

BIEE Seminar

# The Energy White Paper: An Academic Critique

BERR, 25th September 2007

## CARBON CAPTURE AND STORAGE

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**UK CARBON CAPTURE AND STORAGE CONSORTIUM**

**<http://www.ukccsc.co.uk>**

*But all marks are entirely subjective and personal!*

*Even with second marking!*

# Objective Performance Measures for candidate D. Berr

	EWP2003	EWP2007
Carbon capture	8	57
CCS	12	134
CC+CCS	20	191
Renewable	217	502
Coal	79	158
Clean coal	1	3
Nuclear	55	435
Renewable/(CC+CCS)	10.9	2.6
Coal/(CC+CCS)	9.9	2.8
Nuclear/(CC+CCS)	2.8	2.3
Renewable/Nuclear	3.9	1.2

*Better than last attempt but still room*

*for improvement  
5/10?*

*Generous for  
this section?  
But OK!*

We are committed to enabling the development of low carbon fossil fuel fired power generation:

### National actions

- We committed in the Budget in 2007 to launch a competition to support the commercial-scale demonstration of CCS.

When operational, this will make the UK a world leader in this globally important technology.

Demonstration will enable the technology to be proven and will contribute to the roll out of CCS on a national and international basis. *Check later ...*

- To support the potential deployment of CCS we will be launching a consultation on the options for the regulation of the full chain of CCS technologies later this year. ✓

- We will be awarding contracts shortly to the successful prototype projects under the Carbon Abatement Technology (CAT) strategy to develop technologies for fossil fuel use that abate emissions. ✓ *Generous here, but extenuating circumstances (EU state aid rules etc.)*

- Later this year we will launch a consultation on the issue of capture readiness in future applications ✓ for consent under Section 36 of the Electricity Act.

*Is this worth a second mark? Repeat of point 2?!*

## International actions

- We will publish our joint study with Norway on the infrastructure needed to transport and store carbon dioxide below the North Sea in July 2007. ✓
- We will work with the European Commission and other Member States on an EU strategy to develop CCS for new fossil fuel power stations by 2020, if technically and economically feasible to do so. *? check*
- We will continue to promote the reform of international regulations affecting CCS. *Bonus here for excellent recent progress* ✓
- We are actively pursuing recognition of CCS in Phase II of the EU Emissions Trading Scheme and full inclusion within the scheme beyond 2012. ✓
- Work on Phase I of the Near Zero Emissions Coal project in China is underway, as is dialogue with other countries on the demonstration/deployment of CCS. ✓

*Pass, obviously simple just arithmetical slip ?*

CCS demonstration in the UK could save **0.25 -1.0 Mt/yr** of carbon by 2020 (depending on the size, technology and the number of demonstration power stations built).

*Worrying though, would expect candidate to notice order-of-magnitude error at this level*

Following the 2007 Budget announcement, the Government is engaged in designing a competition framework for the UK CCS demonstration. Our intention is to launch the competition in November 2007. We recognise that individual companies will incur significant costs to participate in the competition. The Government is therefore committed to regular progress meetings with project developers and publication of competition details as they are decided. We will hold early discussions on the timetable for the competition including the relative merits of a one or two phase competition. The criteria against which proposals will be assessed are likely to include the need for any project proposal to:

