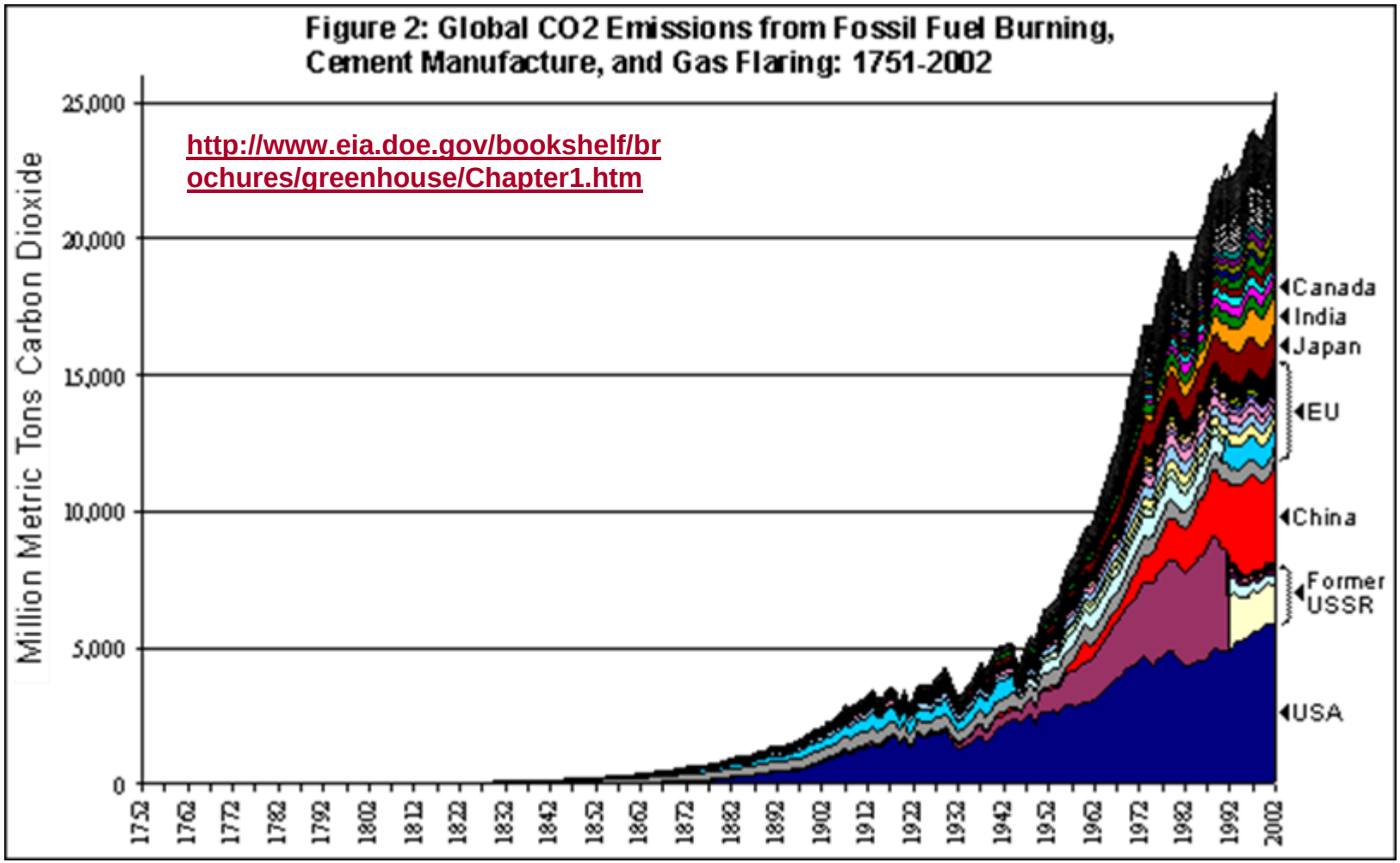
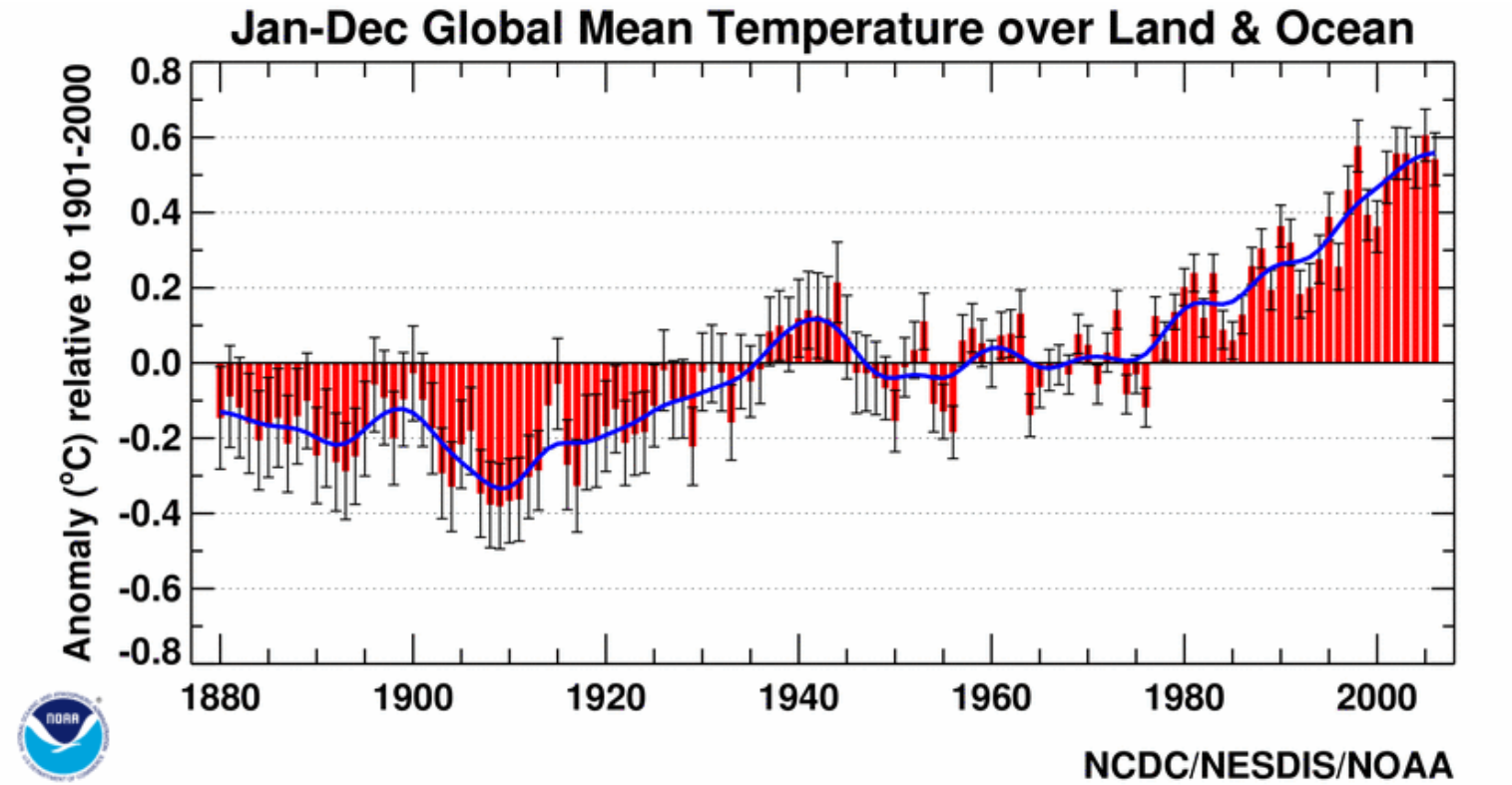
Carbon Capture and Storage

