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CCS in the UK:
Context, Competition, Comparisons

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Context

European and UK CCS environment
– policy, finance, opportunities

CCS in the UK – The Imperative

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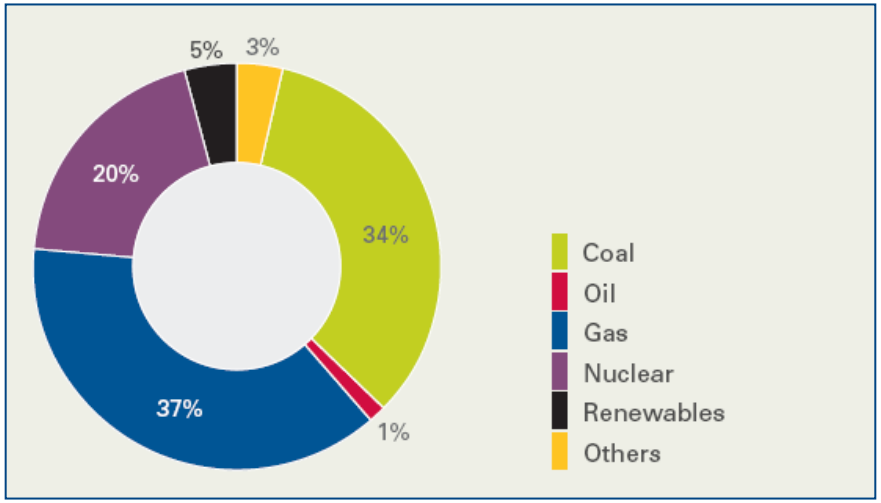
- Europe has binding legislation with ambitious climate and energy targets for 2020 ("20-20-20").
- UK has legally binding target of an 80% reduction in carbon dioxide emissions by 2050.
- …requires almost complete decarbonisation of the electricity generating sector by 2030.
- 20% of existing UK power stations set to close within the next decade
- Industrial sources not related to power generation also significant.

UK Electricity Generation Mix (2005)



Source:Energy Review, DTI, 2006

‘Enabling’ legislation

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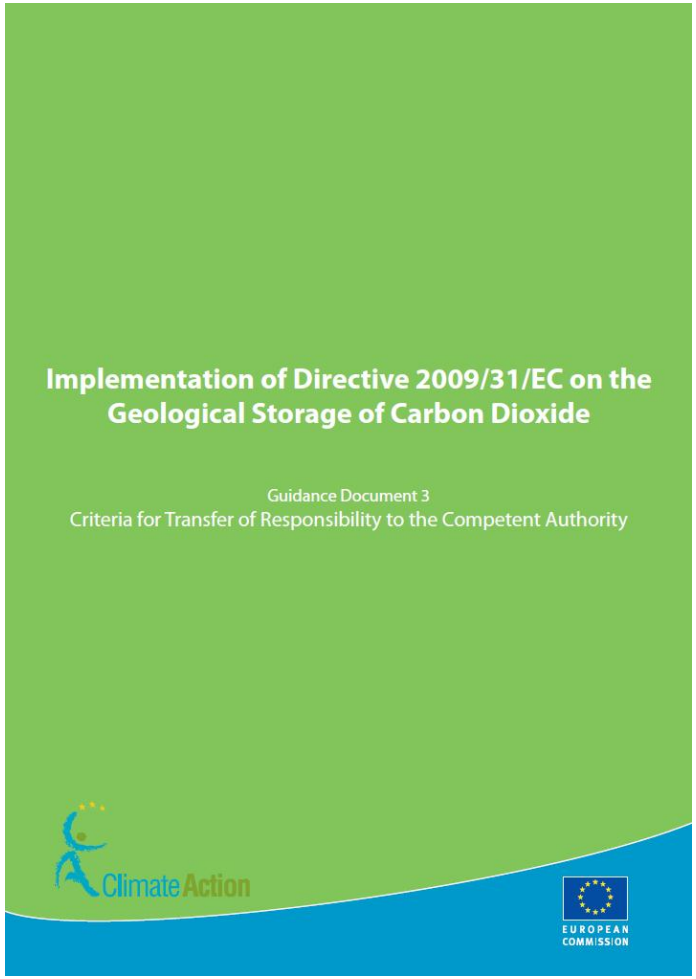
- The EU ‘CCS Directive’ covers all CO_2 storage in geological formations with requirements which apply to the entire lifetime of storage sites.
- CCS Directive was supposed to have been transposed into law by all Member States by 25th June 2011.
- EU Emissions Trading Scheme (part of the EU implementation of the Kyoto Protocol) puts a price on Carbon



