



CO2 storage and disposal technologies

SCI coal CCS conference
London, 7 Nov 2013

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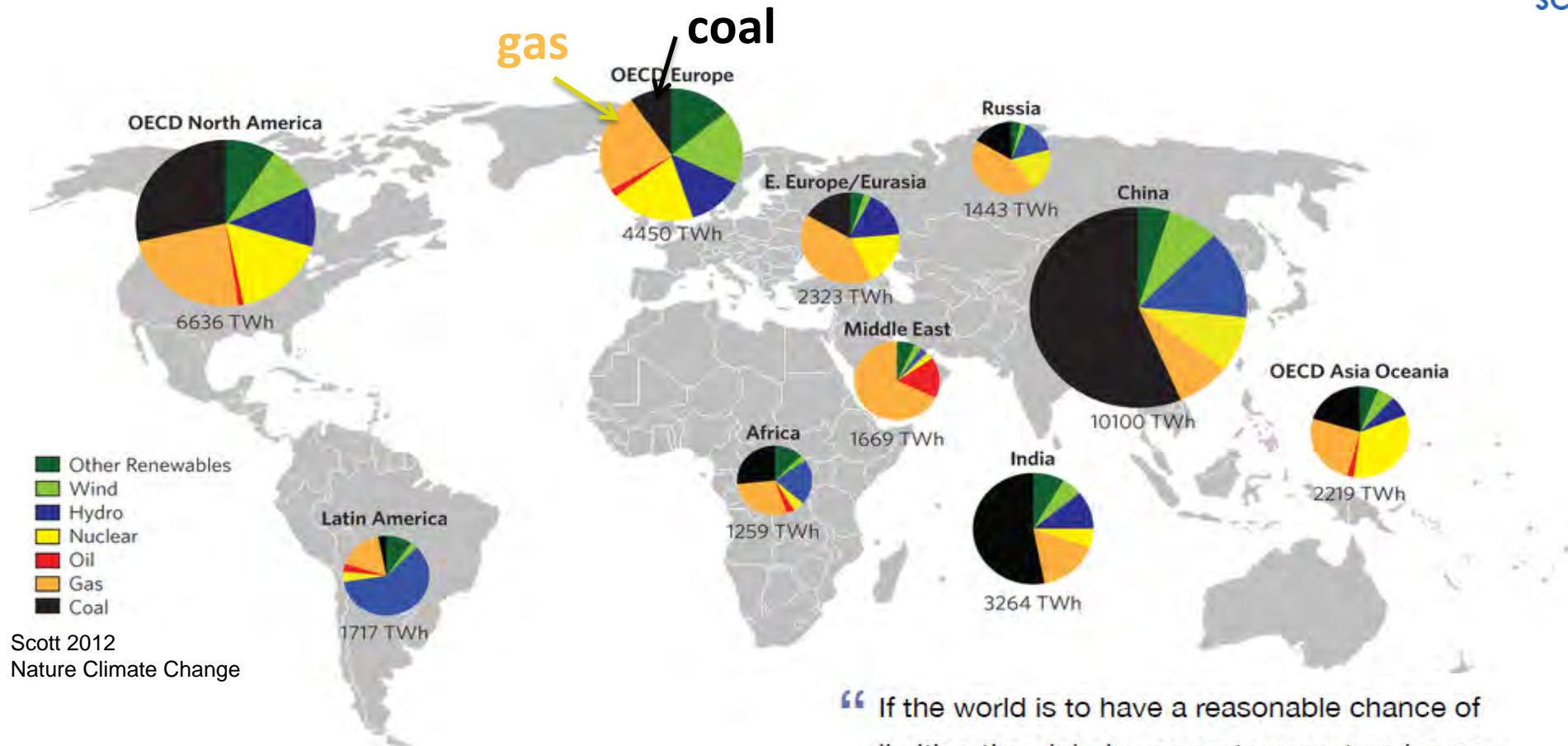
About SCCS



Scottish Carbon Capture and Storage (SCCS) is the largest carbon capture and storage research group in UK universities. We provide a single point for all aspects of CCS research, ranging from capture engineering and geoscience, to public engagement, policy and economics.



The case for coal : view in 2030



Scott 2012
Nature Climate Change

Projected electricity sources in 2030
(International Energy Agency 2011)

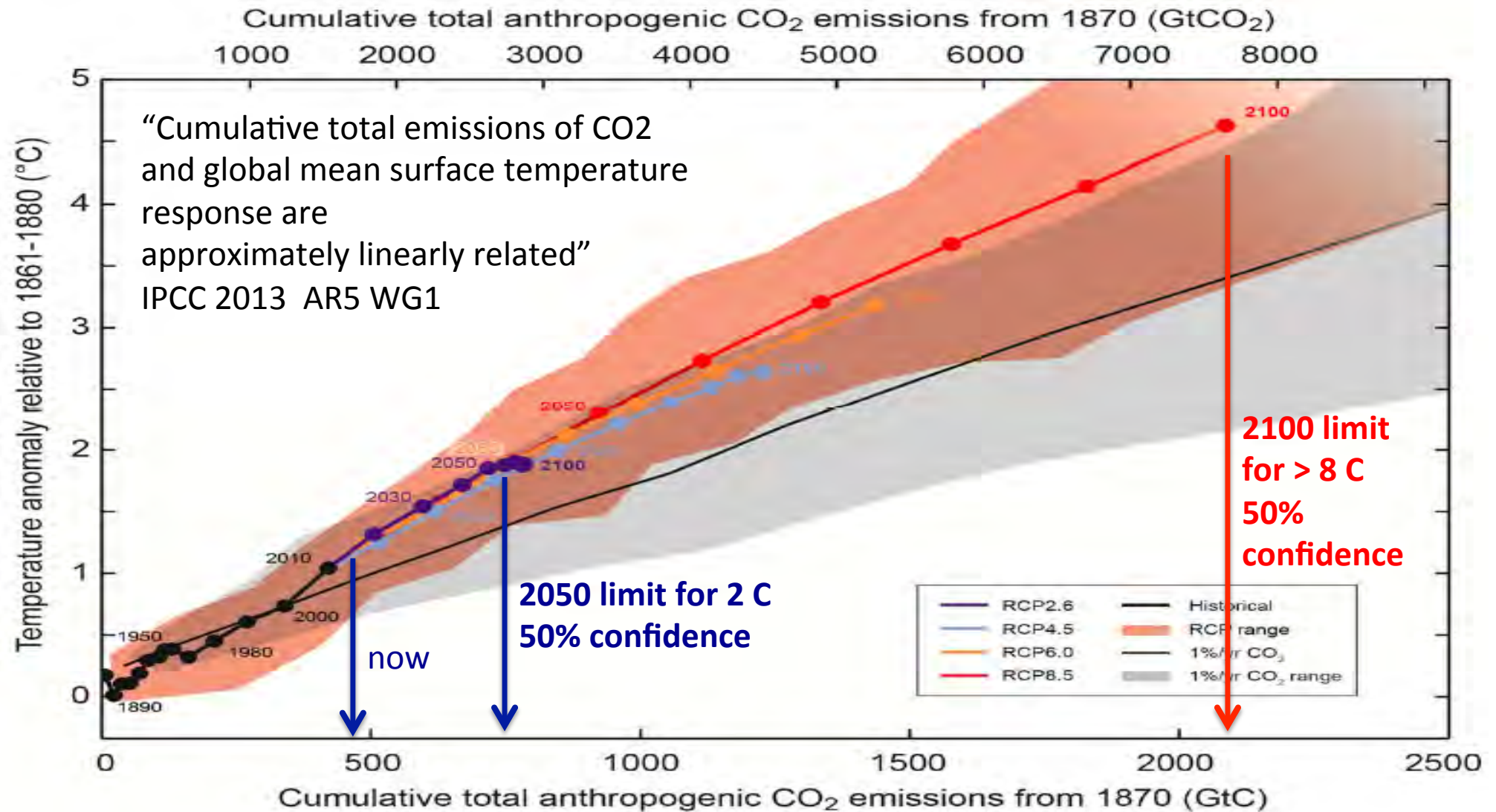
Fossil fuels : coal gas oil
Still supply more than 50% globally, EU 33%

“ If the world is to have a reasonable chance of limiting the global average temperature increase to 2°C ... less than one-third of proven reserves of fossil fuels can be consumed prior to 2050, unless CCS technology is widely deployed.”