Jonathan Periselneris
E.ON UK
15th May 2009

Global CO_2 emissions are rising rapidly…

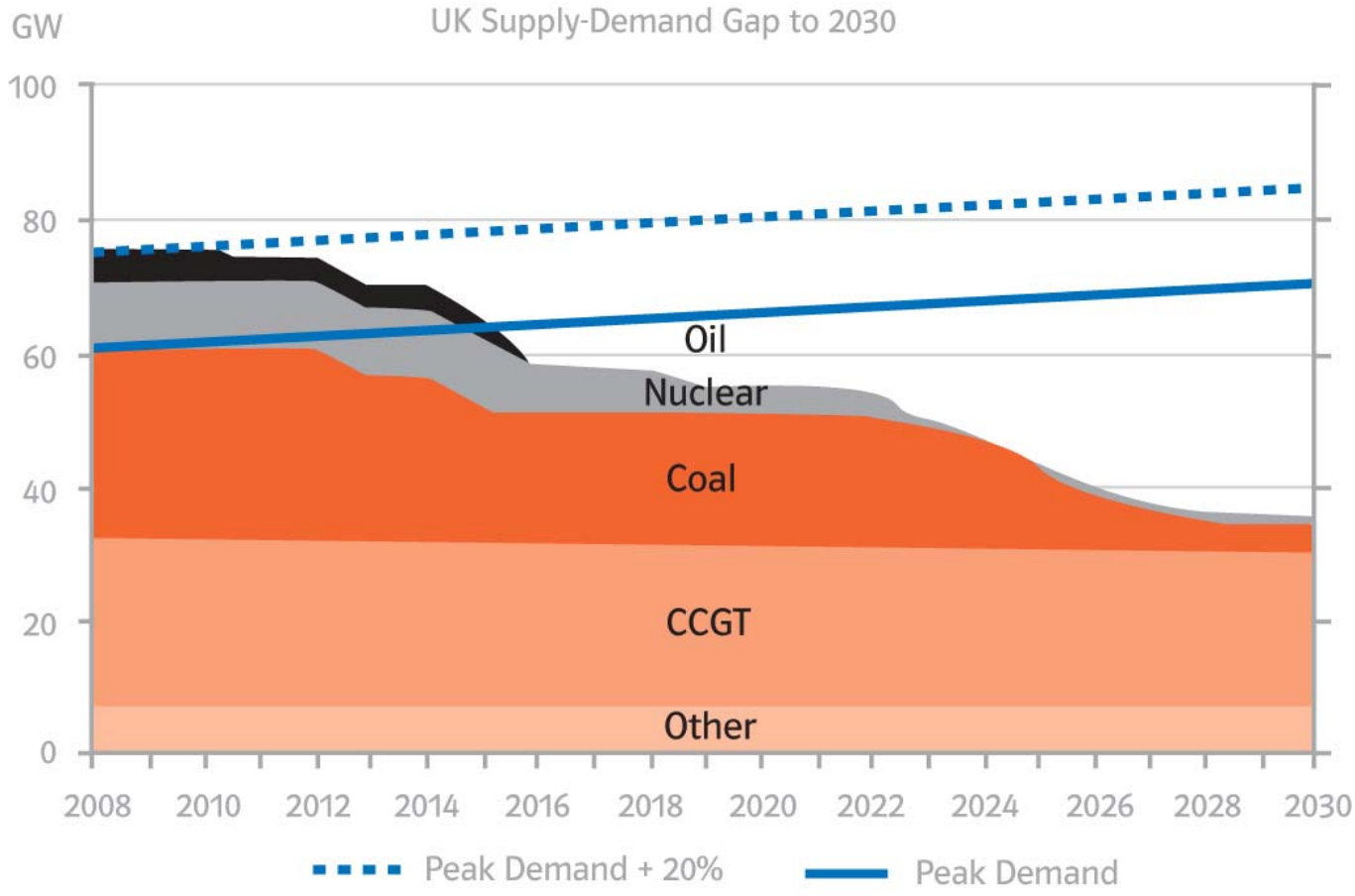


…and so are global temperatures.



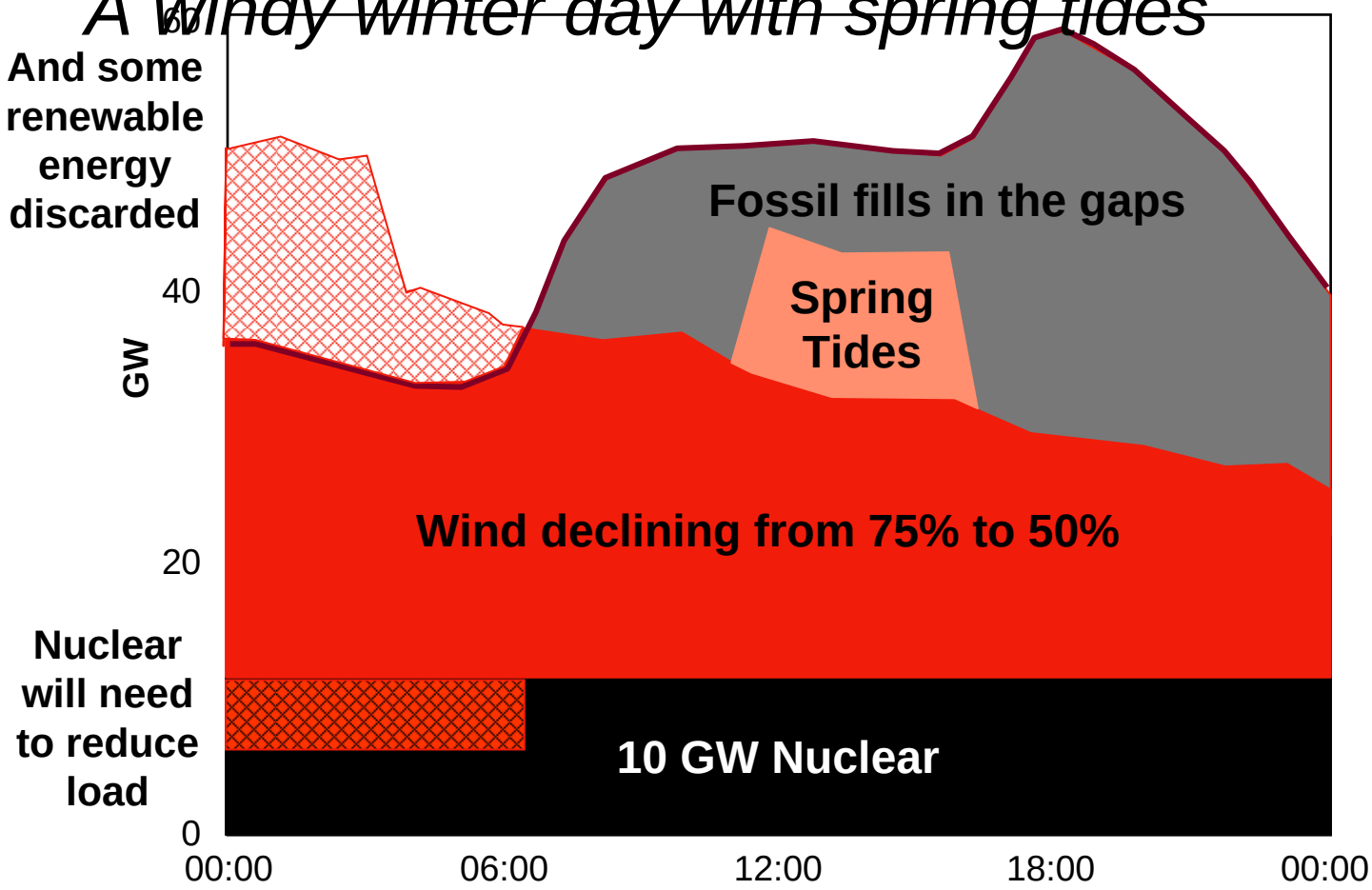
Source http://www.epa.gov/climatechange/science/recenttc_triad.html