EU CCS Directive – Guidance Document 3

"Criteria for Transfer of Responsibility to the Competent Authority"

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Four conditions are specified:

a. all available evidence indicates that the stored CO_2 will be **completely and permanently** contained;

b. a minimum period after closure, to be determined by the competent authority, has elapsed – that minimum to be **no less than 20 years**, unless the authority is convinced that condition (a) has been met sooner than that;

c. **financial obligations** … requiring the operator to contribute to a financial mechanism to pay for the competent authority's post-transfer costs, have been met; and

d. the **site has been sealed** and the injection facilities removed.

Requires the operator … document how it has fulfilled condition (a) demonstrating at least three factors:

1. **conformity of the actual behaviour** of the injected CO_2 with the modelled behaviour;
2. **absence of any detectable leakage**; and
3. **evolution** of the storage site towards a situation of **long-term stability**.

Financial Support for UK CCS Projects

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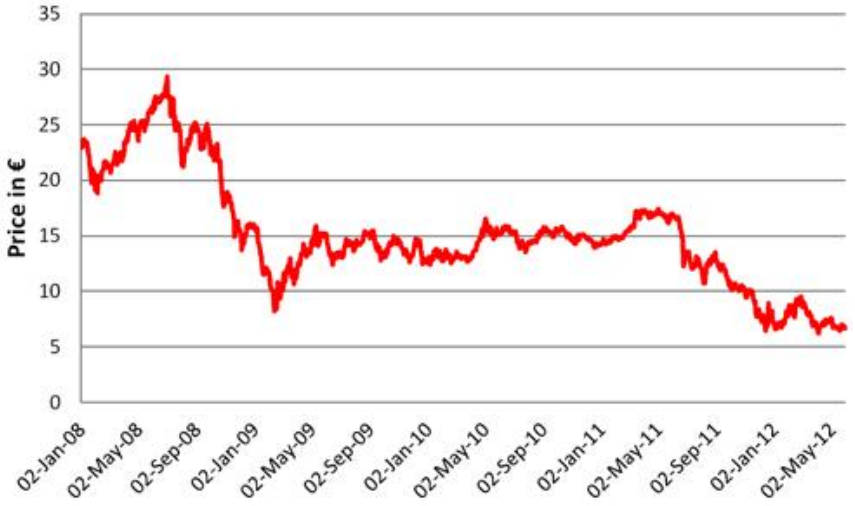
- European Energy Programme for Recovery (EEPR, 2009)
  - €1bn for CCS projects
- 'New Entrants' Reserve' (NER-300, 2009)
  - 300 million allowances set aside
- Member State contributions
  - (but beware 'State Aid' constraints)
- UK CCS 'Competition(s)' (2007)
  - £1 billion on the table
- Industry and other investment



Also…

- UK Electricity Market Reform
  - Carbon Price Floor
  - Contract for Difference feed-in tarrif
  - Capacity mechanism
  - Emissions Performance Standards

Illinois (150,000 km^2) vs. England (130,427 km^2)

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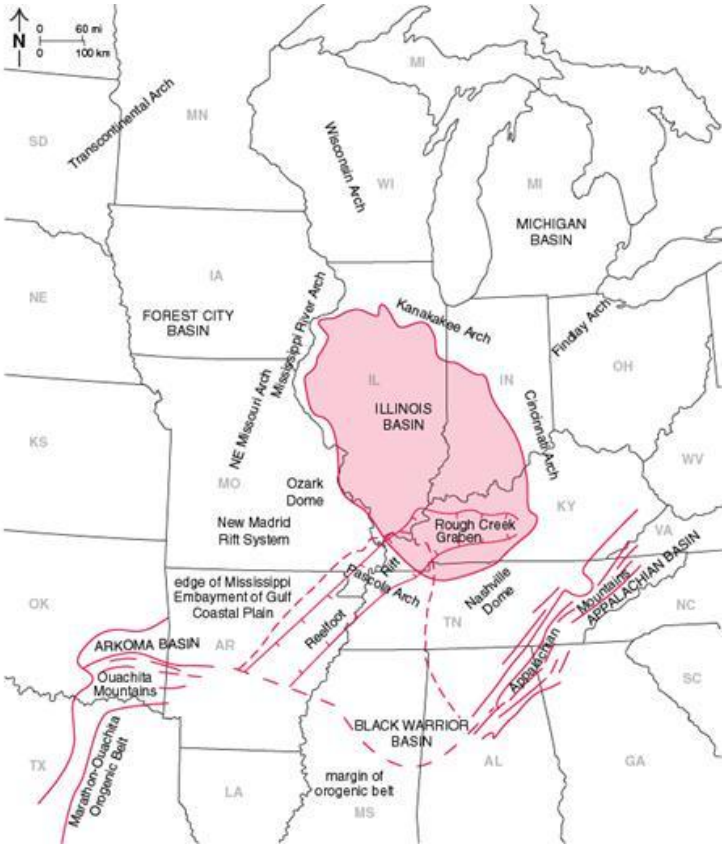