World Energy Outlook 2012, IEA

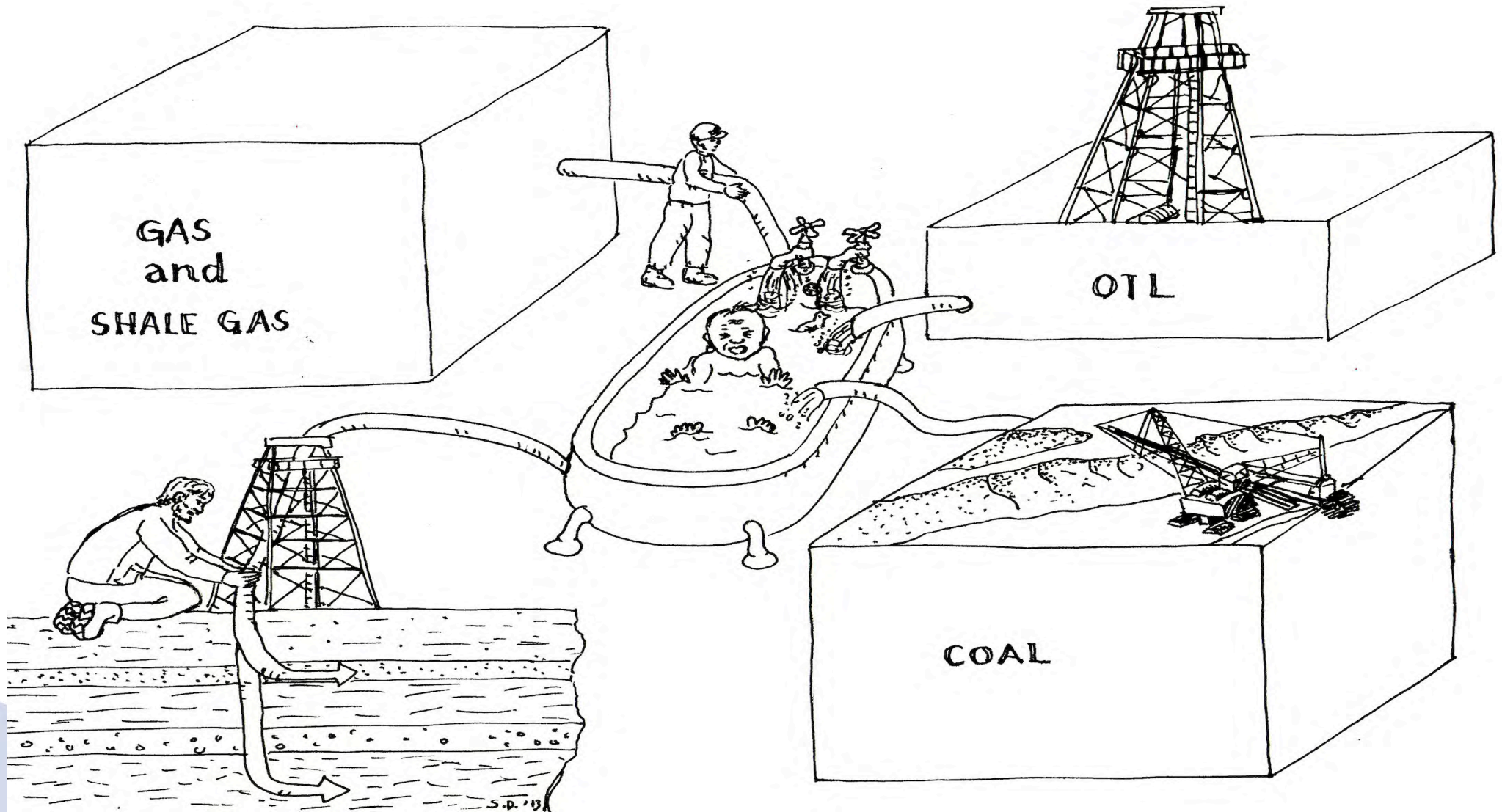
CCS is essential to operation

Too much fossil carbon : IPCC



**TOTAL emissions of fossil carbon have to be contained
Not just the rate of emission**

Too much fossil carbon



**Injecting CO₂ – not ready yet
But needs to be**

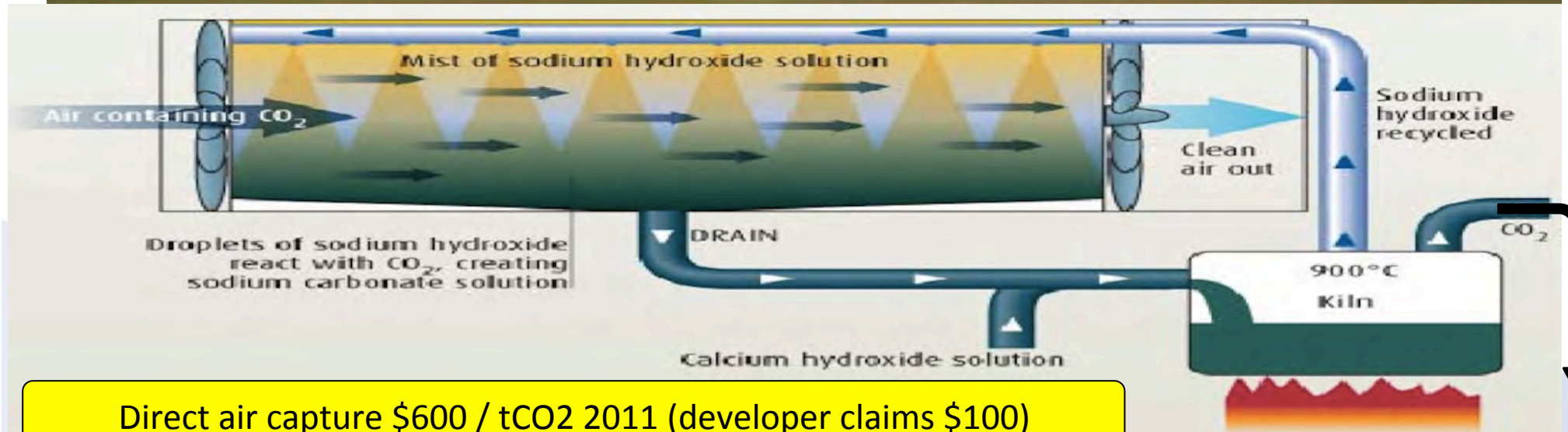
**The world has a finite carbon budget
And that is much less than the available carbon**

Many options for CO₂ disposal

Air capture



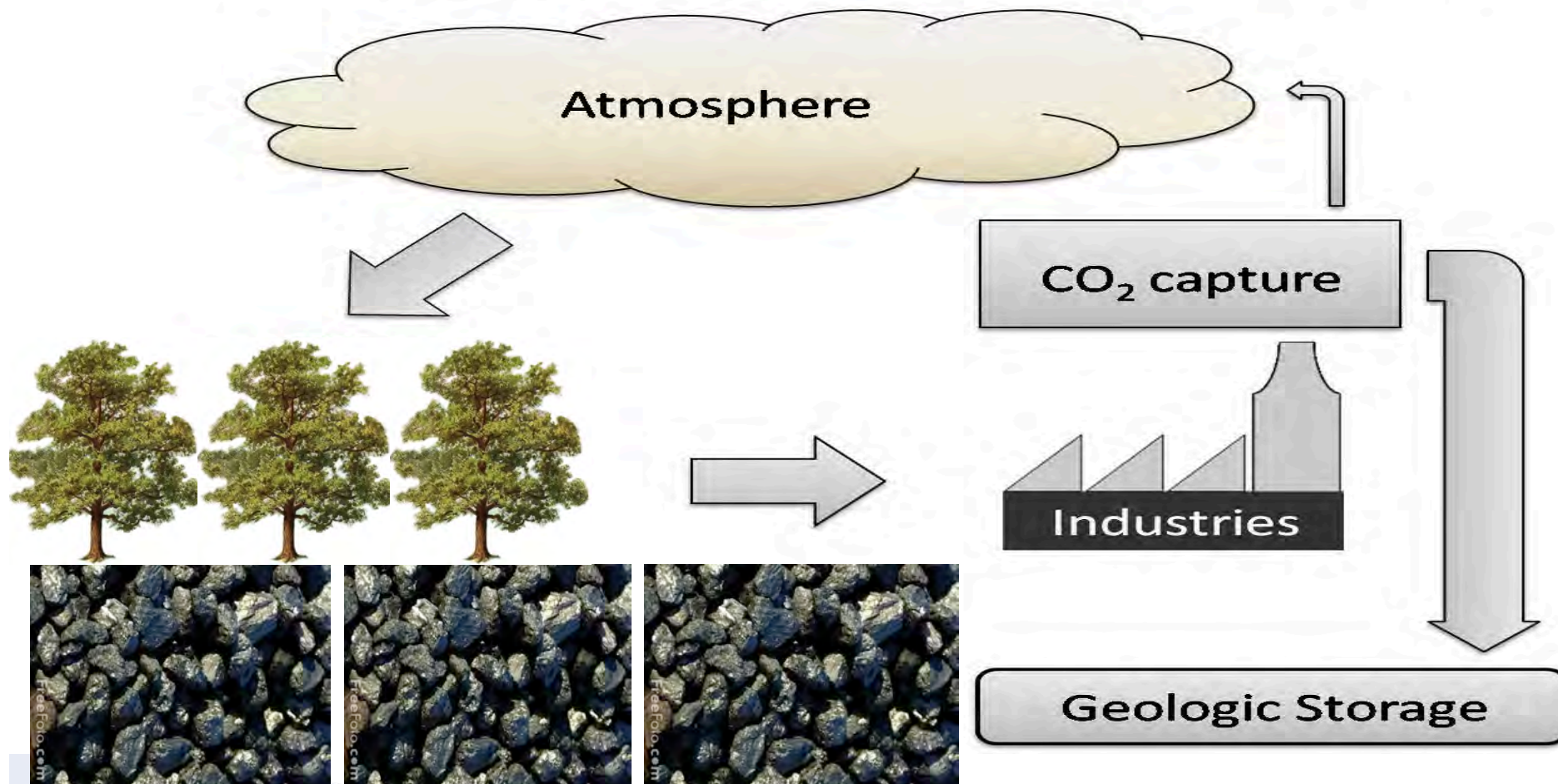
car



Direct air capture \$600 / tCO₂ 2011 (developer claims \$100)

Industrial negative carbon

Bio-Energy with CCS (BECCS) carbon flow



BECCS costs \$100 / tCO₂ 2013

Carbon accounting not clear at large scale

What about coal ?

Political policy is closing in on coal



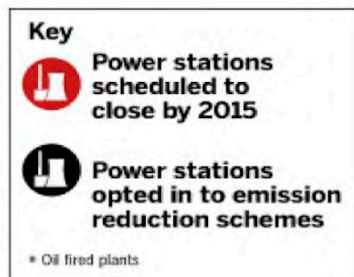
- **Lords vote to limit coal-fired carbon emissions**

- Posted on 05 November 2013 by Priyanka Shrestha - EnergyLive News

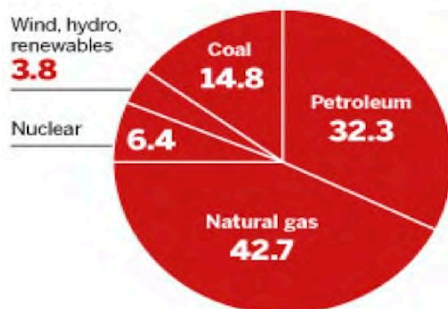
- The House of Lords yesterday voted in favour of forcing coal-fired power plants to cut their greenhouse gas emissions.
- The Government was defeated by the Labour party by 237 to 193 as the Lords agreed to get plant operators to apply the Emissions Performance Standard (EPS) to cut their carbon emissions.
- Power plants using coal, largely considered to be the dirtiest energy source, could upgrade their systems using carbon capture and storage (CCS) in order to avoid reducing their emissions. The amendment supported by the Lords will force all coal powered stations to curb their emissions.
- It will however still need to be considered by MPs who could vote to overturn it when the Energy Bill returns to the House of Commons.
- Shadow Energy Minister Baroness Worthington (pictured), who led the vote, said the EPS is not currently consistent with the UK's decarbonisation objectives.
- She added: "Low coal prices and high gas prices have caused coal stations now to be operating at higher levels than they have ever before. As a result we've seen UK emissions going up and not down and our carbon intensity increasing last year not decreasing. How are we going to hit [our] decarbonisation target if we do not have a tool in our armoury to do something about this issue?"
- She went on: "If we don't take this most obvious, most easy, most simple way of reducing our carbon emissions... we will be forced to adopt more expensive subsidies."
- Energy Minister Baroness Verma however warned the amendment risks "deterring or increasing" the cost of new gas investments as well as increase cost to consumers and risk security of supply.
- She said: "The Government's goal is an orderly transition away from coal to lower carbon fuels over time in a way which does not create unnecessary costs for consumers."
- "While we do not expect large numbers of coal plants to invest in clean-up equipment a very small number of our efficient plants may wish to do so. This amendment is very likely to deter that investment."
- The news to toughen up pollution controls has been welcomed by environmental groups.
- Joss Garman, deputy political director of Greenpeace said: "Cutting carbon pollution from coal burning is the cheapest and most effective way to clean up the energy system."
- Friends of the Earth Head of Campaigns Andrew Pendleton added: "Coal is an out of date technology and it's right that the Lords have voted to rein it in – the House of Commons must adopt the same policy."
- Coal power plant operators are unlikely to welcome the news although many in the UK have already closed plants or at least plan to shut them down