The Challenge Facing the UK Power Market



Even with Renewables and Nuclear, we still need fossil plant

A windy winter day with spring tides

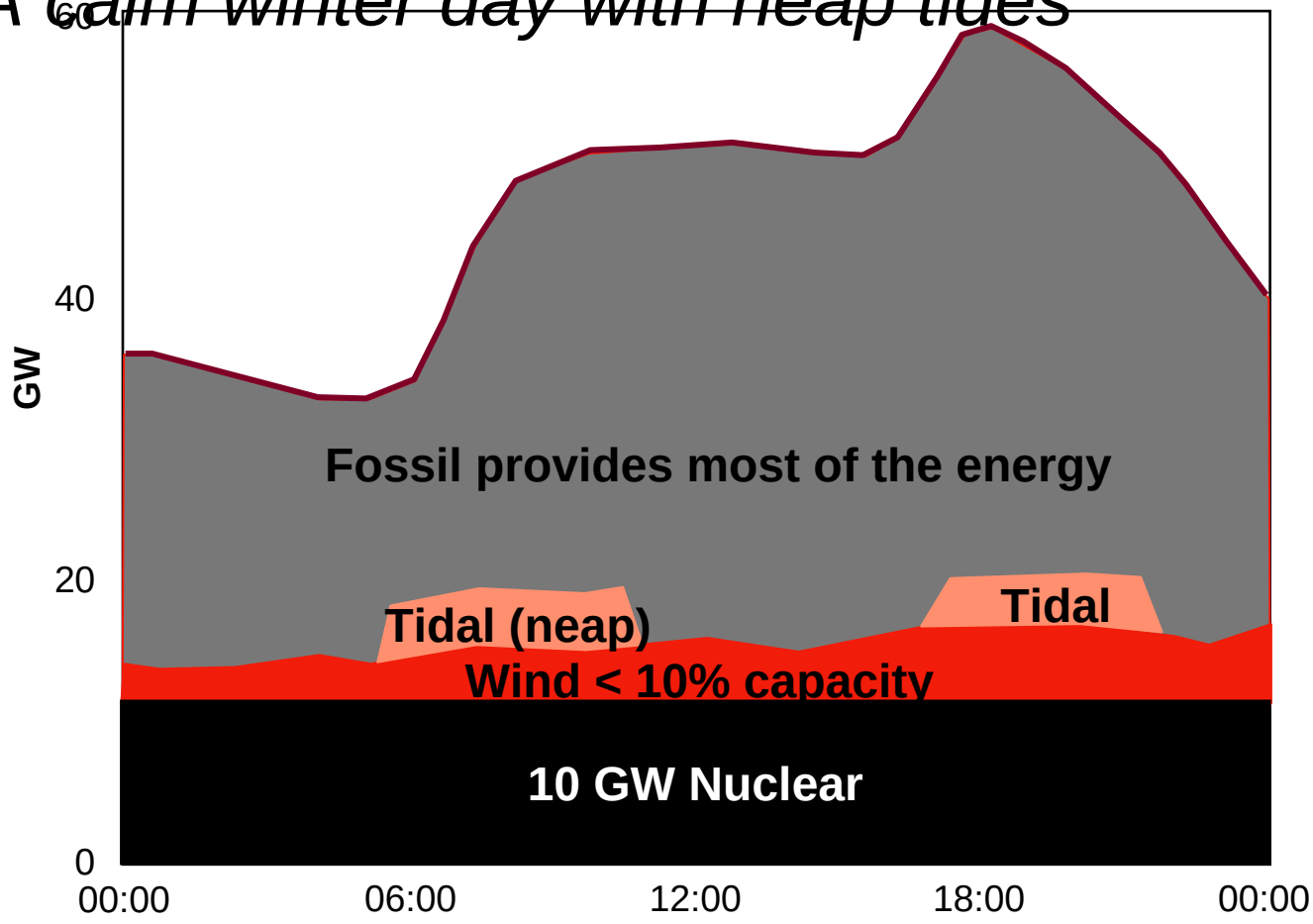


Assumptions

40 GW Wind (Onshore/Offshore)
9 GW Severn Barrage
10 GW Nuclear
50 GW Fossil (Coal and Gas)
In this scenario 40% of electricity is renewable

Even with Renewables and Nuclear, we still need fossil plant

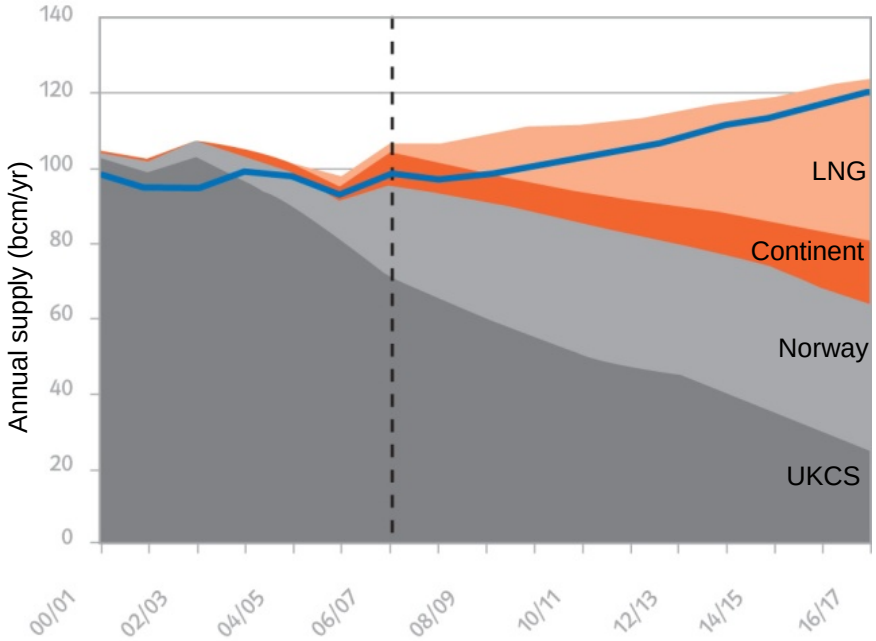
A calm winter day with neap tides



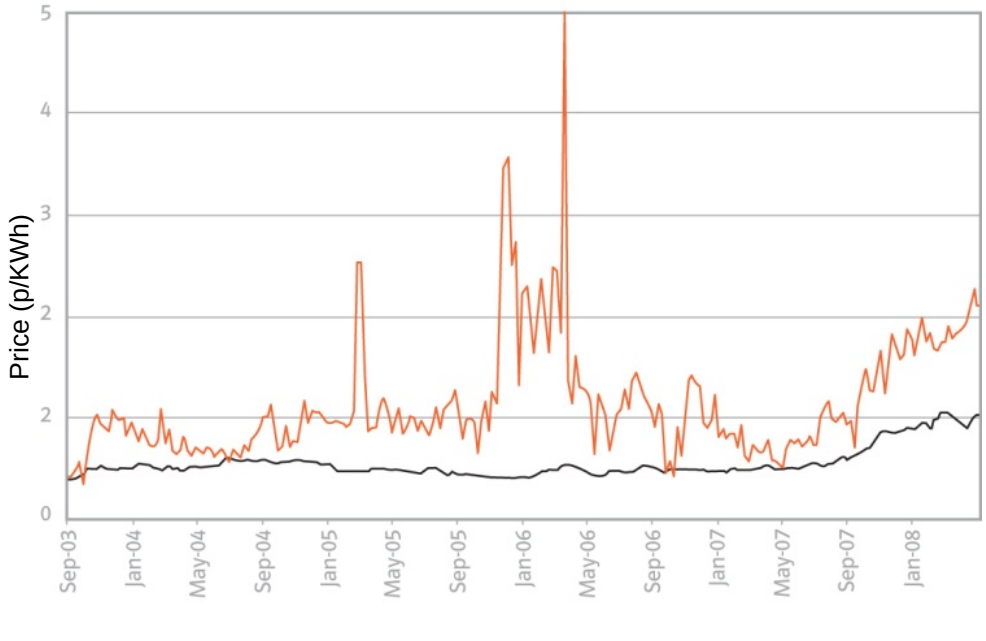
Assumptions

40 GW Wind (Onshore/Offshore)
9 GW Severn Barrage
10 GW Nuclear
50 GW Fossil (Coal and Gas)
In this scenario 40% of electricity is renewable

