countries	343	587	750
Transition Economies	16	72	90
European Union (25)	39	105	132
North America	83	141	171
China	162	210	260
India	24	66	97
Russia	5	27	34

A rapid anticipated growth in power generation to 2030, with the bulk of the increase coming from developing countries

Source IEA Clean Coal Centre

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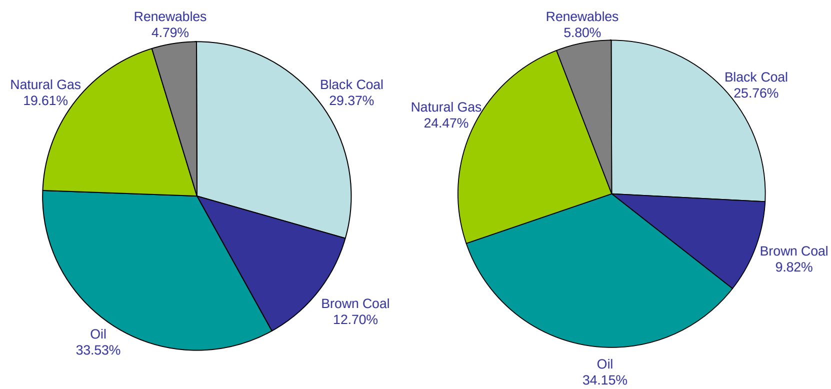
Primary energy growth in Australia

2004
Total Consumption: 5,345 PJ

2030
Total Consumption: 8,728 PJ



In 2030 Australian primary energy consumption increases by more than 60%

Source ABARE 2005

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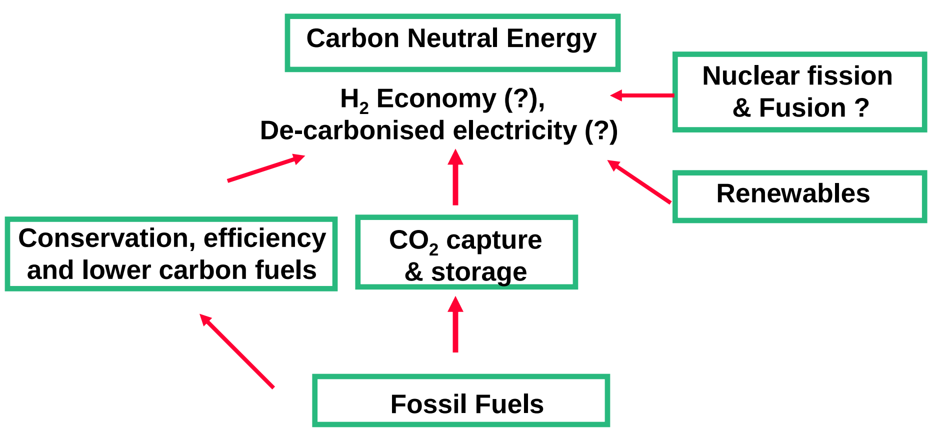
Options to reduce CO_2 emissions

- Reducing energy use
  - Energy conservation
  - Improving efficiency of production and end use
- Increasing the use of alternative energy technologies
  - Renewables: wind, solar, hydro, biomass, geothermal
  - Nuclear
- New lower emission fossil fuel technologies
  - Clean coal with carbon capture and storage (CCS)
  - Natural gas with carbon capture and storage

The options in a carbon constrained future



2003 to 2030 >50% increase; 85% fossil fuel, 10% renewables, 5% nuclear

The pathway for CO_2 capture & storage (CCS)

SOURCE

Energy, Electricity or H_2
(*with zeroing emissions*)

CO_2 capture

Fossil fuels

Utilisation

Storage

"Greener" Fossil Fuels (Enhanced oil and coal seam methane recovery)