UK Energy Minister Baroness Verma said (5 Nov 2013)

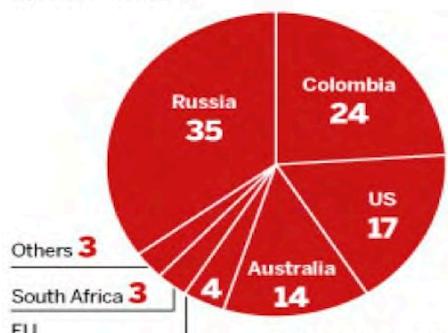
The Government's goal is an orderly transition away from coal to lower carbon fuels over time



UK energy consumption
Energy mix by fuel, 2010 (%)

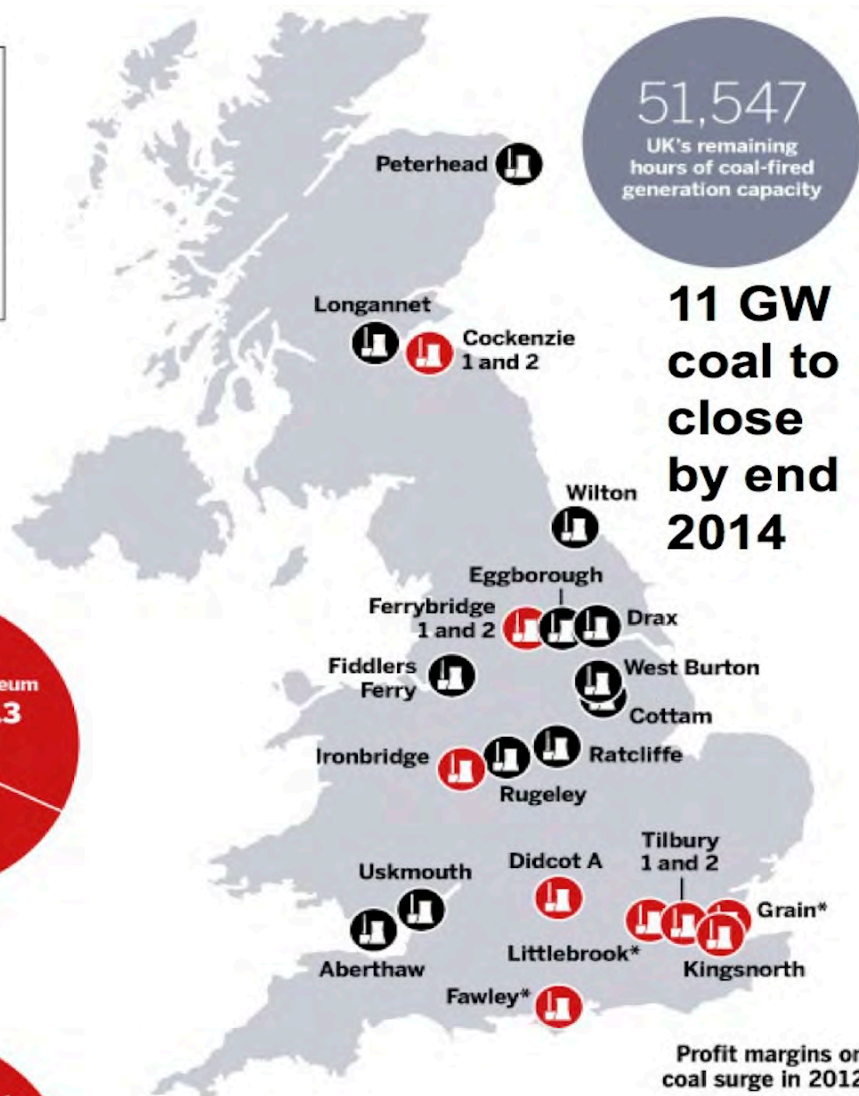


UK coal imports
By source, 2010 (%)



Sylvia Pfeifer Financial Times
11 March 2013

Source: DECC; Elexon; RWE npower

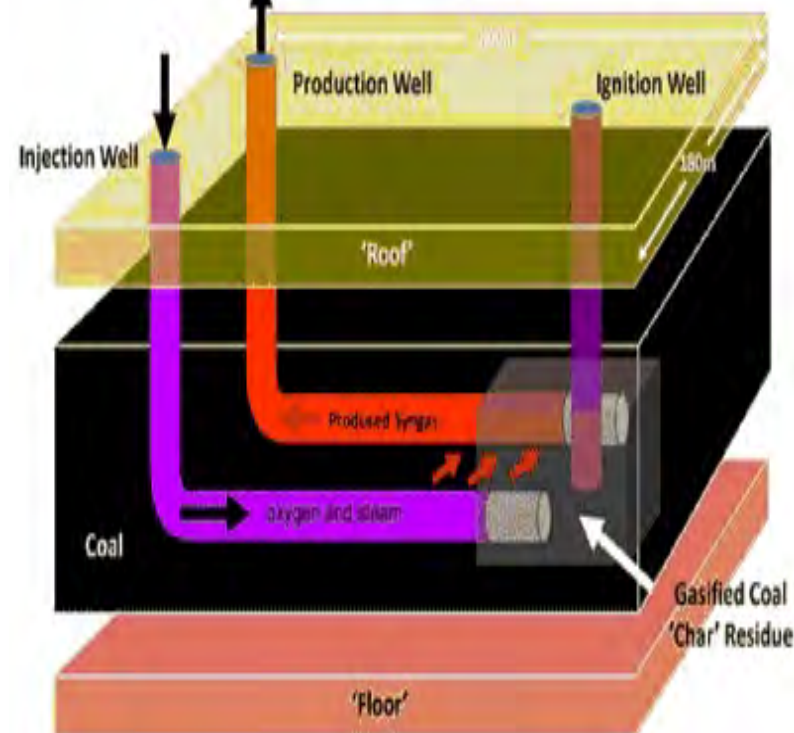


51,547
UK's remaining hours of coal-fired generation capacity

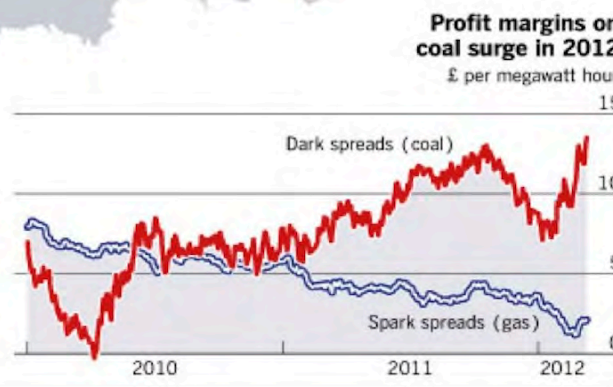
Coal in UK on closure path



UCG future for resource ?

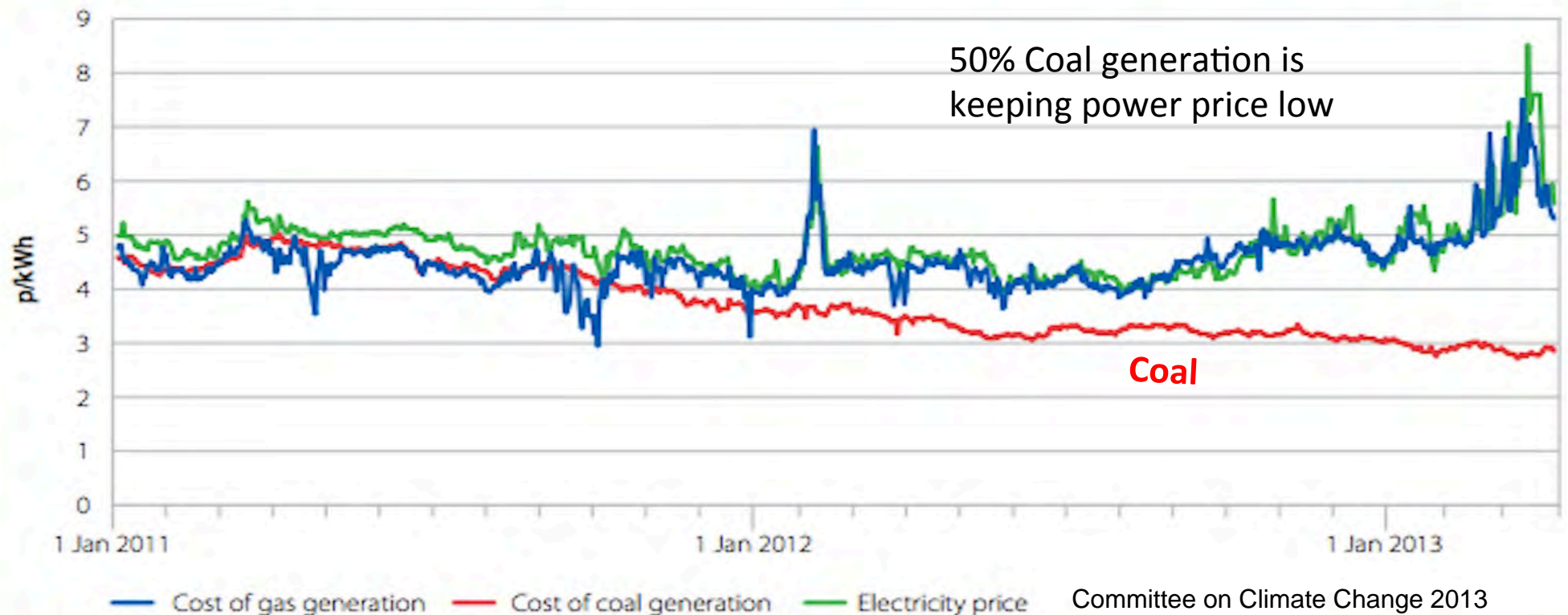


To maintain coal – coal users need to help develop CCS



But coal could reduce power cost

Figure B2.1: Short-run cost of gas and coal generation and electricity price (January 2011 to March 2013)