We also should avoid over-dependency on gas



Geographic source of UK consumed gas – past and future

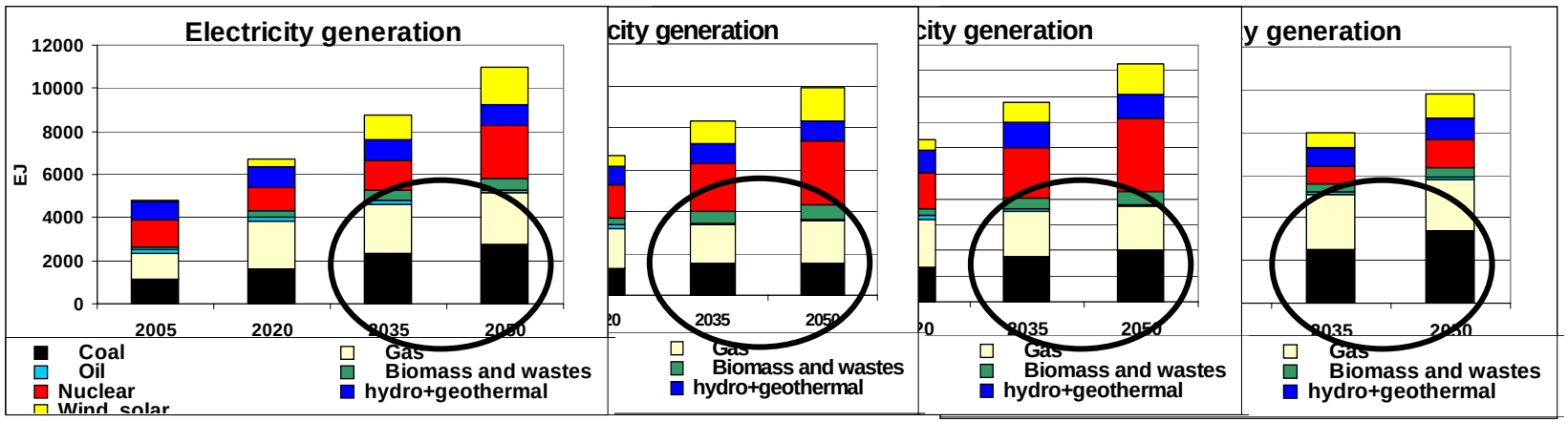


Coal vs gas prices change over past 5 years

Coal will still have a major global role in the future

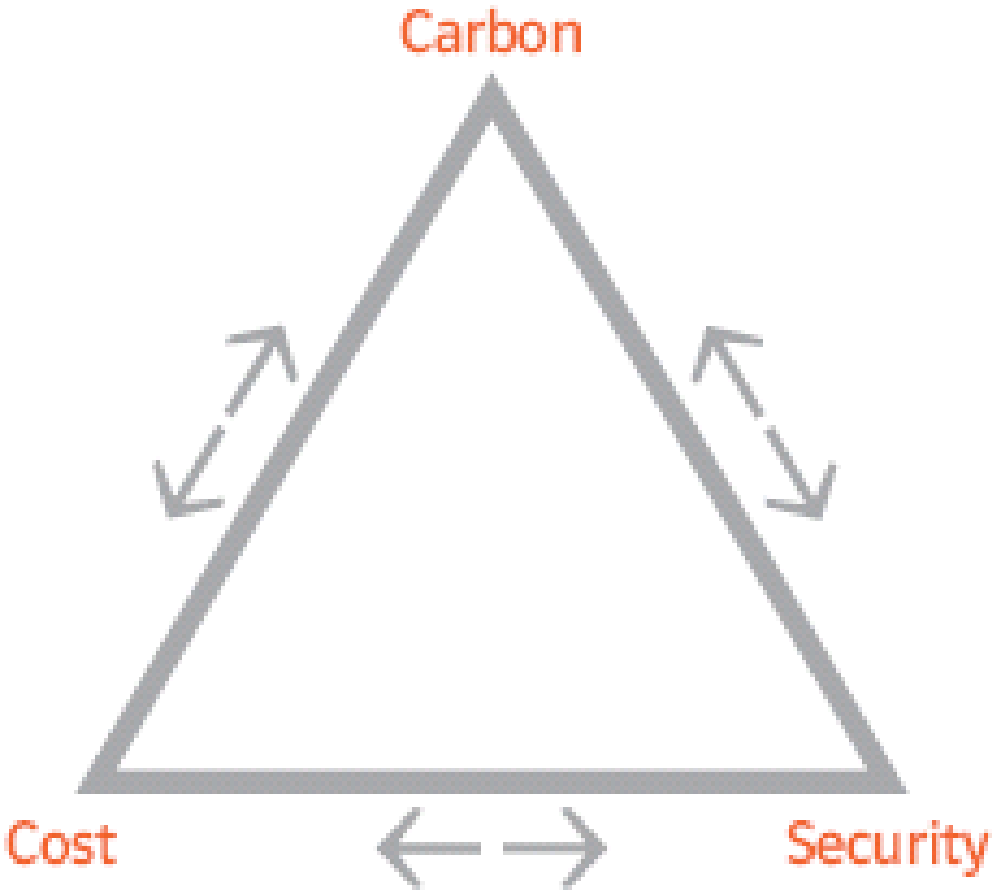
For example, a recent World Energy Council study:

Four scenarios were evaluated to characterize the global fuel mix of the future including “accessibility” and “acceptability”. In all four scenarios, coal is still needed in the year 2035 and in the year 2050 to produce electricity.



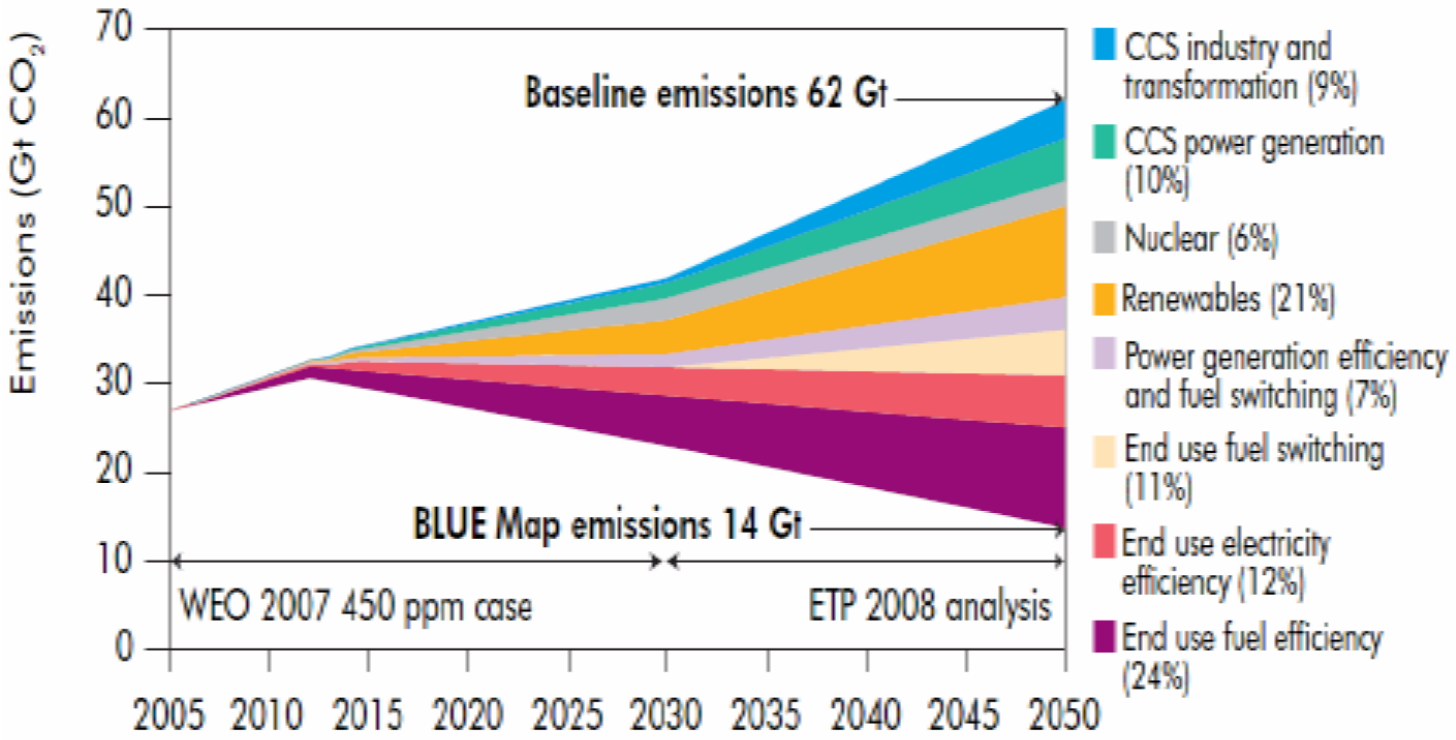
Sources: http://www.worldenergy.org
“Energy Policy Scenarios to 2050” (WEC, 2007)
“The energy industry unveils its blueprint for tackling climate change” (WEC statement 2007)