elementenergy
PÖYRY
British Geological Survey

North Sea CCS Infrastructure
Report to the North Sea Basin Task Force

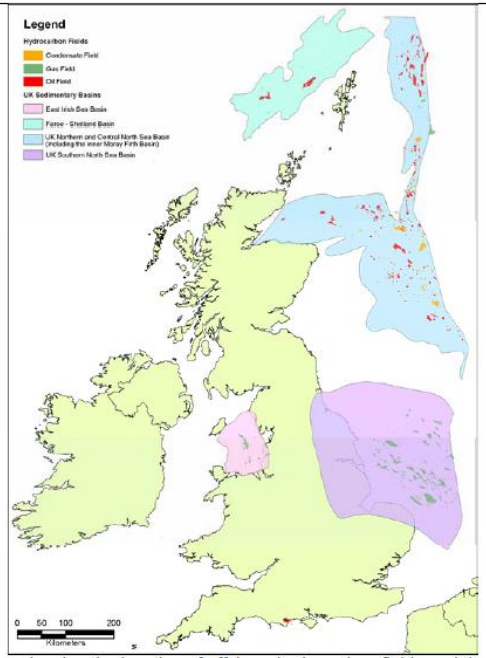

Figure 4-1 Map showing the location of offshore hydrocarbon fields and the major oil and gas-bearing sedimentary basins on the UK Continental Shelf.

Scotland 78,772 km², Wales 20,778 km², Northern Ireland 13,843 km², UK 243,820 km²
(thank you Wikipedia)

North Sea offers storage options for UK & Europe

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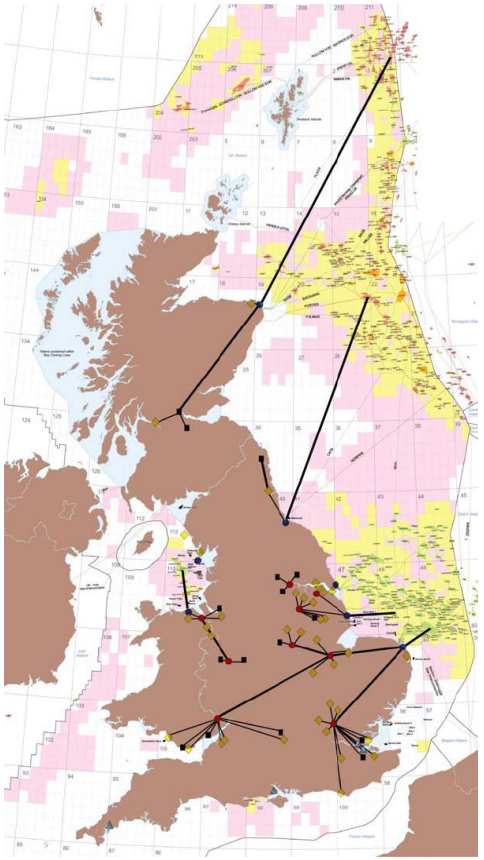
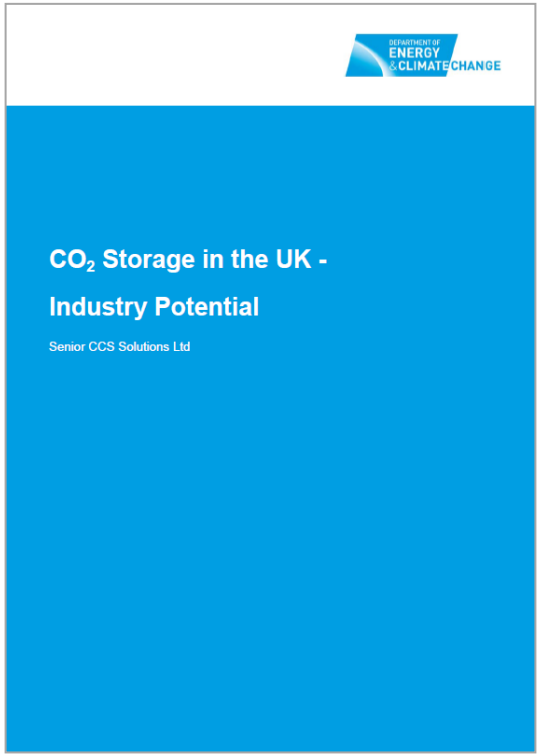
North Sea has an abundance of depleted oil & gas reservoirs and deep saline formations.