•Spent oil/gas fields
•Saline reservoirs

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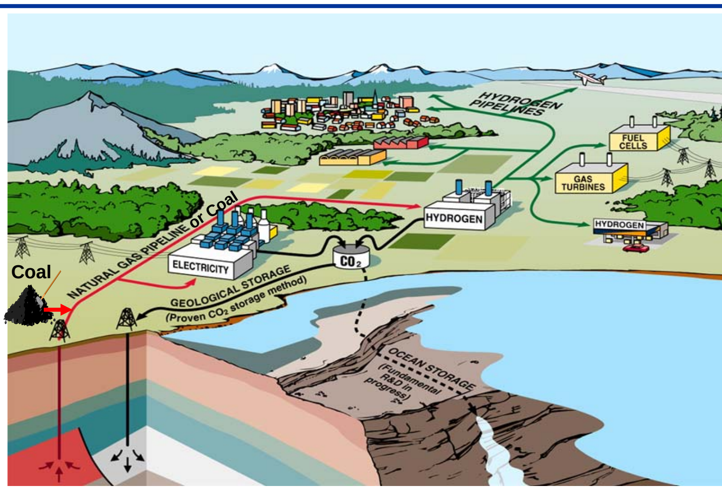
The vision for low emissions technology



With CO_2 capture & storage, will this be a bridge to our energy future?

Source: Adapted from Olav Karstaad, Statoil

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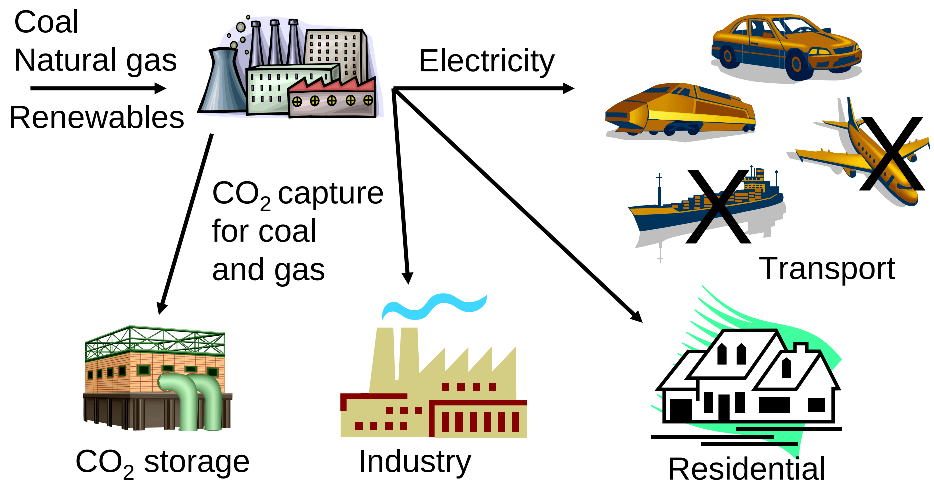
Electricity energy carrier



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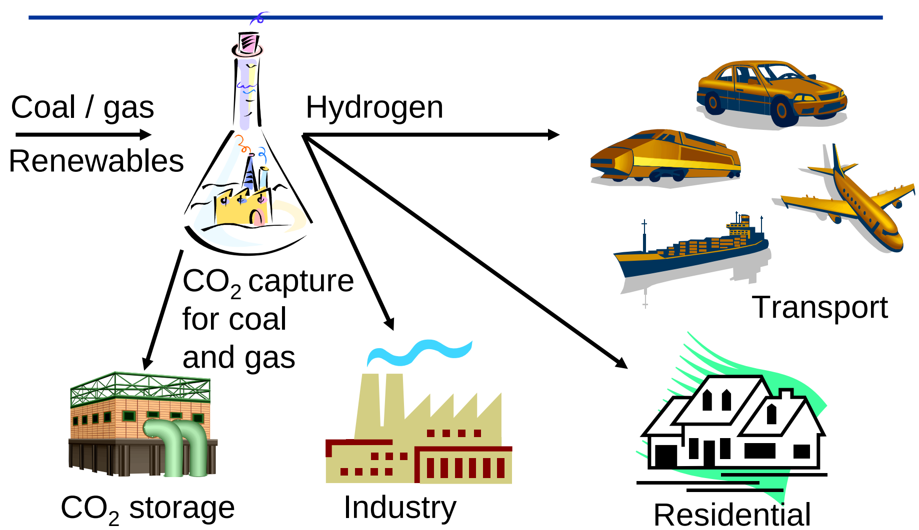
Hydrogen energy carrier