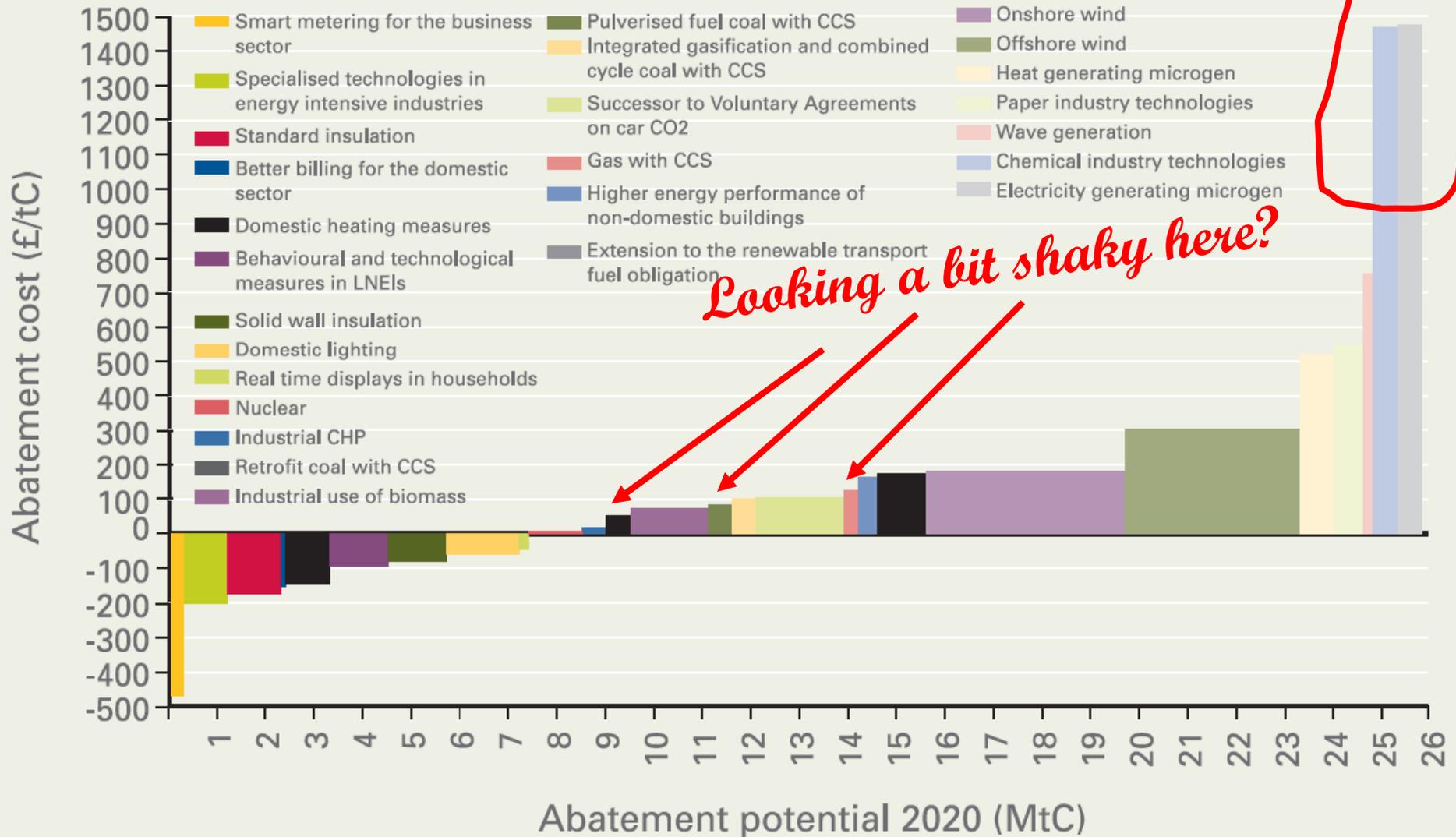
- be located in the UK;
- cover the full chain of CCS technology on a commercial scale power station (capture, transport and storage);
- be based on sound engineering design (reliable and safe) underpinned by a full front-end engineering and design study;
- set out the quantum of financial support requested;
- be at least 300MW, and capture and store around 90% of the carbon dioxide and thereby contribute at least an additional 0.25 Mt/yr of carbon savings to the UK's domestic abatement targets (relative to a gas-fired power station of equivalent size without CCS);
- start demonstrating the full chain of CCS at some point between 2011 and 2014;
- address its contribution to the longer term potential of CCS in the UK, (for example, through the potential of shared infrastructure) and to the international development of CCS; and
- be supported by a creditworthy developer entity.

*But is it just one project, or more – CCS isn't just one technology!*

*This will rule out any plant flexibility if they keep it in*

*Looks OK?*

FIGURE 10.2. MARGINAL ABATEMENT COST CURVE 2020



Under the central fossil fuel price assumptions published alongside this White Paper, each technology or policy option was compared against a counterfactual in order to calculate its carbon abatement potential – for example, in the case of electricity generation, the alternative source of generation was assumed to be a new combined cycle gas turbine (CCGT) station. For energy efficiency and transport options, assumptions were made about the fuel displaced and their associated emissions.