Carbon, Cost and Security – The Trilemma

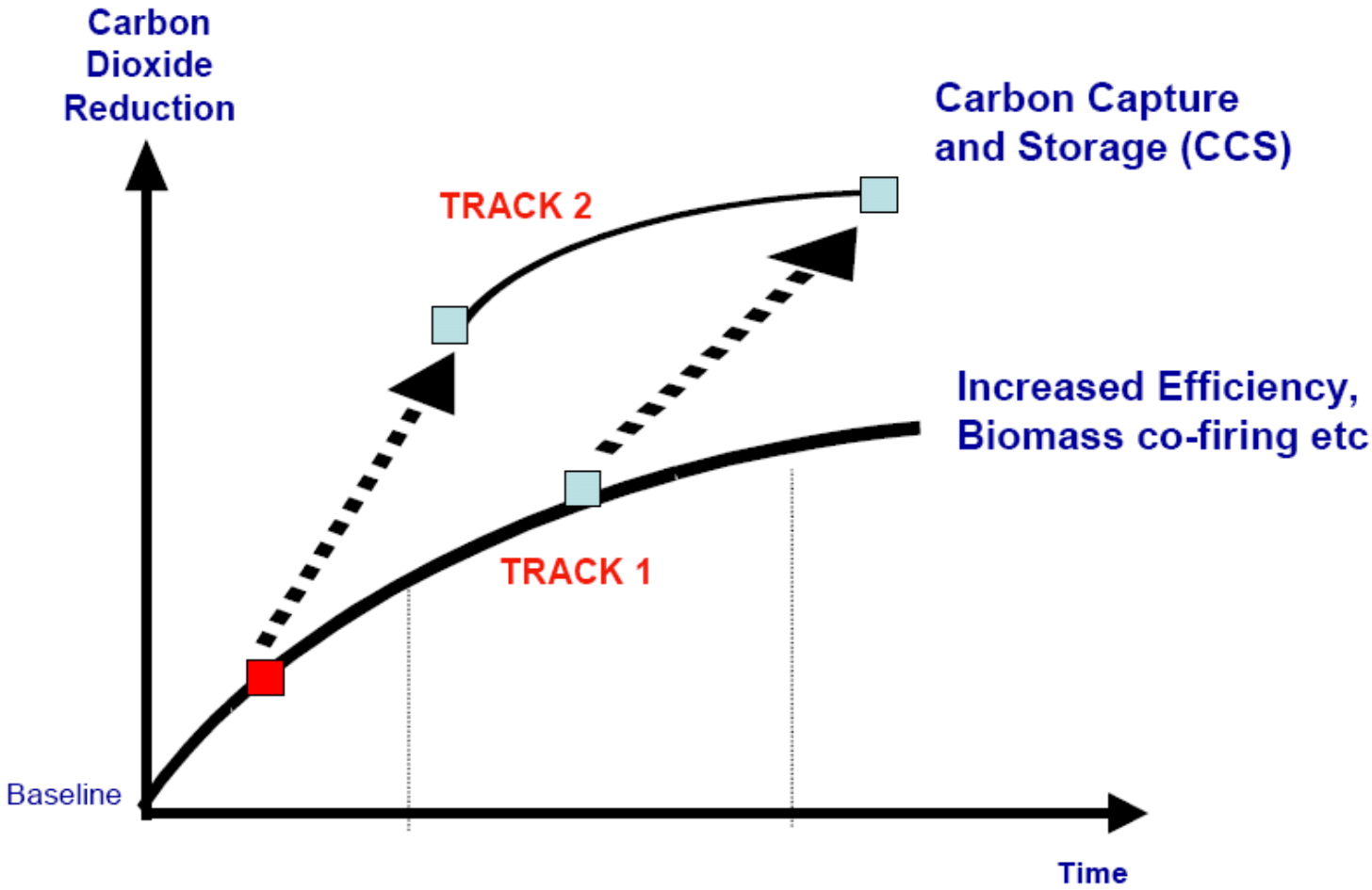


So how do we achieve CO_2 reductions?

Figure ES.2 ▶ Comparison of the *World Energy Outlook 2007* 450 ppm case and the BLUE Map scenario, 2005-2050



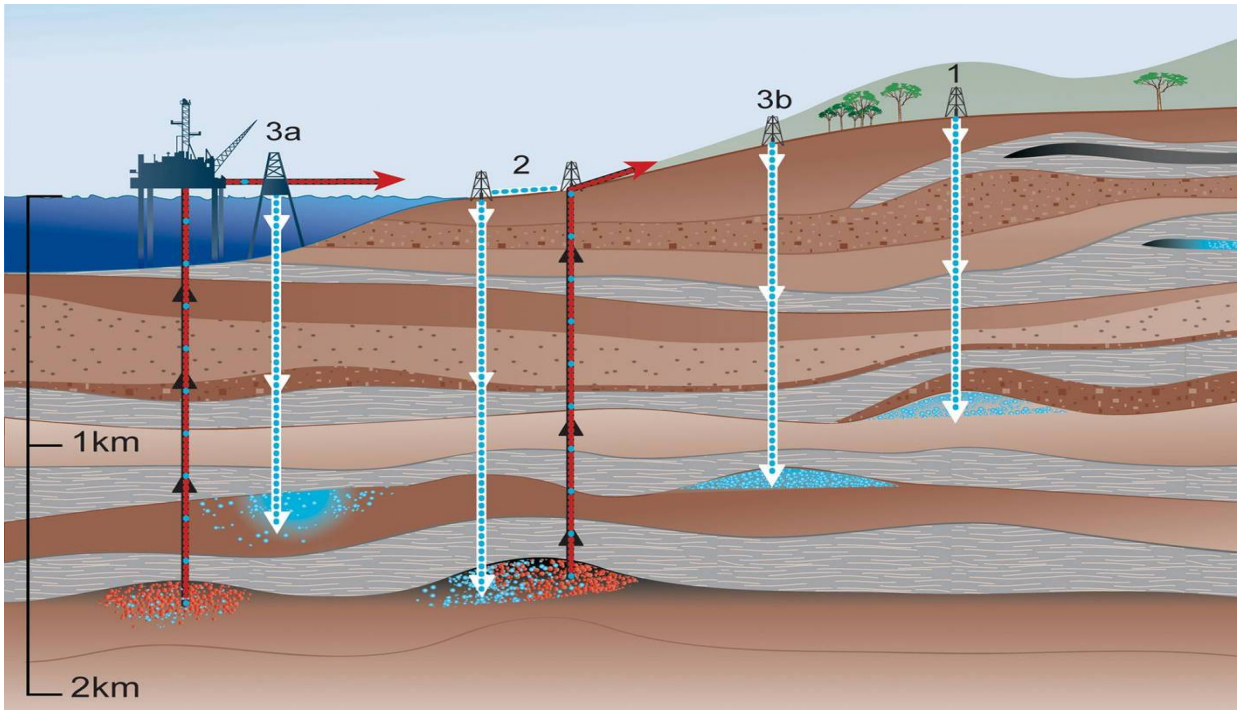
CO2 Abatement from Coal – Twin Track Approach



Source: IEA

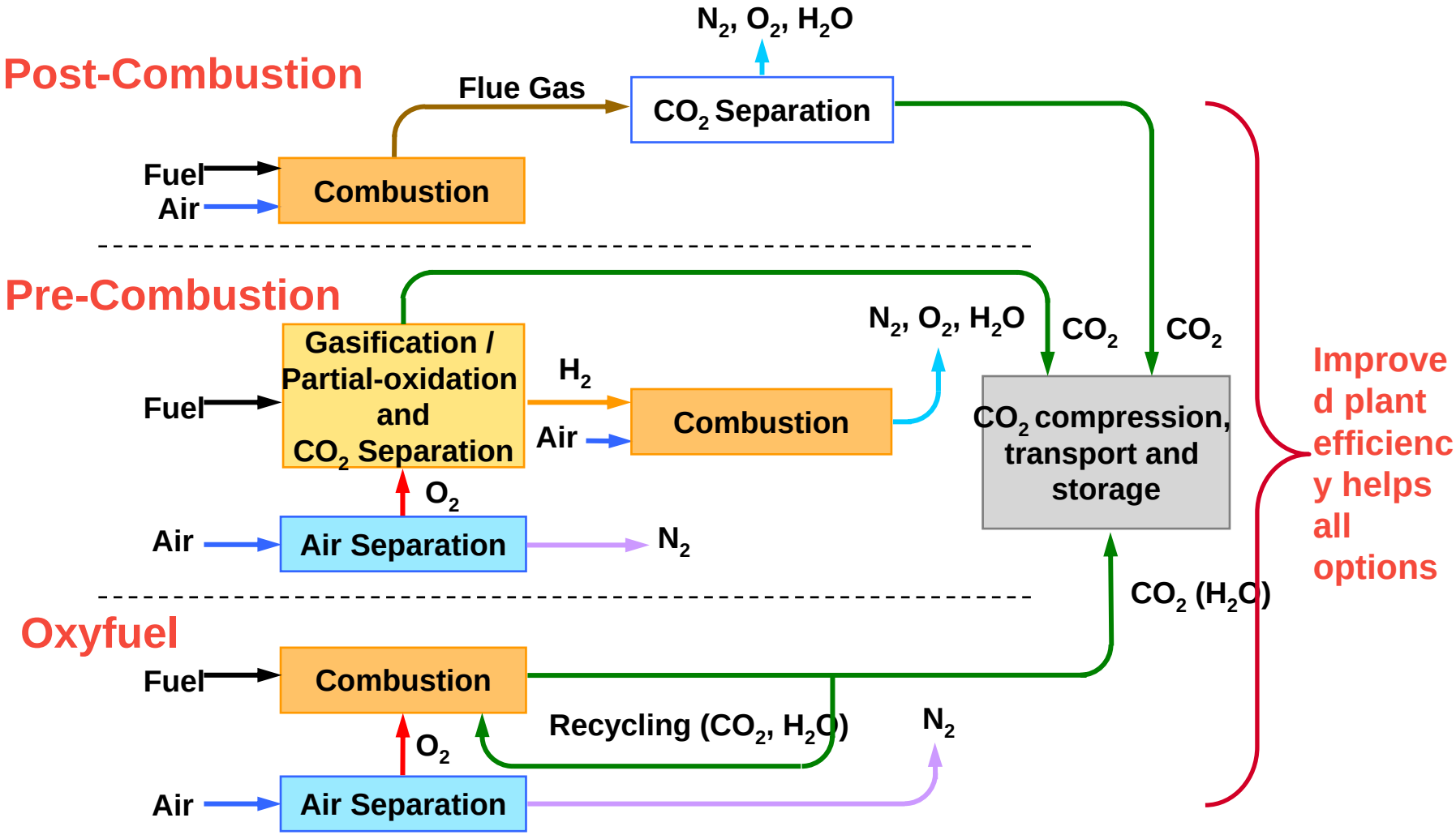
Carbon Capture and Storage (CCS)