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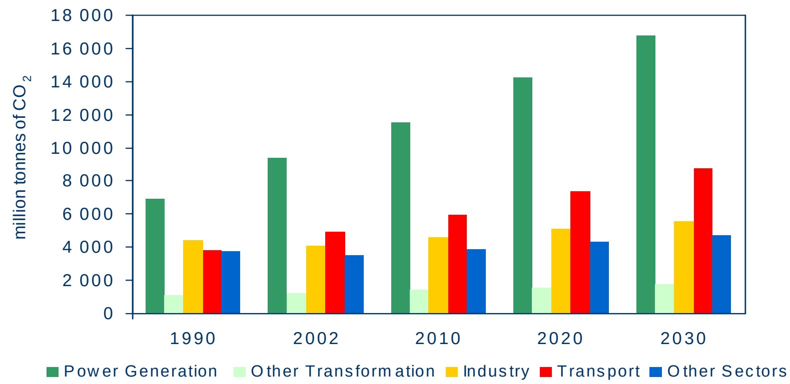
Where best to capture CO_2?



Significant emissions growth in power generation and transport sectors - large power generation and industrial plants represent over 60% of 2030 emissions

Source IEA world energy outlook, 2004

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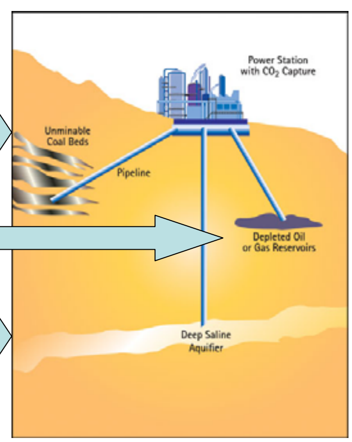
Can we store CO_2 - global storage capacity

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: Economical CO_2 Storage potential at a storage cost of 20 US $ per tonne of CO_2

Source: IEA GHG studies

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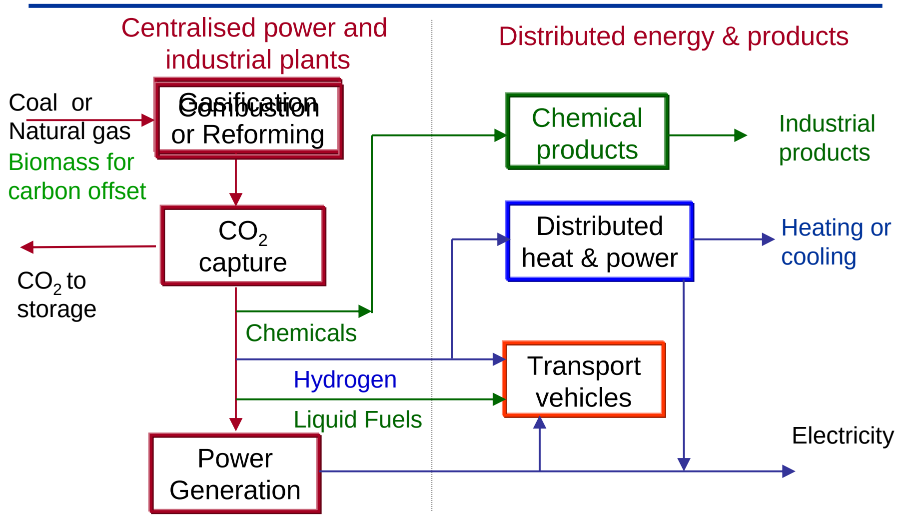
The options for low emissions plants with CCS