*OK here .... maybe they know what they are talking about?*

The curve should not be taken as a prediction of the exact volume of carbon abated from each technology or policy, since the precise impact of policies, and the timing of the entry and cost of a new technology, are both subject to some uncertainty. This is particularly true for emerging technologies, such as Carbon Capture and Storage (CCS), which is yet to be developed on a commercial scale.

*Does candidate understand implications of counterfactual choice?  
And difficult to get all relevant factors into economic assessment!*

*(checking marking scheme against another paper – see comments over)*

# AN ENERGY POLICY FOR EUROPE

10 January 2007 [http://ec.europa.eu/energy/energy\\_policy/index\\_en.htm](http://ec.europa.eu/energy/energy_policy/index_en.htm)

**To provide global leadership, the EU must provide a clear vision for the introduction of CCS:**

- **Regulatory framework (including EU ETS)**
- **More and effective research**
- **International action**
- **By 2020 all new coal-fired plants should be fitted with CCS**
- **Existing plants should then progressively follow the same approach**

**The Commission will in 2007 start work to stimulate construction and operation by 2015 of up to 12 large scale demonstrations of sustainable fossil fuel technologies in commercial power generation in the EU25.**

**The Commission will assess .. whether, if not equipped with CCS, new coal- and gas-fired installations are prepared for later addition of CCS technologies ('capture ready'). If this turns out not to be the case, the Commission will consider proposing legally binding instruments as soon as possible, after a proper impact assessment.**

*Candidate E. Union looking good, but evidence of copying?* ✓

# EU ENERGY SUMMIT: A NEW START FOR EUROPE?

<http://www.euractiv.com/en/energy/eu-energy-summit-new-start-europe/article-162432>

Published: Tuesday 13 March 2007 | Updated: Friday 29 June 2007

**The European Council on 9 March 2007 backed Commission proposals on energy and climate change, agreeing on an action plan to put in place a European energy policy by year 2009. The most significant progress was achieved in the following areas:**

## **Greenhouse-gas reduction:**

- **A binding target to reduce EU emissions by 20% by 2020, regardless of progress made in international negotiations for a post-Kyoto agreement, and;**
- **a binding 30% target should other industrialised nations including the US take similar steps.**

*I thought we didn't try to pick winners?*

## **Renewable energies:**

- **A binding target to have 20% of the EU's overall energy consumption coming from renewables by 2020, and;**
- **as part of the overall target, a binding minimum target for each member state to achieve at least 10% of their transport fuel consumption from biofuels. However, the binding character of this target is "subject to production being sustainable" and to "second-generation biofuels becoming commercially available".**

?

## Energy efficiency:

**● Achieve the Commission's objective of saving 20% of the EU's energy consumption compared to projections for 2020;**

**● by 2008: Commission to make proposals for increased energy savings from office and street lighting**

**● by 2009: Commission to make proposals for increased energy savings from incandescent lamps and other lighting in private households.**

*E. Union's moved on to a different track here?  
Typical case of a student writing down the answer  
they've prepared in advance rather than trying to  
answer the actual question?*



# Presidency Conclusions of the Brussels European Council (8/9 March 2007)

## 10. Aware of the huge possible global benefits of a sustainable use of fossil fuels, the European Council:

- **underlines the importance of substantial improvements in generation efficiency and clean fossil fuel technologies;**
- **urges Member States and the Commission to work towards strengthening R & D and developing the necessary technical, economic and regulatory framework to bring environmentally safe carbon capture and sequestration (CCS) to deployment with new fossil-fuel power plants, if possible by 2020;**
- **welcomes the Commission's intention to establish a mechanism to stimulate the construction and operation by 2015 of up to 12 demonstration plants of sustainable fossil fuel technologies in commercial power generation.**

*What does E. Union mean by this?* ✓

*OK, will have to check the sums here – see below*

- The new EU energy 2020 committed targets look quite like the IEA World Energy Outlook ‘Alternative Policy Scenario’ for the EU in 2030.
- The APS examines what might happen “if countries were to adopt all of the policies they are currently considering related to energy security and energy-related CO2 emissions.”
- i.e. Current EU commitments are more of the same delivered more quickly.
- Will use WEO 2006 APS results for the EU to examine what happens with these commitments but without CCS.