- Technology to capture CO2 from the combustion process , condition it, transport it and store it permanently
- Stored deep underground in porous rock under an impervious cap rock



Source: IEA

CO2 Capture



CO2 Capture

Buggenum IGCC, Holland (Pre-combustion capture * does not include CCS)

MHI Demo, Japan (Post-combustion capture)

CO2 Conditioning and Transportation

- Two main forms of transportation being considered:

Pipeline

Shipping

- Both options draw analogies and trends from Natural Gas transportation

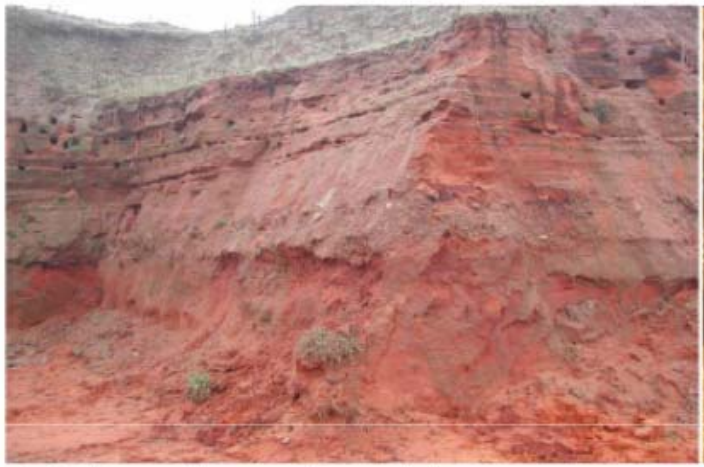
CO2 Conditioning and Transportation

- CO2 product purity from Capture process is high
- However additional conditioning required to ensure safe and effective transmission
- CO2 compression required to increase pressure for transportation and injection
- CO2 storage pressure depends on individual site and can change during lifetime
- Moisture removal crucial issue
- Consequentially final CO2 product for sequestrat is > 99% pure

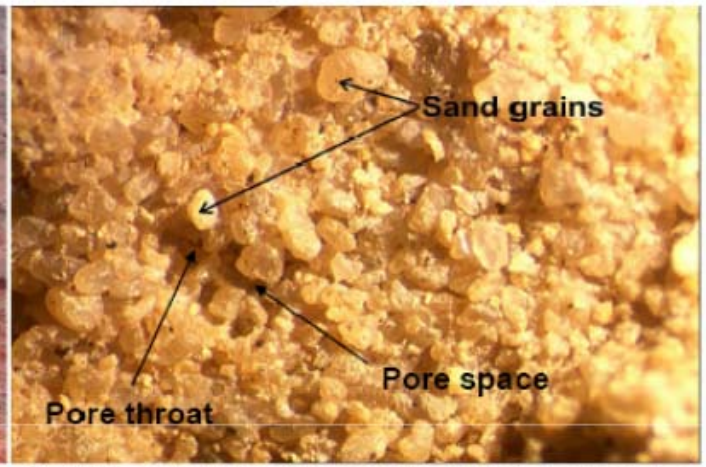
CO2 Storage

- Depiction shows existing offshore injection facility in the North Sea
- Injection of CO2 can draw on experience of NG/oil extraction techniques
- Injection of CO2 is already being carried out for EOR mainly in the US
- Injection options still being explored and may be site specific:
  - Direct subsea tie-in
  - Reuse of existing facility
  - New platform

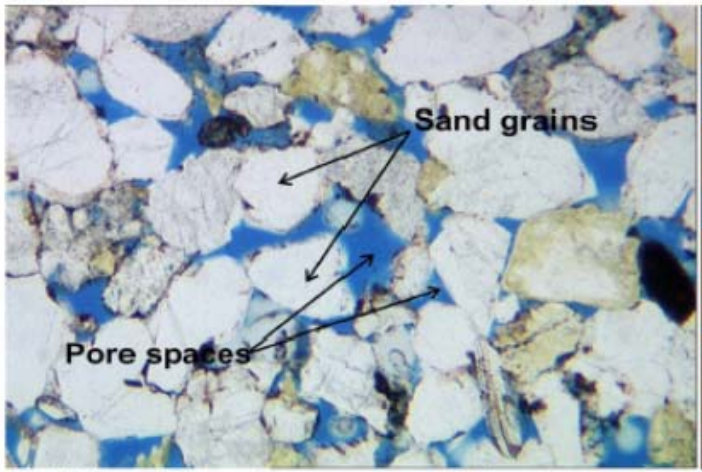
CO2 Storage



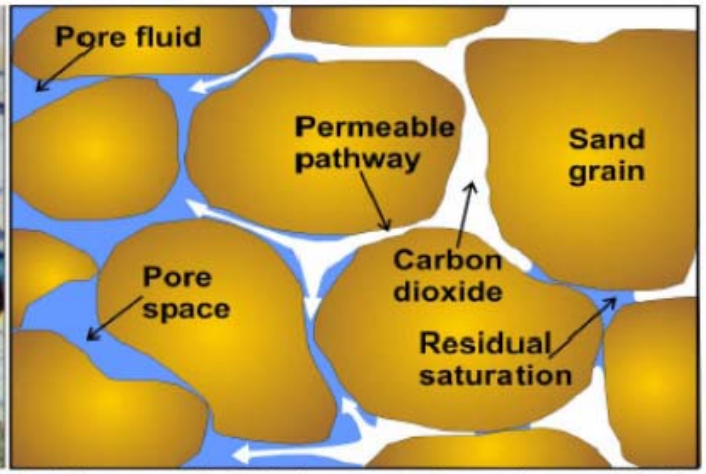
1. Outcrop of reservoir sandstone



2. Close up photograph of reservoir sandstone



3. Thin section of reservoir sandstone microscope



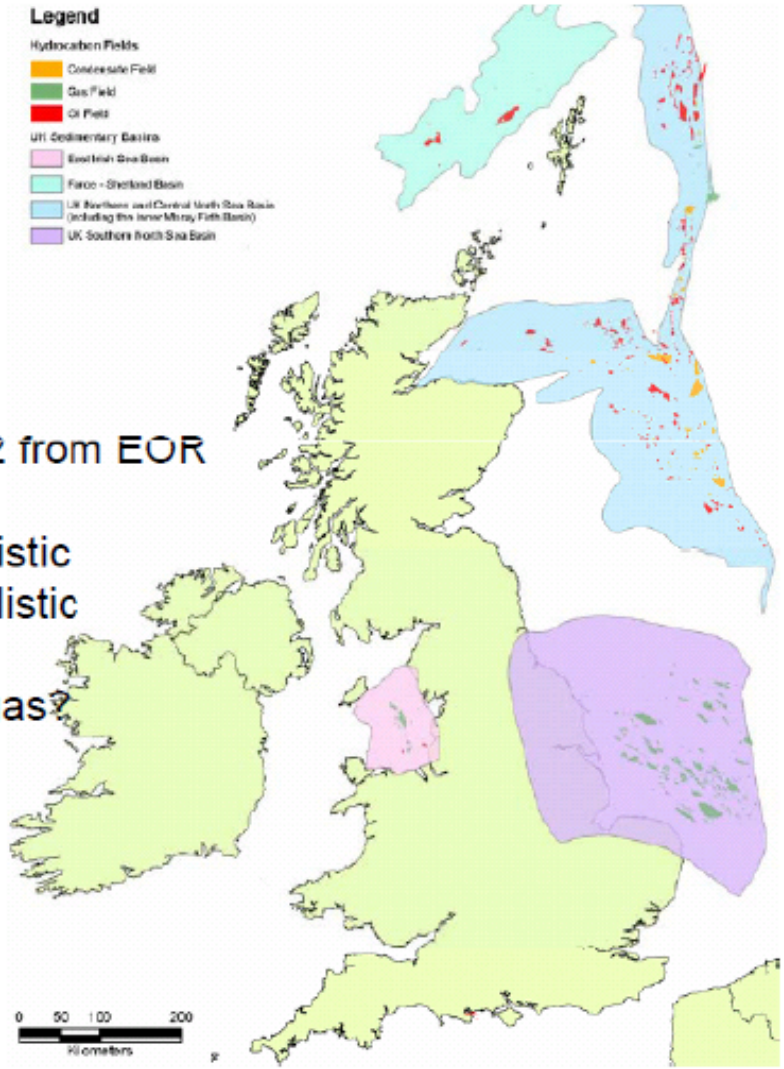
4. Diagram highlighting porosity and permeability