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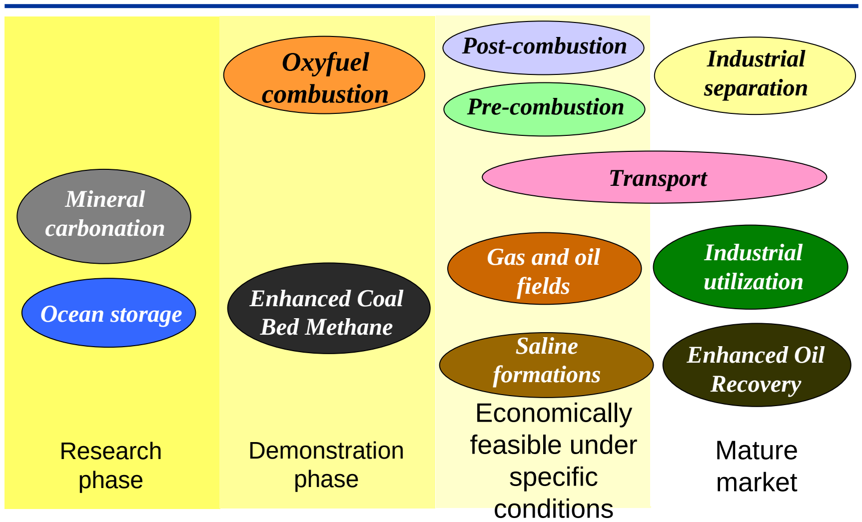
Technology maturity of CCS components



Source IPCC 2005

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Technology maturity - capture in power plants

- Power generation with post combustion capture
  - SC/USC pulverised coal and NGCC power plants are reliable and proven
  - Scale up of solvent capture units/integration with power cycle is unproven.
- Power generation with pre-combustion capture
  - IGCC for coal (1 GWe) is near commercial and proving reliability, better experience with 3 GWe of IGCC capacity on oil and petcoke. No experience to date with reforming/POX/ATR based natural gas power plants
  - Solvent capture units for CO_2 available at scale, integration and power block hydrogen utilisation issues
- Power generation with oxyfuel combustion
  - No proven experience of operation of pulverised coal power plants in an oxyfuel combustion mode – the issue is *"confidence building"*
  - Large scale ASU's for O_2 production proven and reliable.
  - Some development issues with tail end CO_2 purification
  - CO_2 or hybrid turbines do not exist for oxyfuel combined cycles

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The cost of CO_2 capture and storage

	Natural gas CC	Pulverised coal	IGCC	Hydrogen Plant
% increase in cost of electricity or hydrogen with capture and geosequestration	38-54	46-90	34-49	17-44
Cost of CO_2 avoided with geosequestration, US$/t	38-91	30-71	14-53	3-75
% increase in cost of electricity or hydrogen with capture and EOR	19-40	14-56	0-23	0-29
Cost of CO_2 avoided with EOR US$/t	19-68	9-44	(-7)-31	(-14)-49

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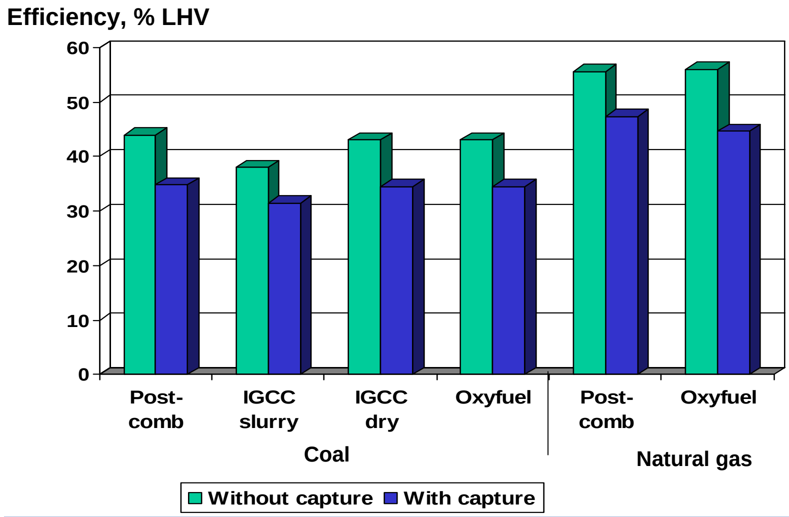
Power generation efficiency with capture today