*Not very happy with your approach – unrealistic to ignore CCS?*

*Not ideal, but maybe OK as simplified hypothetical case?*



## WEO 2006 APS EU electricity generation mix

- With new renewables targets coal can be reduced by third from APS to ~12%
- Renewables and hydro about 40% of generation
- Gas generation up by about 40% from 2004 values
- Energy efficiency aspirations not included

**Case A adjustments  
~2020**

EU electricity	1990		2004		2015		<del>2030</del>		Adj	New
<b>Total generation (TWh)</b>	<b>2444</b>		<b>3154</b>		<b>3484</b>		<b>3681</b>			
Coal	1012	41%	975	31%	955	27%	657	18%	-6%	12%?
Oil	205	8%	131	4%	121	3%	53	1%		1%
Gas	159	7%	605	19%	617	18%	856	23%		23%
Nuclear	778	32%	988	31%	995	29%	822	22%	+3%	25%?
Hydro	271	11%	300	10%	369	11%	405	11%		11%
Renewables (ex. hydro)	19	1%	156	5%	427	12%	888	24%	+3%	27%?
<i>Biomass &amp; wastes</i>	14	1%	90	3%	144	4%	191	5%		5%
<i>Wind</i>	1	0%	59	2%	261	7%	586	16%	+3%?	19%?
<i>Geothermal</i>	3	0%	6	0%	8	0%	17	0.5%		0.5%
<i>Solar</i>	0	0%	1	0%	12	0%	77	2%		2%
<i>Tide &amp; wave</i>	1	0%	1	0%	2	0%	18	0.5%		0.5%

**IF** binding commitment for 20% of energy from renewables by 2020 is met,

- and there is some progress on energy demand reduction,
- and a lot of progress on biofuels
- and we can burn possibly more gas than now
- and some existing nuclear is life-extended,

*Why assume transport renewables is all biofuels?  
What about electric vehicles?*

**THEN** • we get oil consumption down by 10%,

*But what about EU flagship CCS demo programme?*

- and we can get 20% CO<sub>2</sub> reductions without CCS.

*So technically correct but shows worrying lack of awareness of practical aspects of this topic*

## BUT WHAT IF:

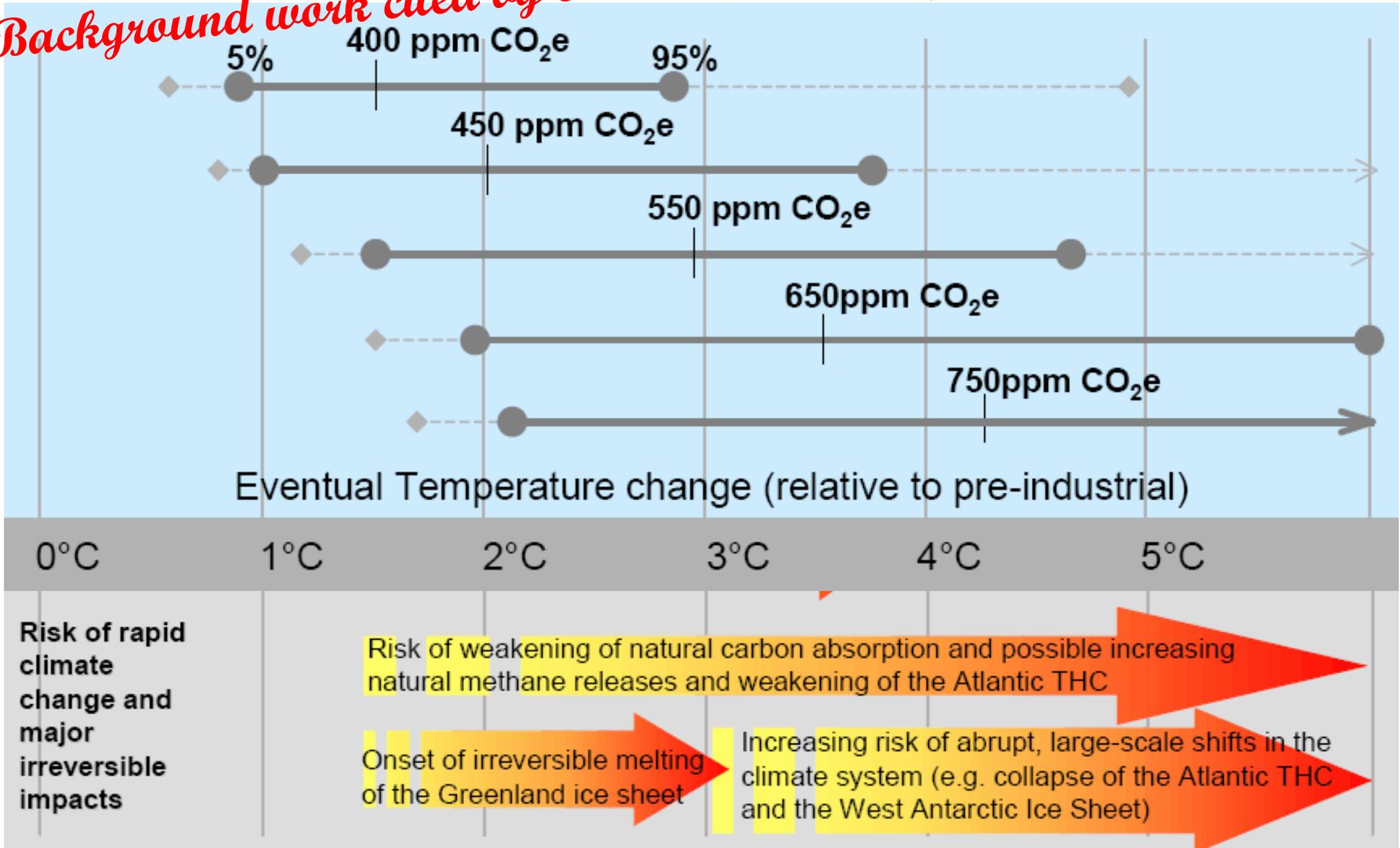
- renewables target not met despite being binding?
- demand increases – especially more electricity?
- biofuels impractical or small GHG gain?
- Russian gas supplies squeezed in 20-teens?
- nuclear has to be closed, replacements slow?
- strong competition for oil?
- China and India are looking to the EU for a lead on CCS?