CO2 Storage

- Oil fields
- Gas fields
- Saline aquifers
- Coal seams

- Oil fields: between 200 million tonnes CO2 from EOR – viable
- SNS gas fields: ~3900 million tonnes - realistic
- EISB gas fields: ~1000 million tonnes - realistic
- Coal seams – difficult?
- Aquifer potential: 10 times that for oil and gas?
- Total “quantified”: ~22 Gigatonnes
- Almost certainly much more available

Information provided by British Geological Society

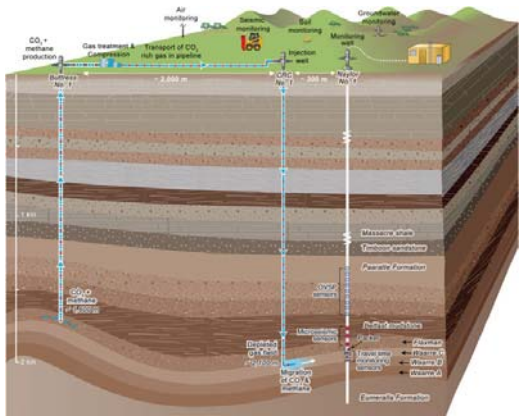


CCS Myths

Myth 1 - It might not work

All the components are demonstrated at scale – all we need is to put them together. CCS will work technically, the challenge for the demonstrators is to find out how best to make it work, and to optimise the technology. The only reason it hasn't been done is lack of commercial driver.

Many EOR projects and some storage demonstrations are underway, including 10Mt injected under the North Sea.



There is about 3000km of CO_2 pipeline in the world already, mostly in the USA

CCS Myths

Myth 2 – It's too risky – the CO_2 may leak

CO_2 will be sequestered (locked away) permanently

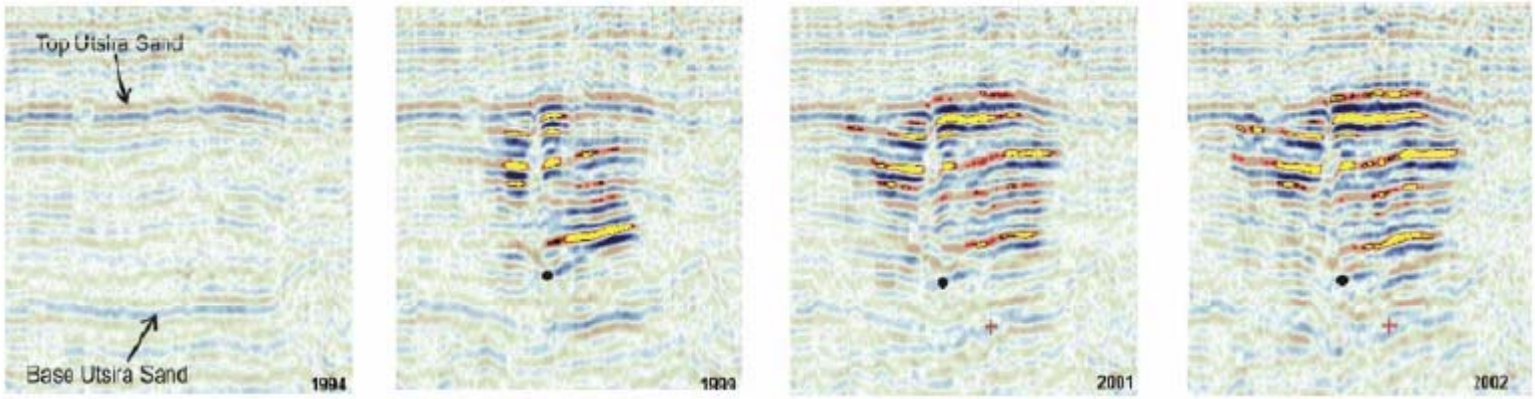
- Storage sites will be well characterised and geologically sound.
- Many geological formations have held gas or oil for millions of years .
- Over time, CO_2 will dissolve in water already trapped in the rocks. This makes it heavier than water without CO_2, so unlike natural gas and oil, the buoyancy that drives leakage will gradually disappear.
- CO_2 slowly reacts with some rocks to create a carbonate (solid). Where this happens, leakage would become impossible.
- All this means that CO_2 should be locked away for geological timescales

And remember, the alternative is 100% leakage

CCS Myths

Myth 2 – It's too risky – the CO_2 may leak

- Sleipner Storage Project – owned by Statoil
- Operating since 1998
- CO2 separated from natural gas production and injected in Utsira formation
- Approx 1 Mt per annum
- 3D seismic surveys show CO2 movement



CCS Myths

Myth 3 – It's too expensive

It is expensive, but whether it is too expensive depends what you compare it with!

- It is more expensive than nuclear power
- But cheaper (and more reliable) than off-shore wind

It is also the newest technology, and therefore can expect the fastest cost reduction with time.

CCS Implications

Trade-offs

Engineering:

- Large energy penalty
- Large footprints
- New operational considerations – power plant and grid implications

Market and Regulatory:

- Health and Safety
- Legality
- Market Mechanisms

Post Combustion Capture - Larger scale

Large scale post-combustion capture entry into UK Government CCS Competition

- **The planned supercritical units at Kingsnorth, combined with UK Government funding gives a unique opportunity to demonstrate CCS on a high efficiency modern plant at nearer commercial scale**

The Government Rules Require

- **300MW$_e$ amine scrubber fitted to a new supercritical coal-fired unit by 2019**
- **Capturing circa 2Mt/y CO_2 and transporting offshore for storage in the North Sea**
- **Competition negotiations and plan submissions during 2009 and 2010.**
- **Full chain of capture, transport and storage should be demonstrated by**

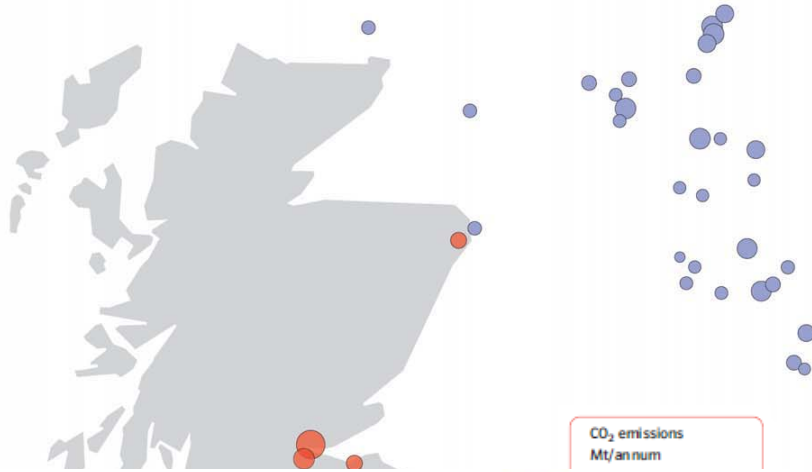
In addition…

>30 MW$_e$ amine test facility

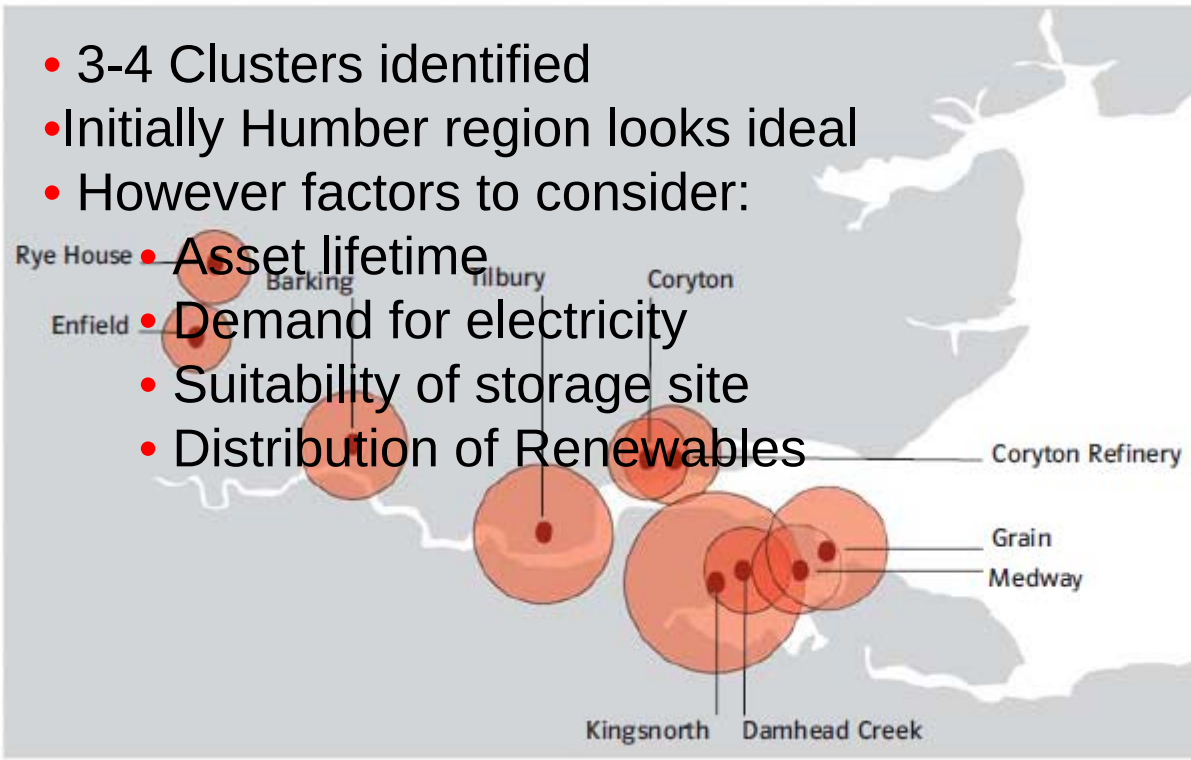
- **A commitment to build a >30MWe facility in Germany ~2014**
- **To test second generation capture technology at scale**
- **With view to commercial implementation circa 2020**