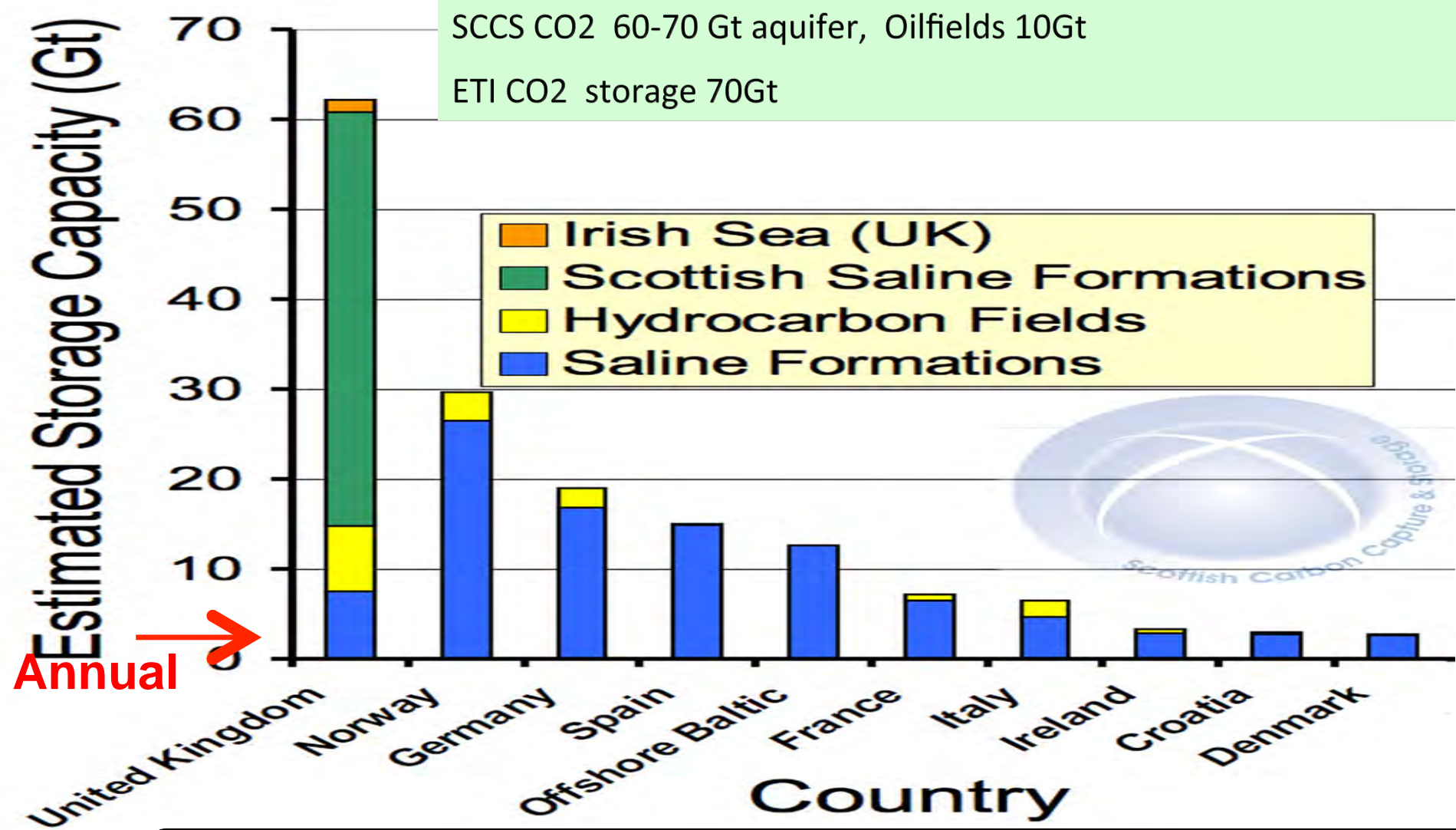
Source: UK Power day-ahead data, WMBA (accessed 9 May 2013); System Average Price data, National Grid (accessed 9 May 2013); Coal ARA data, ICIS, (accessed 12 May 2013); CCC calculations.

Notes: Assumes plant efficiency 49% for gas and 35% for coal (based on average for existing fleet). Carbon intensity 378 g/CO₂/kWh for gas and 1,000 g/CO₂/kWh for gas. Based on day-ahead electricity and gas prices, and coal monthly forward price.

Coal is a fuel with low direct cost : may be attractive if “clean”

Storage resource

North Sea Basin has storage shared by UK, No, Dk, D, NI



UK offshore has 35% of EU CO2 storage

Where is CO₂ storage offshore of UK ?

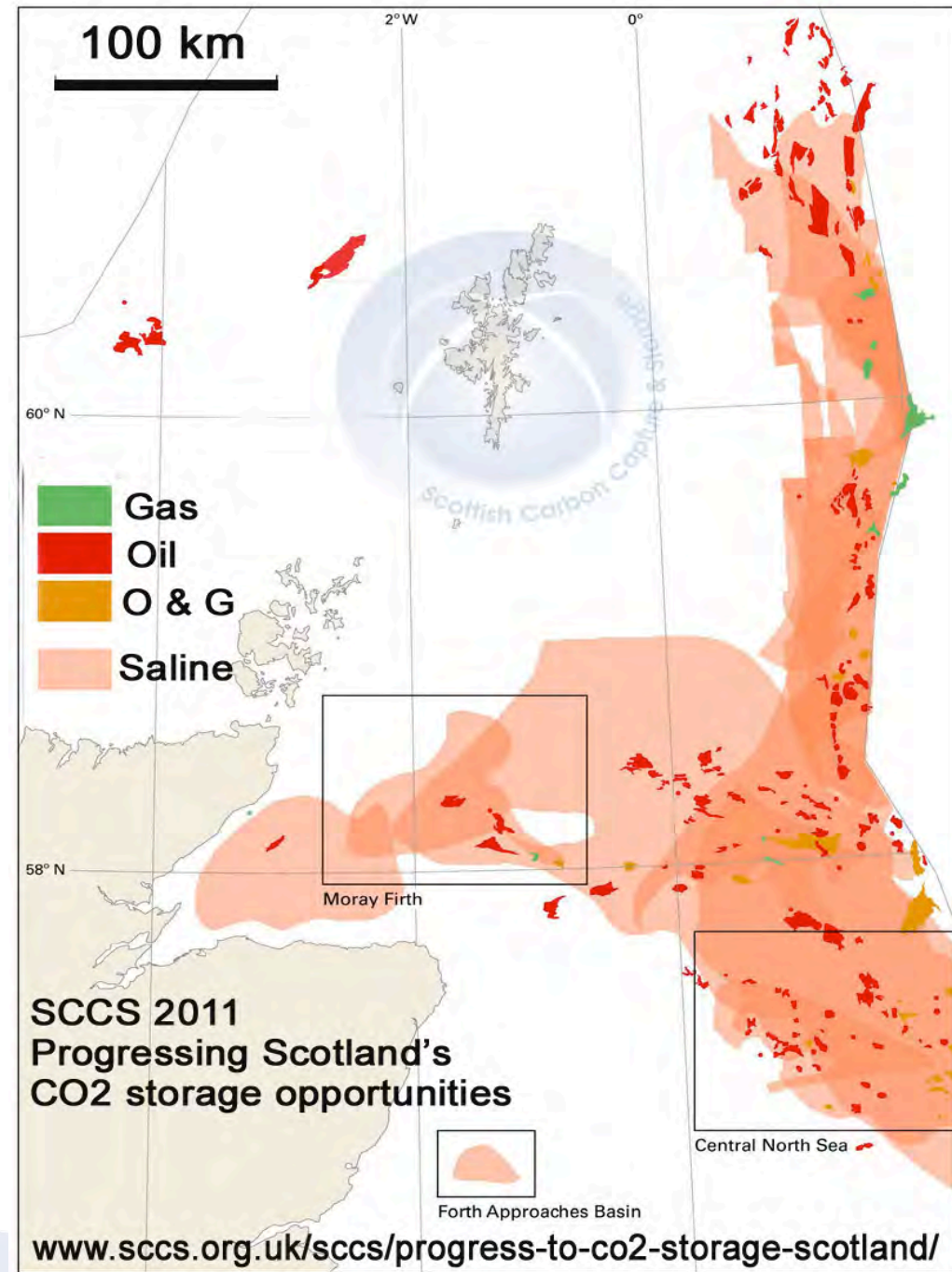
Mapped by SCCS 2009

UK North Sea:

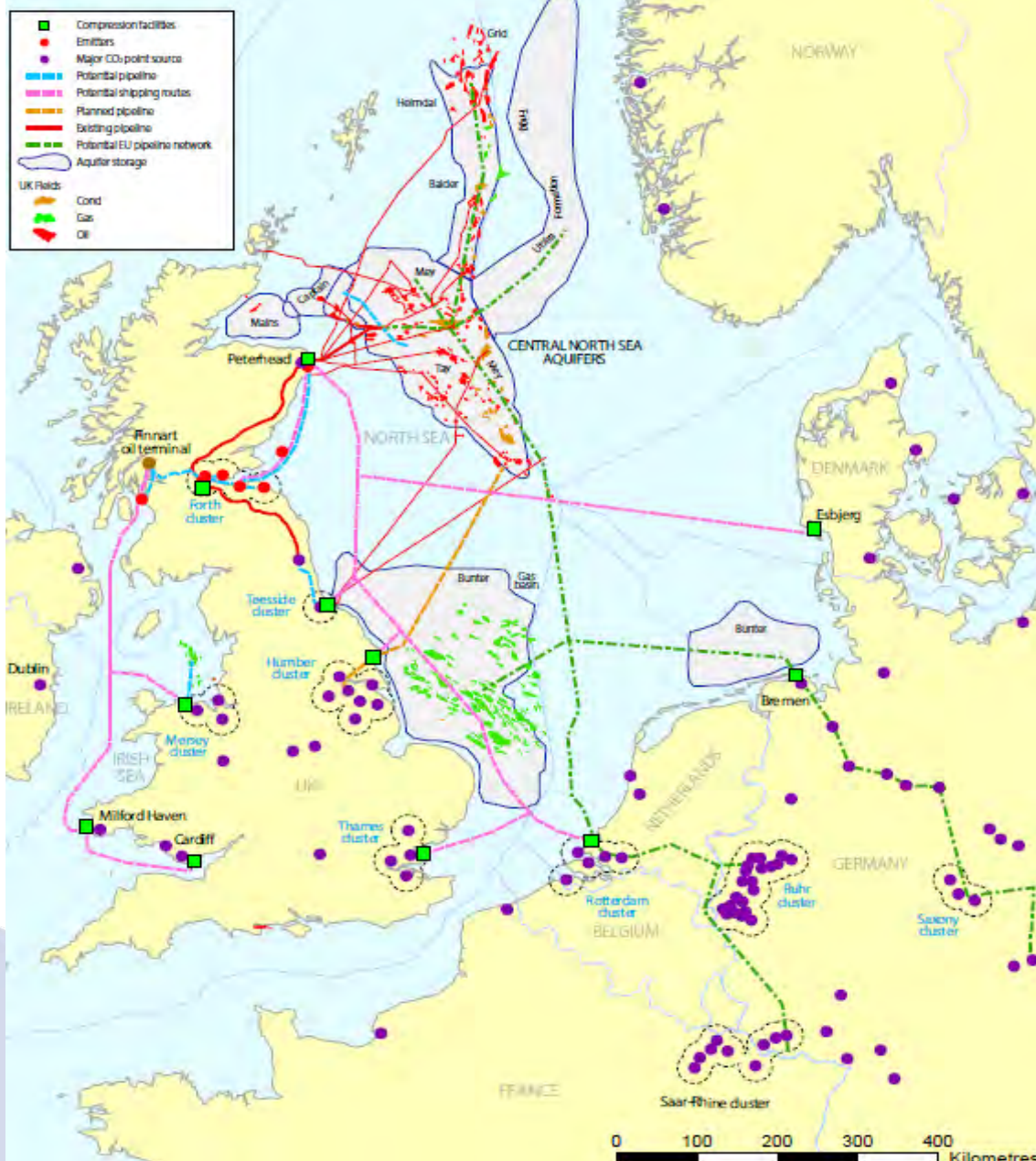
60 - 70,000,000,000 tonnes CO₂ storage

More than 200yr UK power & industry CO₂

35% of EU storage



North Sea CCS network for Europe in 2030s (SCCS)



Vision of 2030 essential
Committed pathway
to
Change potential into
deliverable



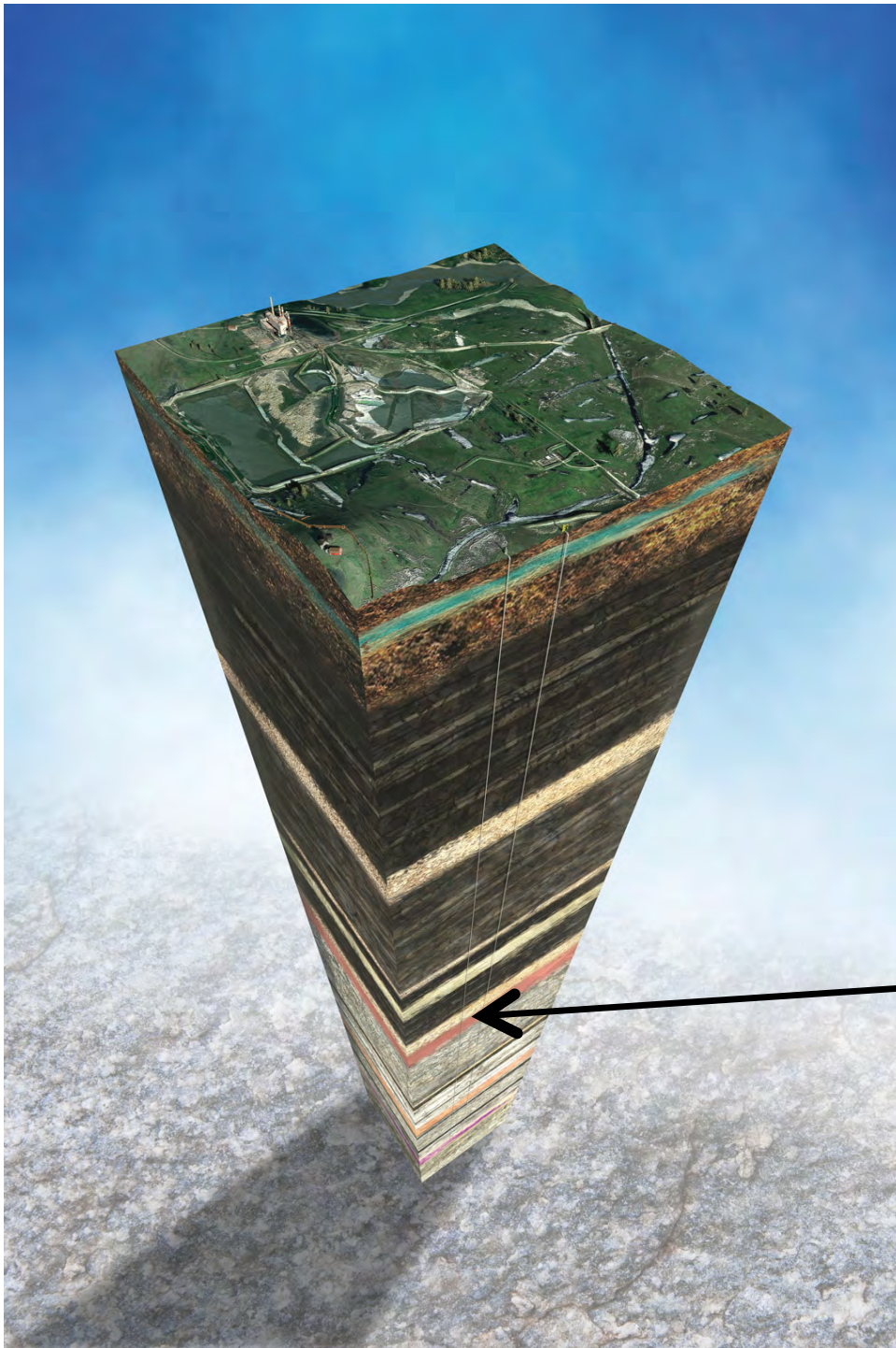
**Power sites in NW Europe
Connected to offshore ex-oilfields
and saline storage**

UK and EU need to
positively support a Plan
Like a renewable ambition

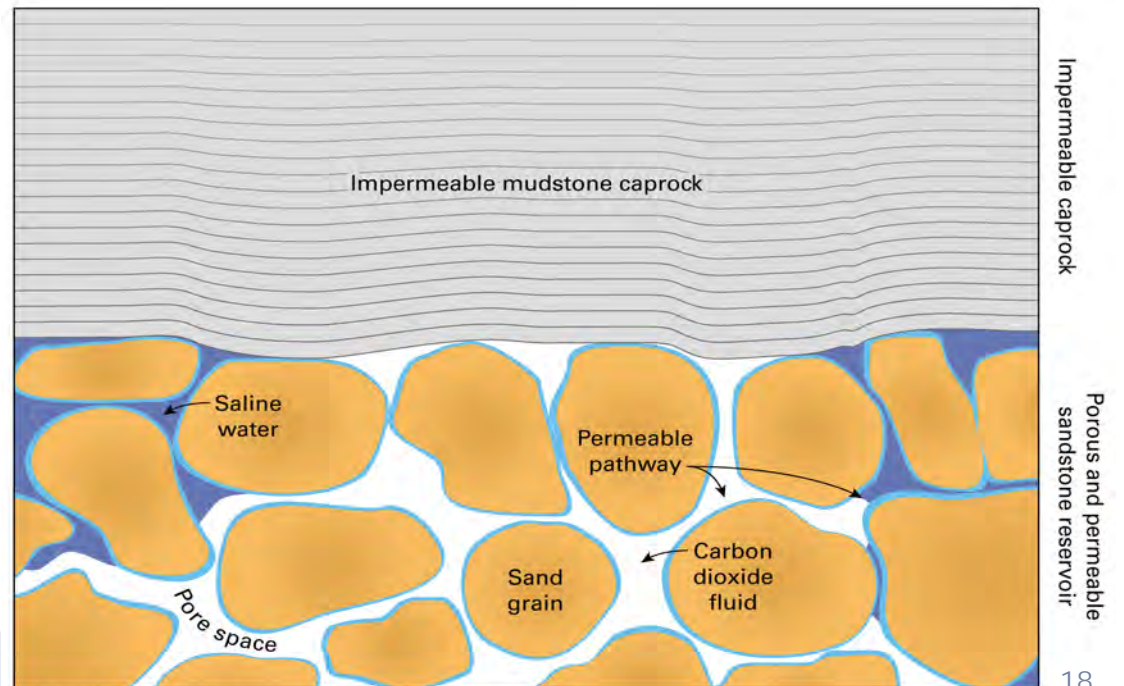
To invent and pilot a new
technology
To become business as
usual