Source: IEA GHG studies

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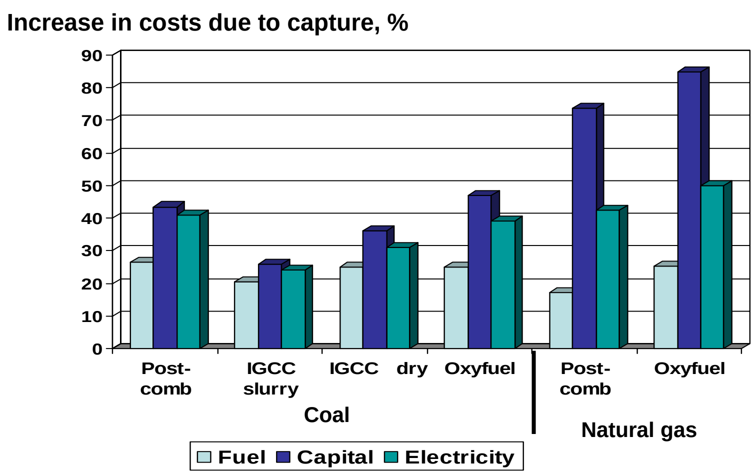
Increase in electricity costs



Assumptions: 10% DCF, Coal $1.5/GJ, Gas $3/GJ; Relative to same base plant without capture

Source: IEA GHG studies

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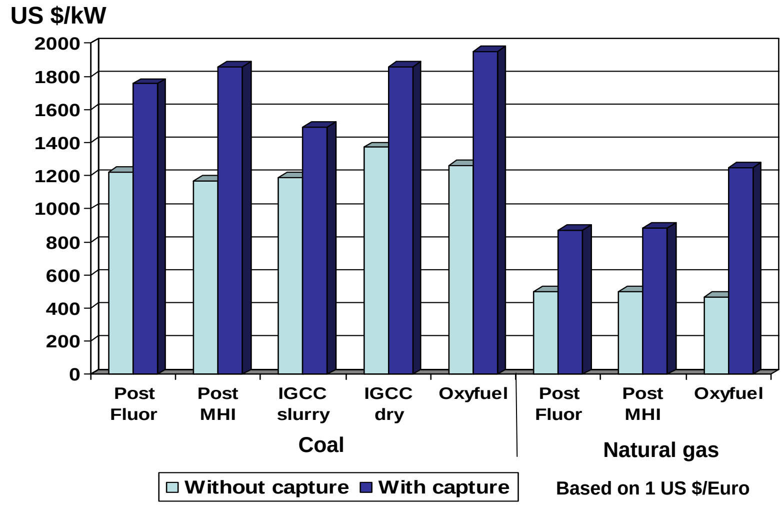
Capital cost



Source: IEA GHG studies

Options for application of low emission plants

- Retrofit equipment for CO2 capture in existing plants – drawbacks include site limitations, poor system integration and significantly reduced energy efficiency
- Replace all equipment at a given site to upgrade process efficiency and with process integrated capture plant – benefit of high efficiency base equipment with lower energy penalties and costs for capture. Also reduces other environmental emissions
- New build "capture ready" or "capture" plants – the former providing opportunities for conversion at a later date when emission reduction incentives apply

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The global economic potential of CCS

- Capacity to remove 220 - 2,200 GtCO_2 cumulatively up to 2100, depending on the baseline scenario stabilisation level (450 - 750 ppmv) cost assumptions
- 15 to 55% of the cumulative mitigation effort worldwide until 2100
- Substantial application above CO_2 abatement cost of 25-30 US$/t$CO_2$
- Cost reduction of climate change stabilisation: 30% or more
- Most scenario studies: role of CCS increases over the course of the century