*Penalise candidate Union for failing to mention above points.  
Let's see how candidate Berr does on this, particularly on China  
and India. Also - what about renewable electricity in the 20%?  
Replaces 2-3 times primary fossil energy.  
And heat pumps - 50-75% of heat is renewable.  
This isn't statistics, it's thermodynamics!*

# STERN REVIEW: The Economics of Climate Change

(already at 430 ppm CO<sub>2</sub>e and currently rising at roughly 2.5 ppm every year)

*Background work cited by Berr - good! But pretty bad really ..*



## **Carbon capture and storage international context**

**5.4.11 It is in our own vital interest that the technologies necessary to make coal low carbon are developed and deployed as rapidly as possible, since fossil fuel generation will remain a significant part of the global energy mix (on the Governments' present policies meeting almost 70% of global electricity demand by 2030). The Government believes that the development and wide-scale deployment of CCS is therefore important for our climate change and security of supply objectives. CCS has the potential to reduce carbon dioxide emissions from fossil fuel power stations by as much as 90%. The Stern Review highlighted the strategic role that CCS technology could play globally to lower carbon emissions, with the potential to contribute up to 28% of global carbon dioxide mitigation by 2050, particularly in fast-growing economies with rising fossil fuel consumption such as China and India.**

EWP2007, pg 173

**5.4.12 In order to deploy CCS in these countries the technology needs to be demonstrated on a commercial scale. Developing countries strongly indicate it is for developed countries to show leadership and to prove the validity of the technology, firm up costs and reduce technical risks.**