Geological storage

CO2 storage is a long way down

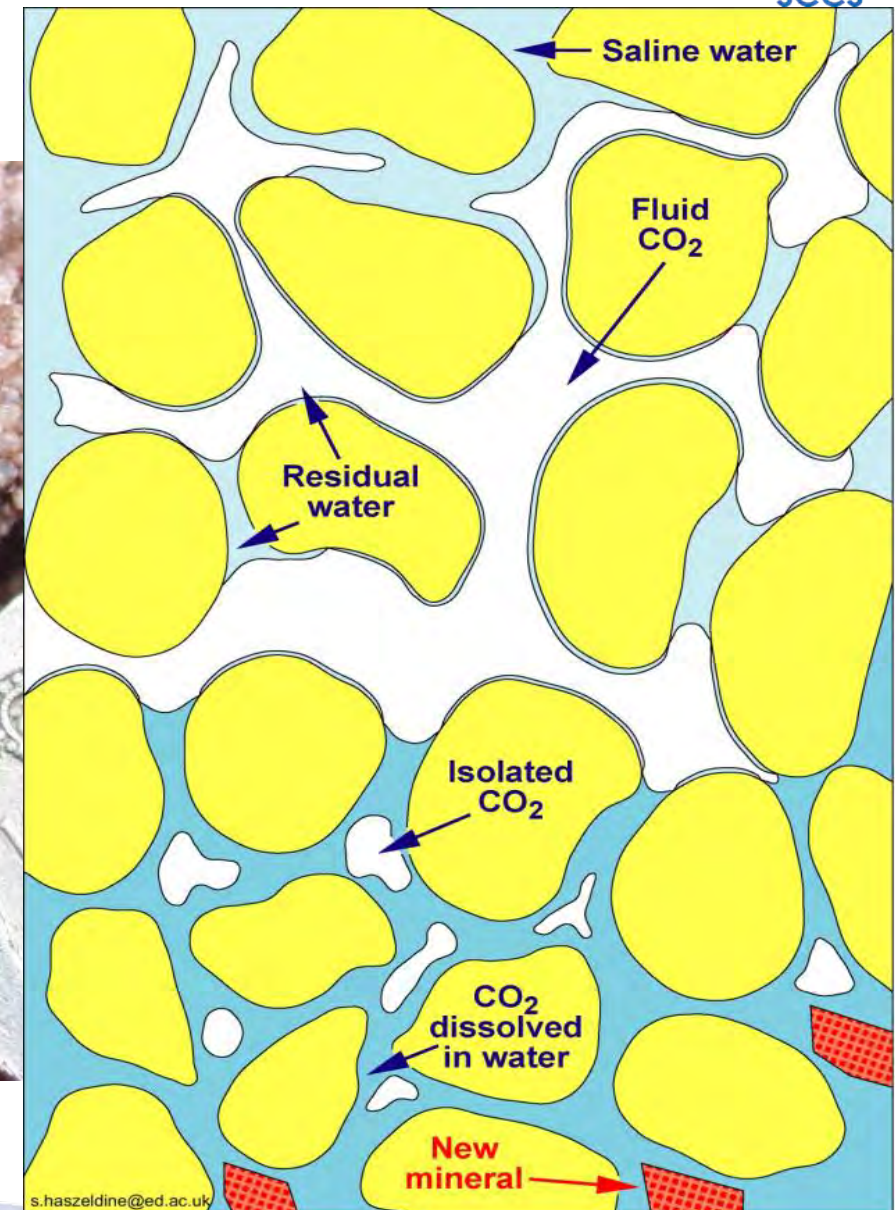


Depth 1 - 4 km
Impermeable SEAL
Overlies
Porous RESERVOIR



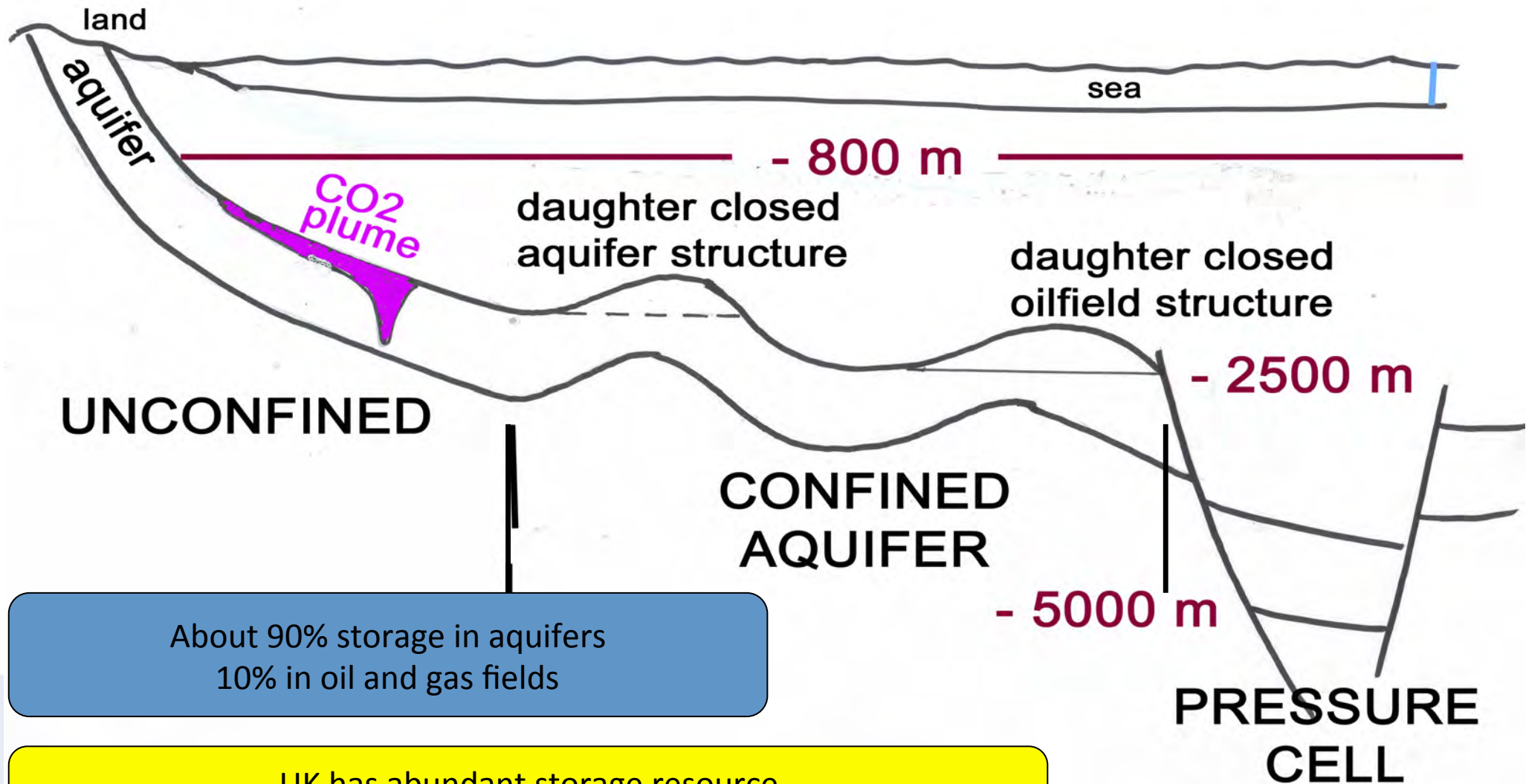
Where does the CO₂ go?

CO₂ fills microscopic pores in sandstone



4 x trapping mechanisms:
physical, soluble, residual, mineral

UK offshore storage: 3 types



About 90% storage in aquifers
10% in oil and gas fields

UK has abundant storage resource
EU Directive: CO2 “permanently” contained

Modelling CO₂ injection – Captain Sst.



Simulation of single well injection for 30 years.



1 year of injection



5 years of injection



30 years of injection



500 years after injection



1000 years after injection



5000 years after injection



Percentage of pore space occupied by CO₂



Then 5,000 years storage.