Source IPCC 2005

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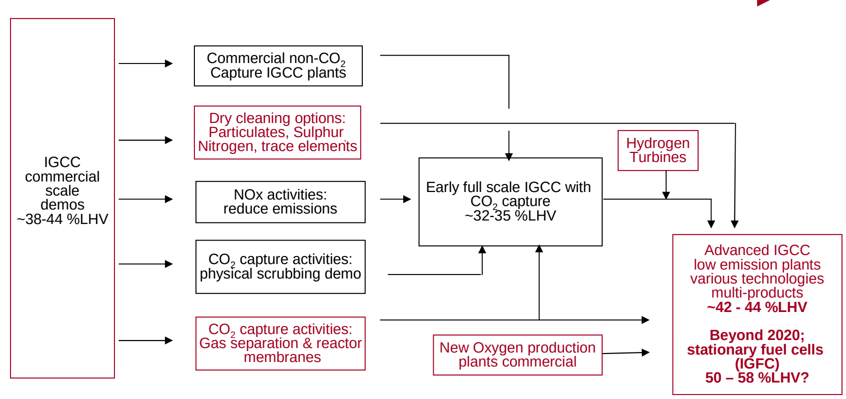
Path to improved low emission coal-fired, IGCC

Now → 2005-10 → 2010-15 → 2015 on

Increasing efficiency, lower emissions, lower costs



An example of technology improvements that can reduce costs by at least 20- 30% or more over the next decade

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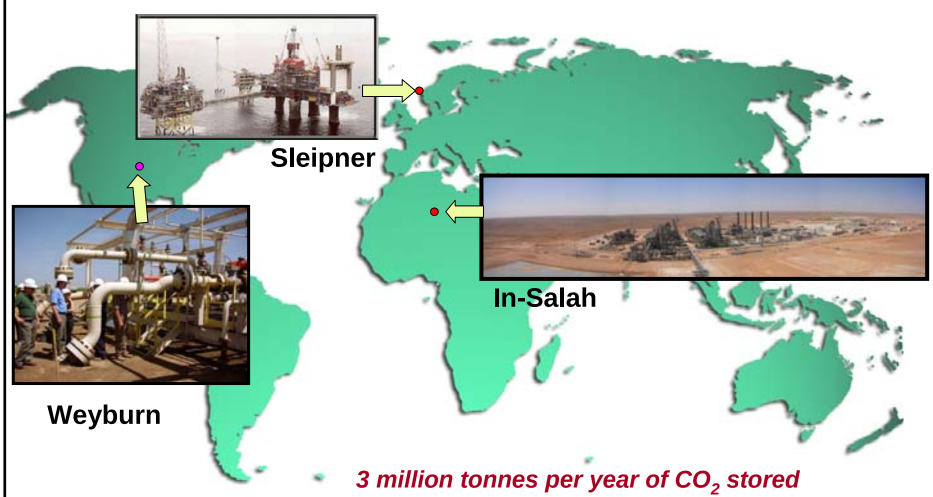
Commercial demonstration projects today



Images Courtesy of BP, Statoil and PTRC, Canada

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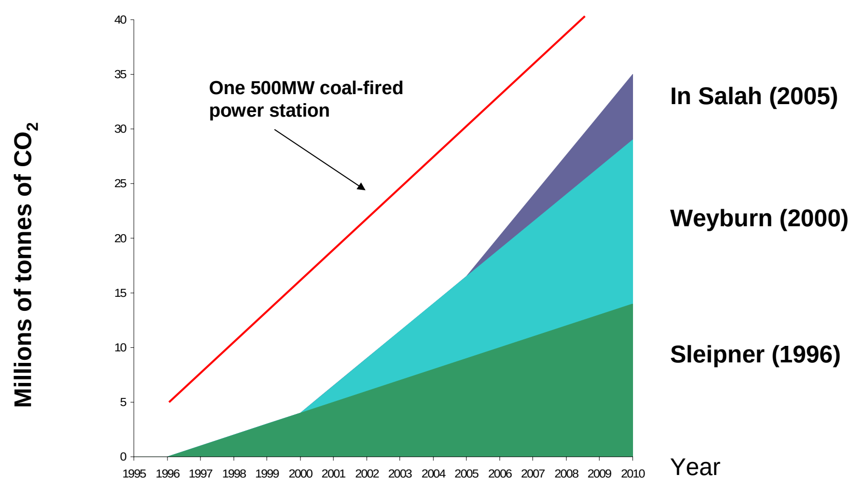
Monitored CO_2 storage experience - today