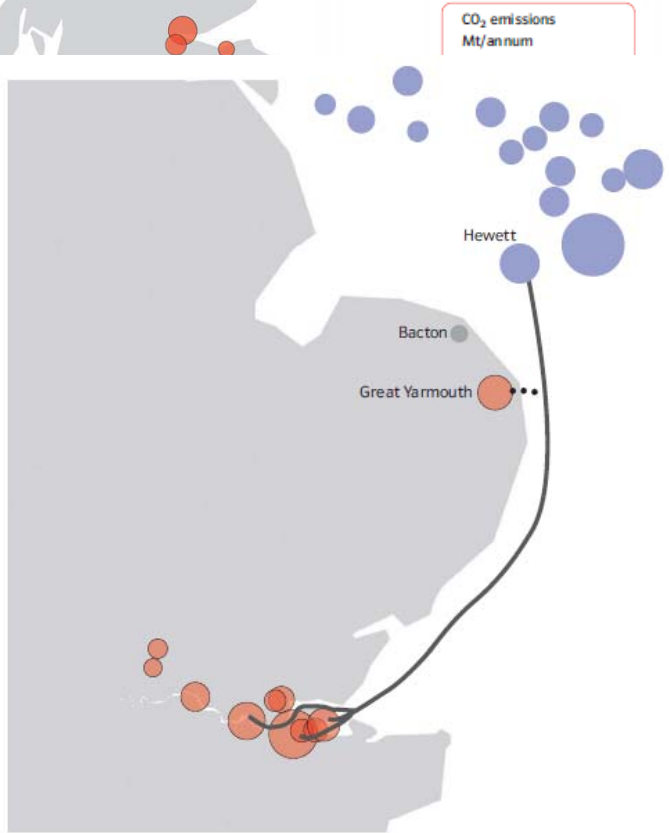
E.ON actively involved in all CCS development

CO2 Clusters – Decarbonising fossil electricity generation

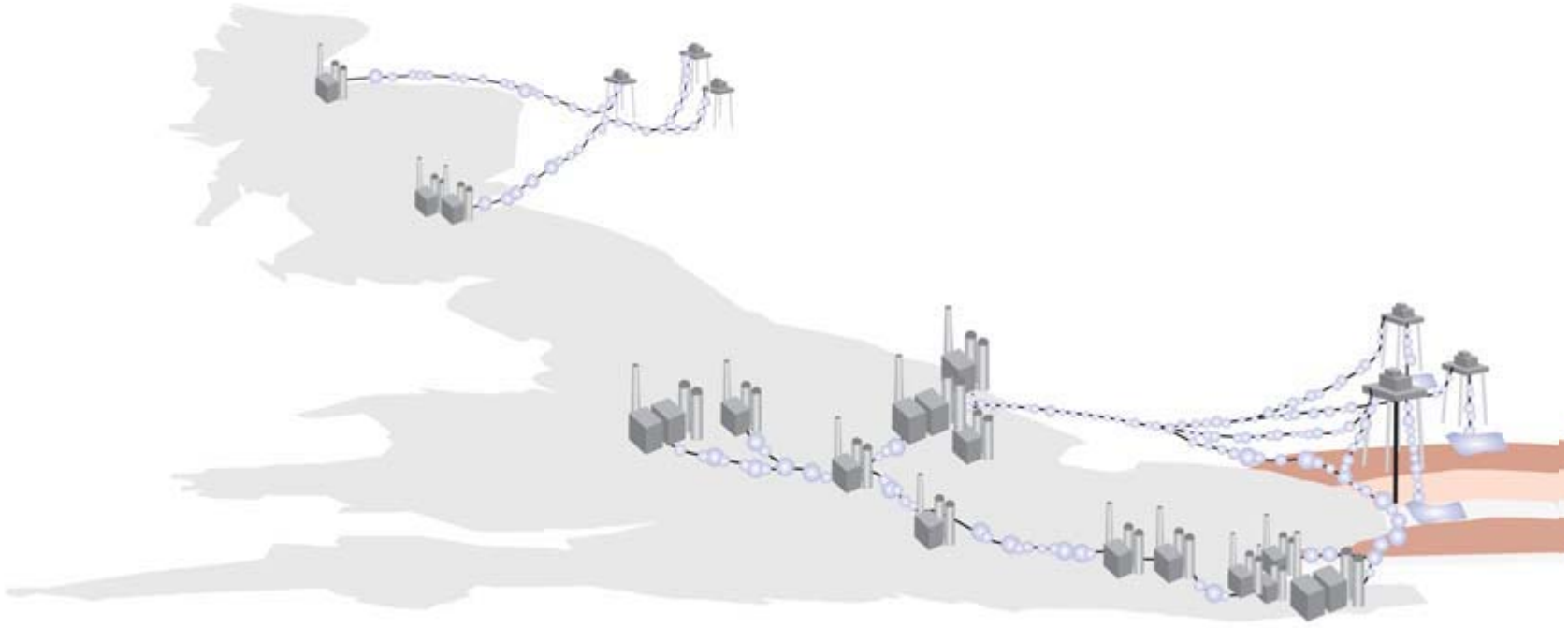


- 3-4 Clusters identified
- Initially Humber region looks ideal
- However factors to consider:
  - Asset lifetime
  - Demand for electricity
  - Suitability of storage site
  - Distribution of Renewables



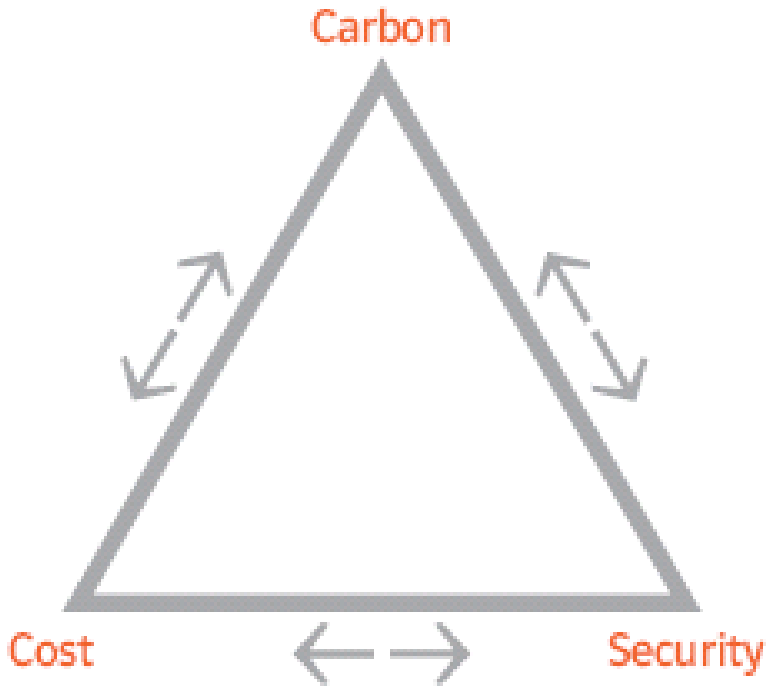


CO2 Clusters – Decarbonising fossil electricity generation



Inland power stations connected to pipeline network

Carbon, Cost and Security – The Trilemma



www.eon-uk.com/generation/carboncostandconsequences.aspx

Given the challenge of climate change, and the need for secure affordable energy supplies, E.ON believes CCS, Nuclear, Gas and Renewable power should all be pursued.