Improving economics of geological storage



TRANSPORT

Pre-commercial transport – ship - £12 /tonne CO₂

Pre-commercial - pipe - £6 / tonne

Commercial - £ 3 /tonne

INJECTION and MONITOR

Pre-commercial £20 /tonne £ 10-20 / tonne

Commercial - £ 5 /tonne

Premature to
analyse detailed
economics and
prices

Need to know
confirmation of
practical costs to
inject CO₂ at
industrial scale

IMPROVED INJECTION and MONITOR

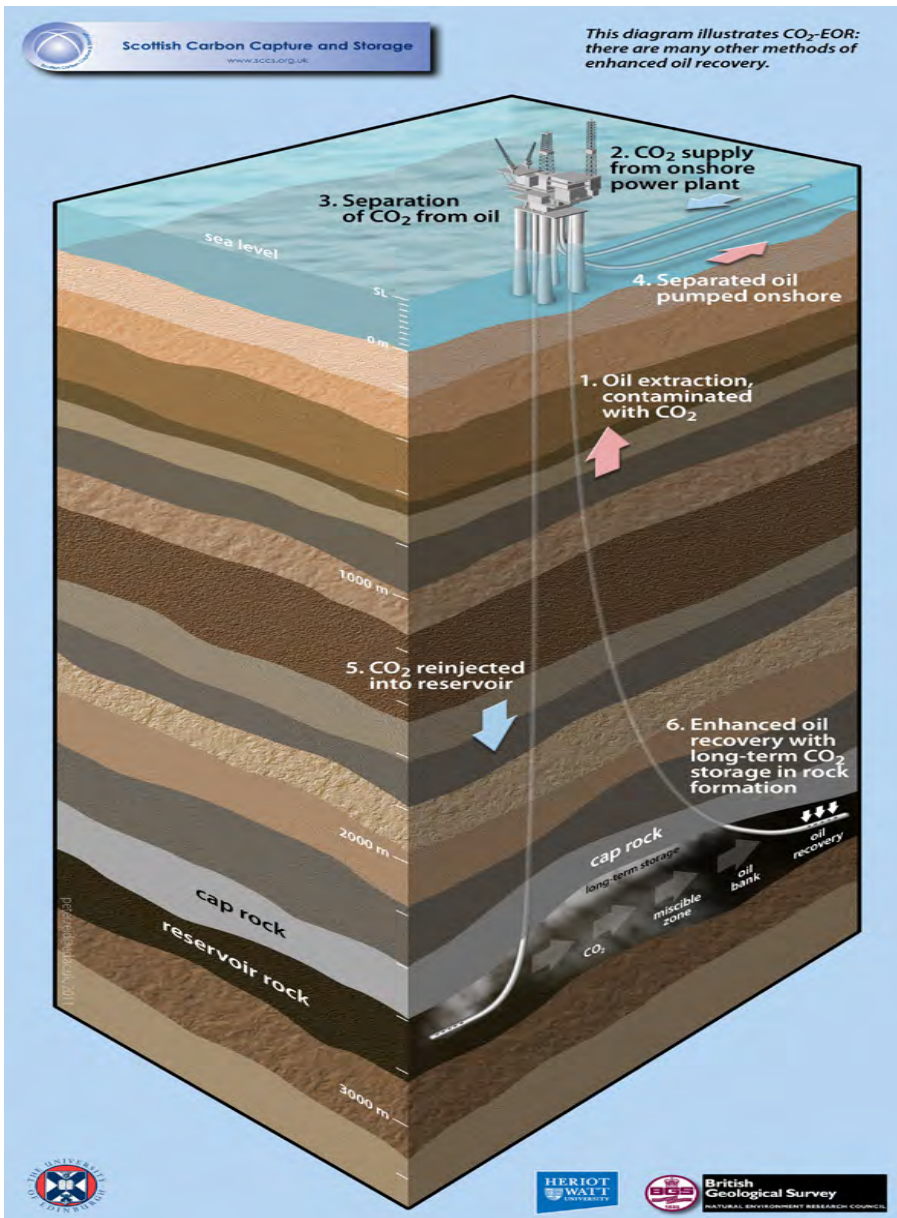
Layered storage £4

Water extraction £ 3 / tonne

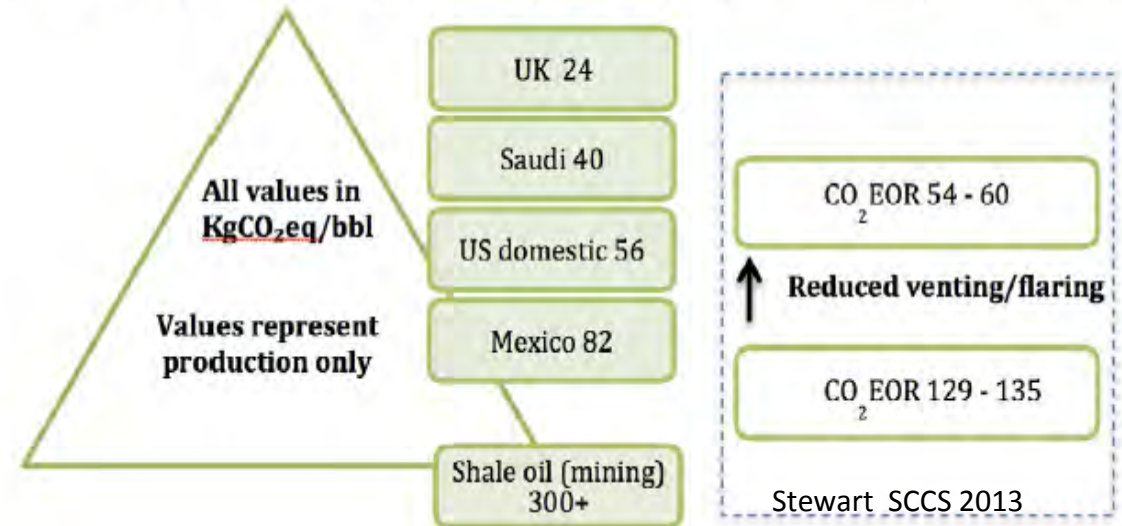
Pre-dissolved £ 2 / tonne

How to get there ?

Establishing CO2 storage : EOR



The carbon intensity of oil sources (adapted from Mangmeechai, 2009)



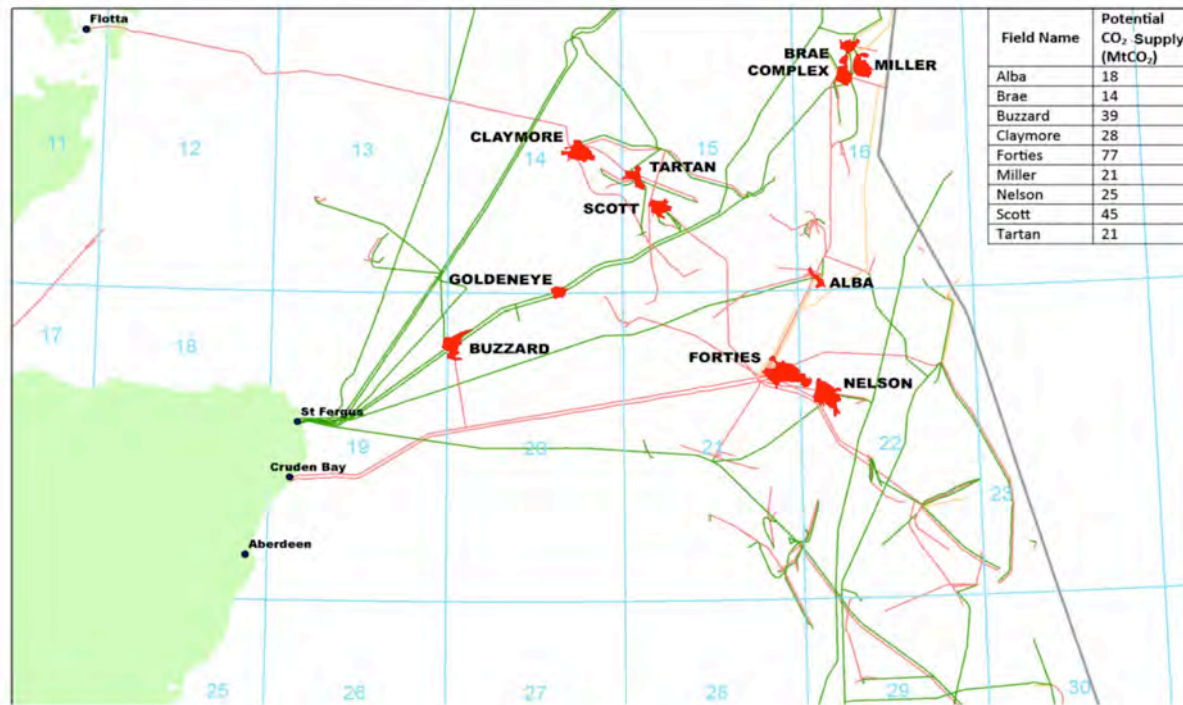
- Enhanced oil recovery – uses CO₂ to produce 10 – 20 % extra oil
- Applies to only 10 – 20 fields in UK and Norway – limited exposure. **Carbon intensity low**
- Will fund new capture, new pipes,
- Needs regulated to ensure carbon stored

ACTION:

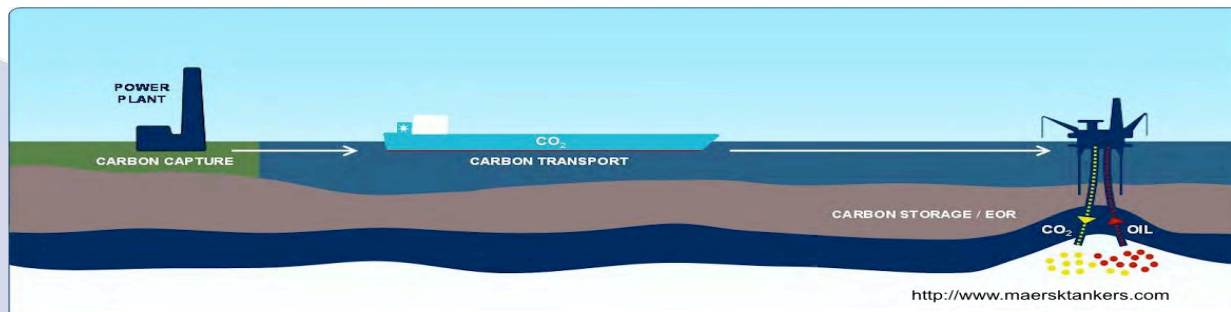
Investigate enhanced oil recovery as method to cost-effectively establishing storage infrastructure.

Transport: connecting source to store

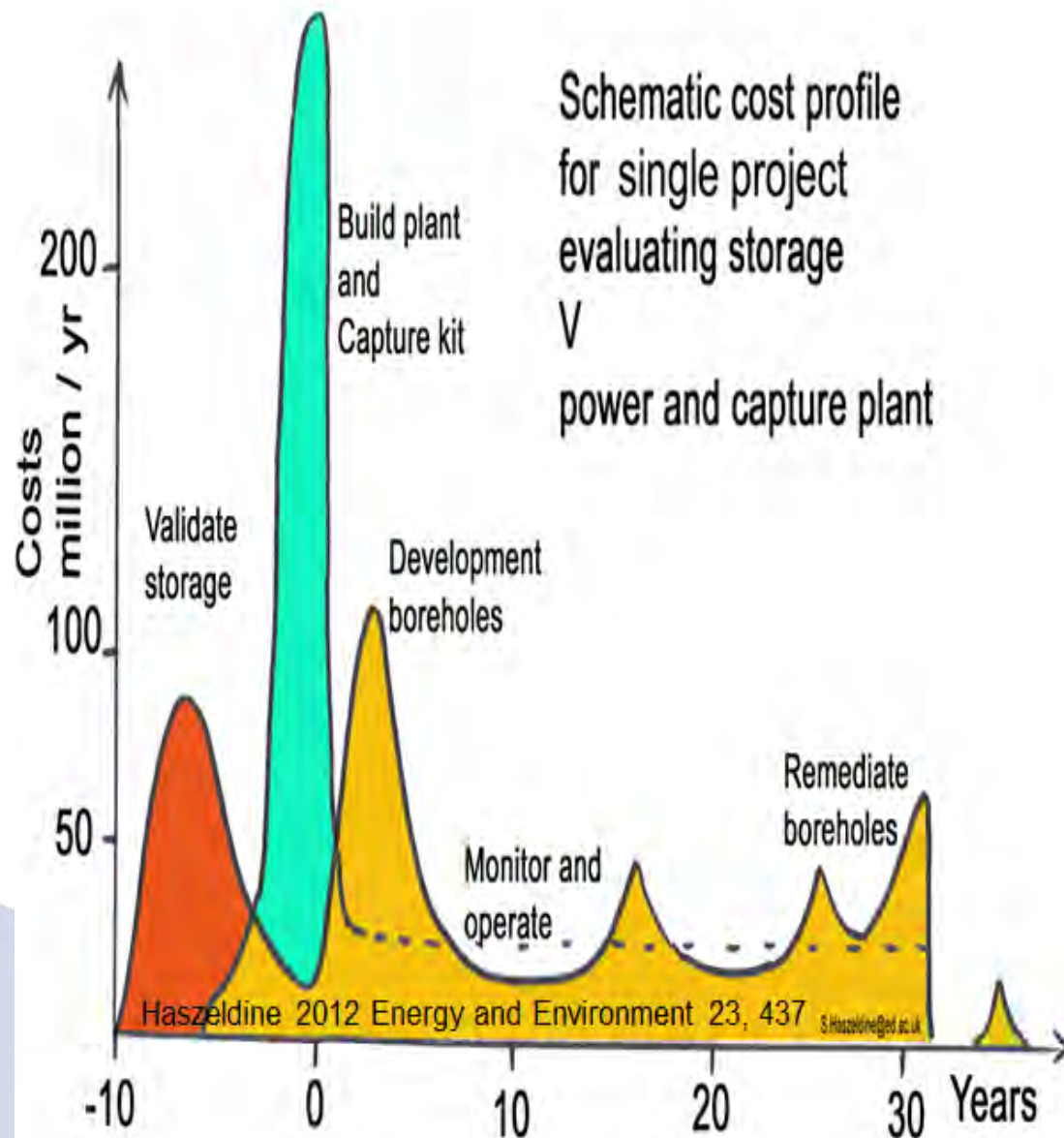
UK Oil Fields with Significant CO₂ Injection EOR Potential and Backbone Pipelines



- Extensive offshore oil and gas infrastructure
- **Add 100km pipe, to access 8 CO₂-EOR prospects**
- Potential for CO₂ shipping to lower-cost access
- Need cross-border permitting for CO₂ transport and storage



Establishing CO2 storage : Saline



- Proving a saline storage reservoir has to be done BEFORE a power plant is built
- Storage is needed for the whole lifetime project at the start
- Learning has to occur early
- 5 to 10 years (oilfield analogy)

ACTIONS:

Six pre-commercial operational CO2 storage sites to validate variety and locations of bankable storage.