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Other planned commercial-scale projects

- Statoil, Snøhvit, Norway (start-up 2006/7)
- Gorgon, Australia (planned start 2008-2010)
- BP, Miller-Peterhead – DF1, Scotland (operation start 2009)
- BP, Carson - DF2, California (operation start 2009)
- Statoil and Shell, Draugen, Norway (operation start 2010)

Total anticipated CO_2 storage arising from these projects is an additional 12.5 million tonnes per year

Proposals for coal based power plant demos

- Zerogen, Stanwell, Australia (proposed)
- SaskPower, Canada (operation start 2012)
- Hypogen/Dynamis, European Union (operation start after 2012)
- FutureGen, USA (operation start 2012)
- RWE
  - Germany - IGCC
  - UK – post-combustion / oxyfuel
- E.ON, UK

Challenges – pipelines and source/sinks

- CO_2 pipeline transmission is well but not widely established
- There are significant investment and infrastructure development issues to be addressed – also in need of source/sink matching
- However:
  - Large CO_2 pipelines have been in use since the 1970s
  - CO_2 supplied for enhanced oil recovery (mostly natural)
  - About 4000 km of pipeline in use today
  - Most pipelines are in the USA (Texas/New Mexico)
  - Individual pipeline capacities up to 20 Mt/y
  - Good source/sink matching in some regions e.g. USA

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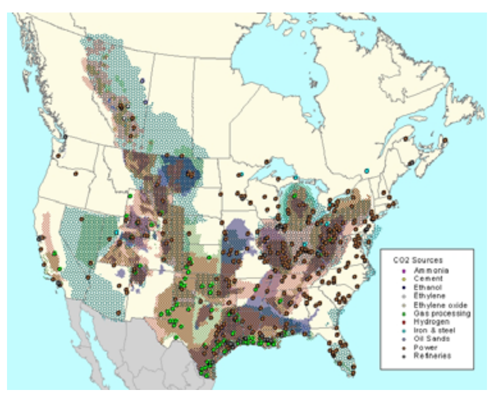
Example - Source/sink matching

North America

- Top 500 sources emit 3.3 Gt CO2/y
- Sources overlay storage formations
- 3.1 Gt CO2/y can be stored in formations within 150km of each source
- Some areas may already have existing pipelines/wells



Not always the case in several regions of the world

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Challenges - legal and regulatory

- Rules and standards
  - ➢Current regulatory practises relevant to CCS
  - ➢Experience in related industries
    - Natural gas storage/ Acid Gas injection/ EOR
    - Other underground injection control programs
- Permitting/Licensing issues
- Long term liability
- Environmental Impact Assessment
- Monitoring requirements
- Remediation practices

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Challenges - public awareness

- Acceptance of CCS as a GHG mitigation option
  - A solution amongst a balanced portfolio of energy technology options – "not a silver bullet"
- Potential for deep reduction in emissions whilst meeting energy demand
  - Allows orderly transformation of existing energy technology infrastructure
  - Address the safety and security of storage
- Vision as a "bridge" to a new energy technology future
  - Seeds the development of a decarbonised electricity and hydrogen energy infrastructure
  - With prospects for greater integration with renewables

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Thank You

More information can be found at:

www.ieagreen.org.uk

www.co2captureandstorage.info