- Should we go for many small stores or a few large ones ?
- Which ones should they be ?
- Studies for pipeline networks (need to know where to go!)



Source for Figure:
Pöyry Energy Consulting Study on CCS costs, commissioned by UK Government

CO_2 Storage in the North Sea – Industry Potential

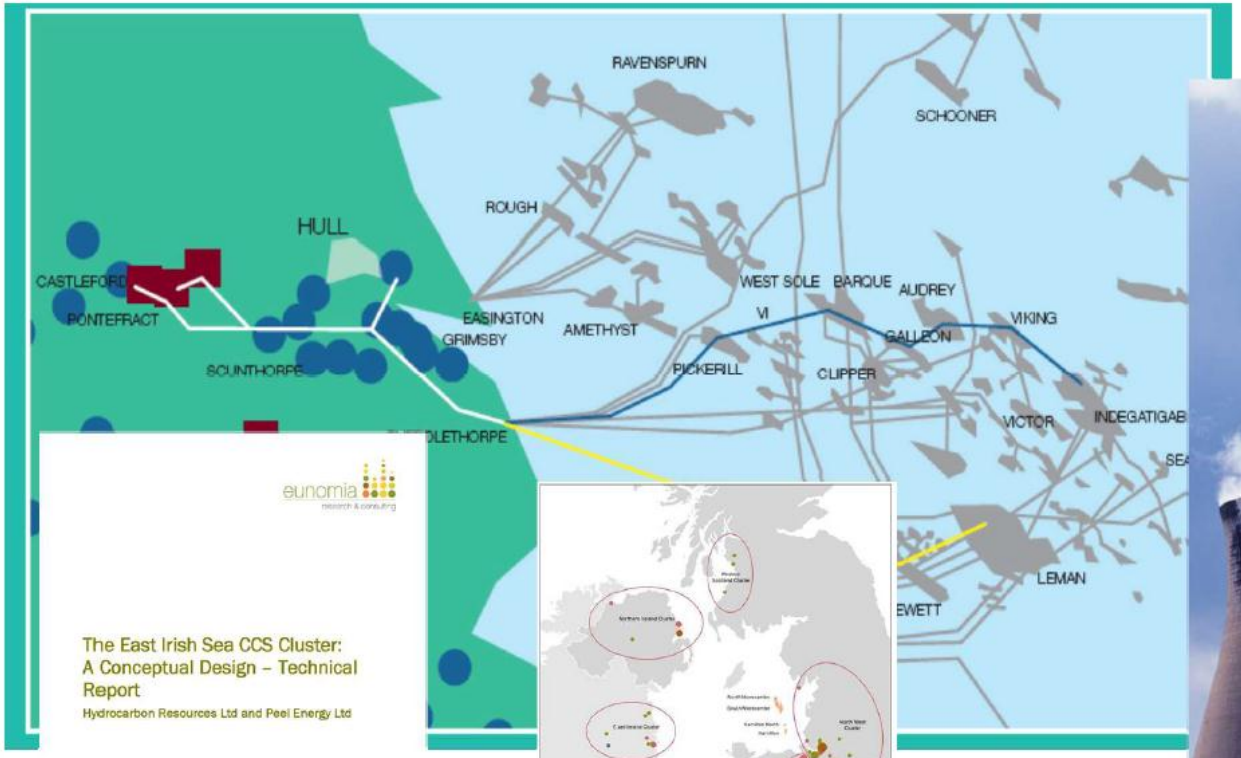


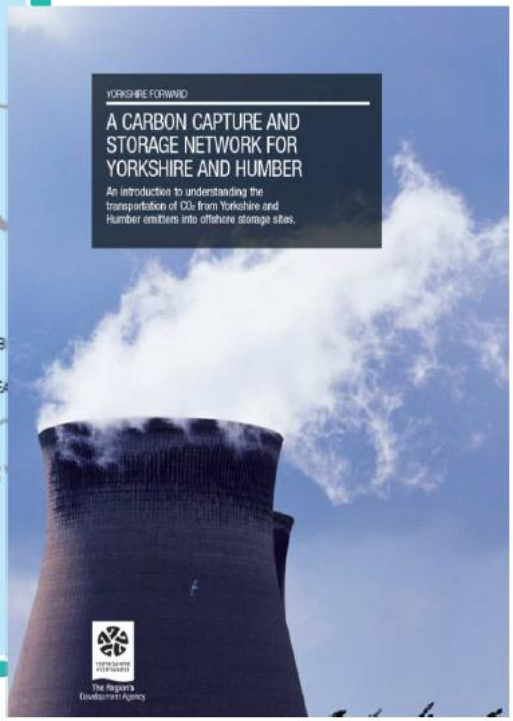
4.6 Storage Site Assessment Requirements

The current assessments of CO_2 storage capacity and opportunities in the UK are at an early stage, so far based only on desktop screening studies. As a result there is significant uncertainty in capacity, and additional technical and non-technical issues have not yet been addressed, and little site specific assessment is available in the public domain (although proprietary work has been conducted for specific demo options).

Lots of work on clusters

NCCCS
The National Centre for Carbon Capture and Storage





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Competition(s)

Competition #1

Competition #2 (‘Commercialization programme’)

First UK CCS Competition

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- 2007 (Mar) – UK Budget puts up £1 billion for CCS ‘demonstration’
- 2007 (Nov) – Details announced, post-combustion only
- 2007 (Nov) – BP cancels ‘DF1’ project (pre-combustion)
- 2008 (Jun) – 9 company/consortia entries
- 2008 (Nov) – Government announces four pre-qualified companies
- 2008 / 2009 – two entrants pull out
- 2010 (Mar) – funding awarded to two remaining for FEED studies
- 2010 (Oct) – one entrant withdraws, leaving one
- 2011 (Oct) – competition cancelled (requirements not met)
- 2012 (Mar) – two FEED studies published in detail (cost ~£40M)

http://www.decc.gov.uk/

Competition #2:
'CCS Commercialisation Programme '

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- Aim:
  - "to enable private sector electricity companies to take investment decisions to build CCS equipped fossil-fuel power stations, in the 2020s, without Government capital subsidy, and at an electricity market price that is competitive with other low carbon generation technologies."
- Stringent Knowledge Sharing objectives

Also:

- CCS Roadmap
- CCS Cost Reduction Task Force

UK EEPR and NER-300 projects

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UK Competition is not the only game in town:

EEPR:

- Don Valley project (was Hatfield)
  - run by 2CO
  - (EOR and storage)

NER-300:

- 13 applications for CCS projects
  - 7 from the UK

…BUT the low ETS price may mean that very few actually get funding.

NER-300 Candidates for award decisions

- Pre-combustion **UK Don Valley** Power Project
- Post-combustion PL Belchatow CCS Project
- Industrial application NL Green Hydrogen
- Pre-combustion **UK Teeside** CCS Project
- Oxyfuel UK UK Oxy CCS Demo
- Pre-combustion **UK C.GEN** North Killingholme Power Station
- Post-combustion IT Zero Emission Porto Tolle
- Industrial application FR ULCOS-BF

NER-300 Reserve list

- Post-combustion RO Getica CCS Demo
- Post-combustion **UK Peterhead** Gas CCS

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Comparisons

…between European/UK and US approaches to CCS

EU Demonstration Programme for CO_2 Capture and Storage...

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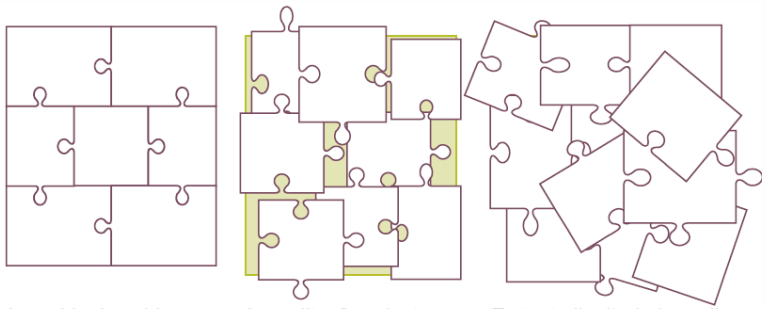
European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) Proposal, Nov 2008:

Conclusion: a total of 10-12 projects is required to achieve the goal of an EU demonstration Programme to commercialise CCS by 2020 (Exhibit 5)

N.B. If some projects experience significant failure, it may be necessary for further projects to be added later to the Programme.