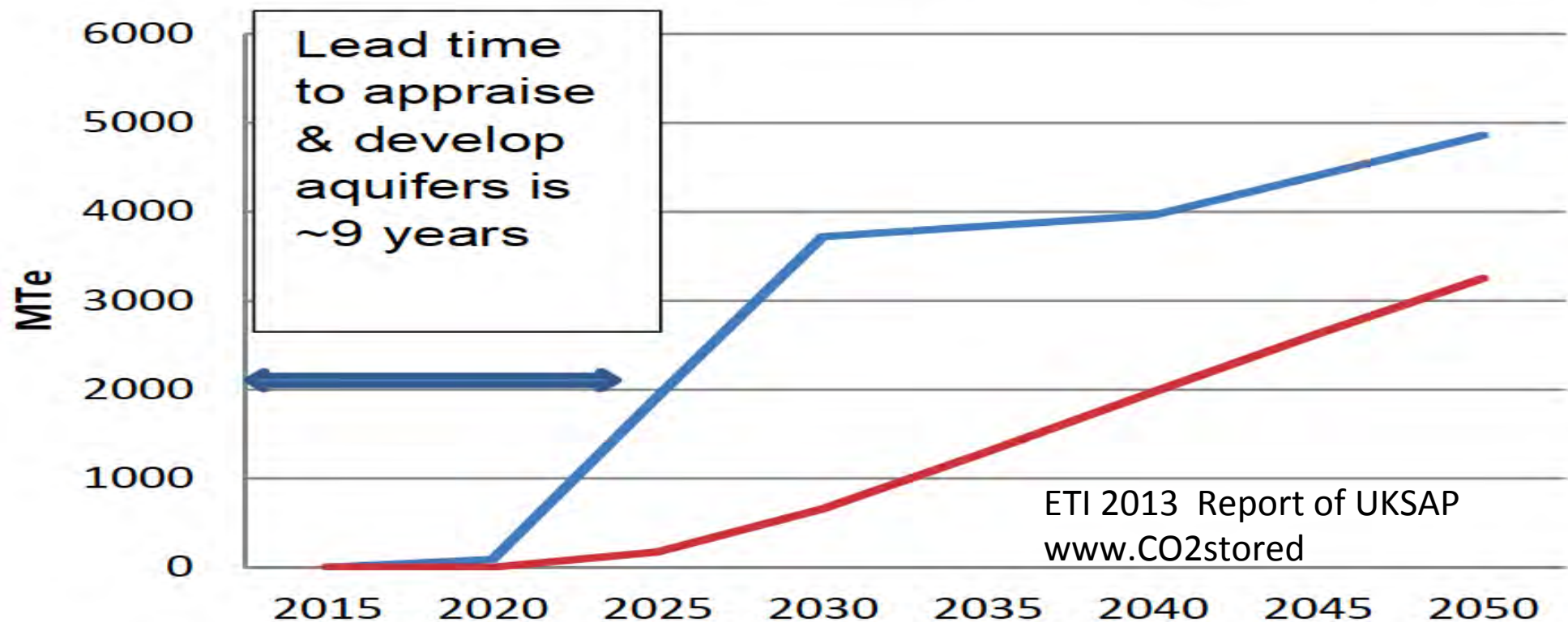
Mediate access to subsurface data for CO2 storage.

Include CO2-EOR

Advance planning for storage: Saline



Storage Requirement



Developing a CCS power or industry project
Requires CO₂ storage BEFORE construction
To a > 99% level of certainty

CCS is starting – in Canada

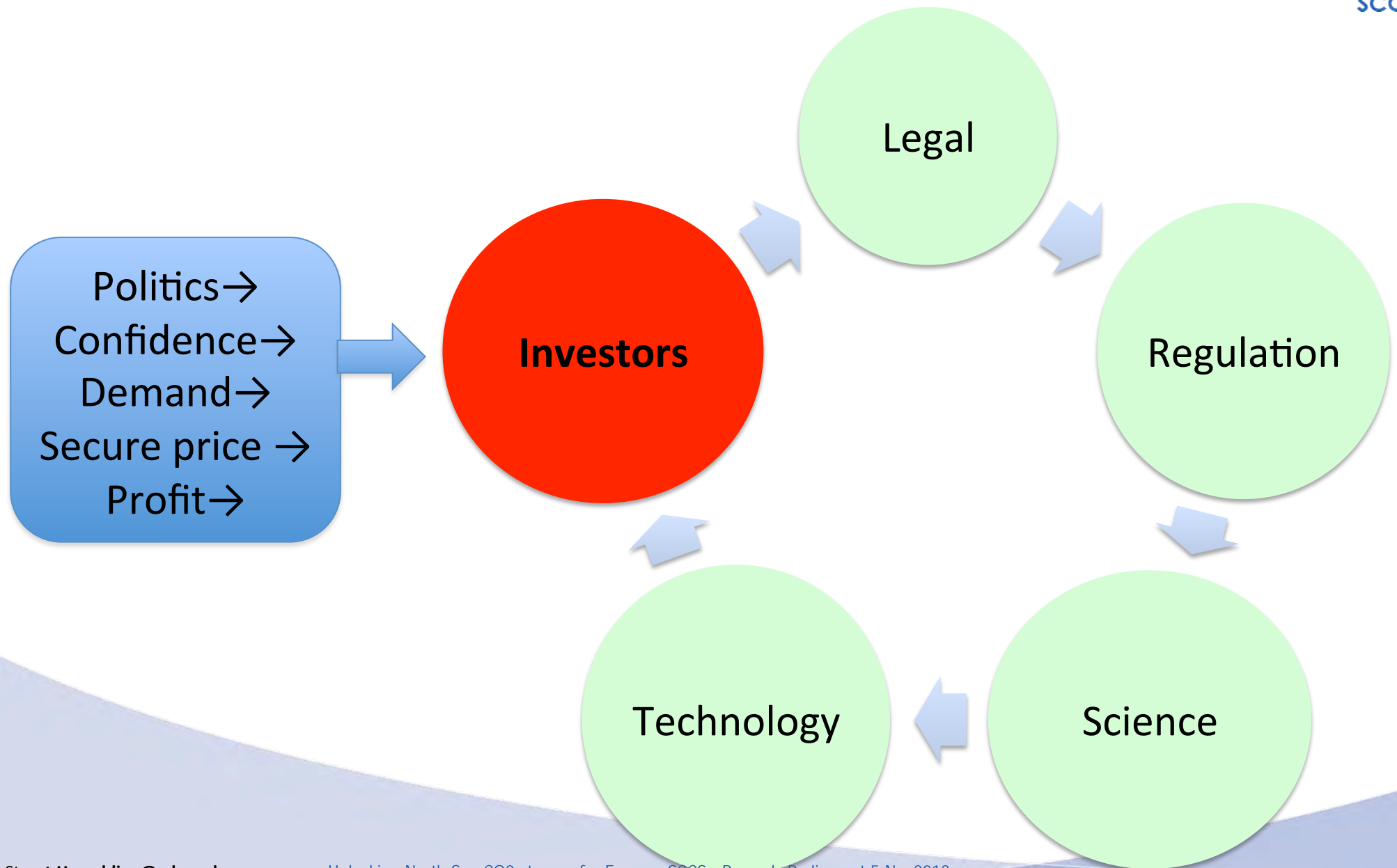


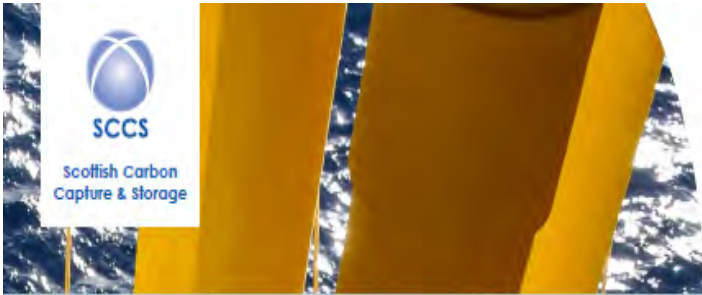
Boundary Dam CCS in Saskatchewan (left) on a new lignite fuelled power plant. Ready in late 2013. Provincial monopoly state funded utility

Is constructing a 150MW CCS system (right), where 1 Mt/yr CO₂ captured. 90% will be sold for EOR, and 10% to aquifer storage



UK and Europe CCS – ready to go... almost





SCCS Recommendations and Conference 2013 Report

Unlocking North Sea CO₂ Storage
for Europe: Practical actions for
the next five years



Summary



- Coal is an abundant fuel. But its combustion is limited scientifically by global carbon budget
- There are many options to reduce, or to capture, CO₂ emissions. CCS is least cost
- CO₂ storage has lasting value for the UK, EU or nation. Capture can be bought-in.
- The UK, EU and USA are facing against new coal power with unabated emissions
- Injection of CO₂ for geological storage is scientifically proven, and now needs deployed
- If the coal industry wishes a renaissance, it has to help by being part of the solution

Full report:

www.sccs.org.uk/unlocking-north-sea-report



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