In an ideal world, a theoretical minimum of 7 projects is needed to test all criteria*

In reality, 8 projects are required to test the vast majority of the criteria

To test all criteria in reality, an estimated 2-4 additional projects are required, bringing the total to 10-12

This assumes full success – if some projects fail significantly, more may need to be added later

* Assumed two different technology variations per capture technology

Exhibit 5: 10-12 demonstration projects are needed to satisfy all selection criteria

NER-300 funding:

8 CCS projects, of which:

- Min 1, Max 3 in the following categories: pre-combustion, post-combustion, oxy-fuel and industrial applications
- Min 3 with saline aquifers & Min 3 with depleted hydrocarbon reservoirs
- Min size threshold: 250 MW. Min capture efficiency: 85%.

DOE's Carbon Sequestration Program Goals

Develop Technology Options by 2020 That...

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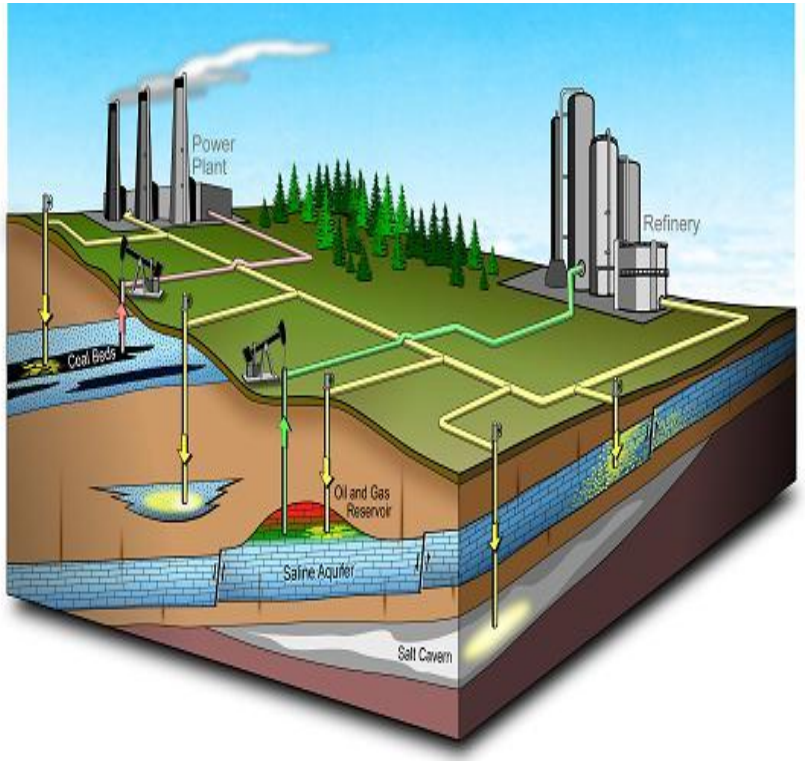
Deliver technologies & best practices that provide Carbon Capture and Safe Storage (CCSS) with:

- 90% CO_2 capture at source
- 99% storage permanence
- < 10% increase in COE
  - Pre-combustion capture (IGCC)
- < 35% increase in COE
  - Post-combustion capture
  - Oxy-combustion



US, European and (new) UK approach to CCS

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US DOE Carbon Sequestration Program Goals:

Deliver technologies & best practices [by 2020] that provide Carbon Capture and Safe Storage (CCSS) with:

- 90% CO2 capture at source
- 99% storage permanence
- < 10% (pre), < 35% (oxy, post) increase in COE

European ZEP Plan: [by 2015]

8 CCS projects, of which:

- Min 1, Max 3 in the following categories: pre-combustion, post-combustion, oxy-fuel and industrial applications
- Min 3 with saline aquifers & Min 3 with depleted hydrocarbon reservoirs
- Min size threshold: 250 MW. Min capture efficiency: 85%.

New UK Plan:

- "to enable … CCS equipped fossil-fuel power stations, in the 2020s, without Government capital subsidy, and at an electricity market price that is competitive ..."