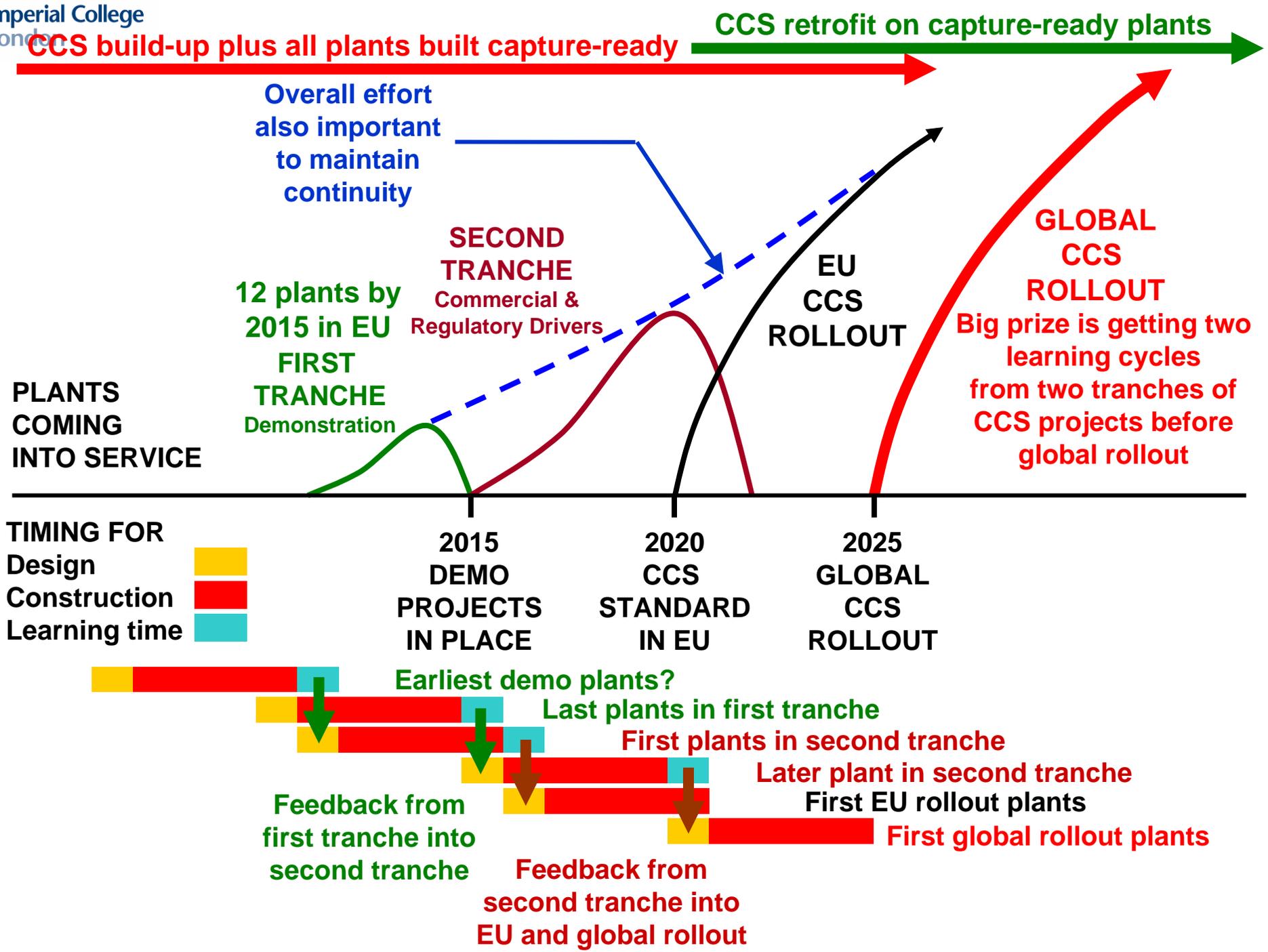
*Looks pretty sound here? ✓*

**5.4.20** There is a strong case for the UK demonstration of CCS on power generation. The UK is well served with potential carbon dioxide storage sites, particularly under the seabed in the North Sea. Providing financial support and hosting UK-based CCS demonstration will help the Government meet its aims for climate change and wider energy policy goals by:

- **reducing risks and demonstrating costs of CCS, and taking the first step towards longer term cost reductions and the deployment of CCS on a wide scale nationally and more importantly, internationally;**
- **reinforcing the UK's international leadership on climate change by investing in CCS technology that in time has the potential to make substantial reductions in global carbon dioxide emissions;**
- **helping to gain global agreement for a more ambitious drive to reduce emissions by demonstrating that CCS can safely deliver large reductions in emissions, and the extent to which it is affordable and reliable;**
- **giving UK business a lead in the design, construction and operation of CCS technologies. This will have the advantage of helping to build the skills base and demonstrate supply chains in the UK building on the existing experience and expertise in the UK of operating in the UK Continental Shelf. This should help put UK business in a stronger position to take advantage of future CCS investment opportunities; and**
- **enabling the UK to develop a comprehensive regulatory framework for CCS.**

*Excellent – got there in the end!*

*But we're not at the end yet?!*



# CCS Proposals – UK

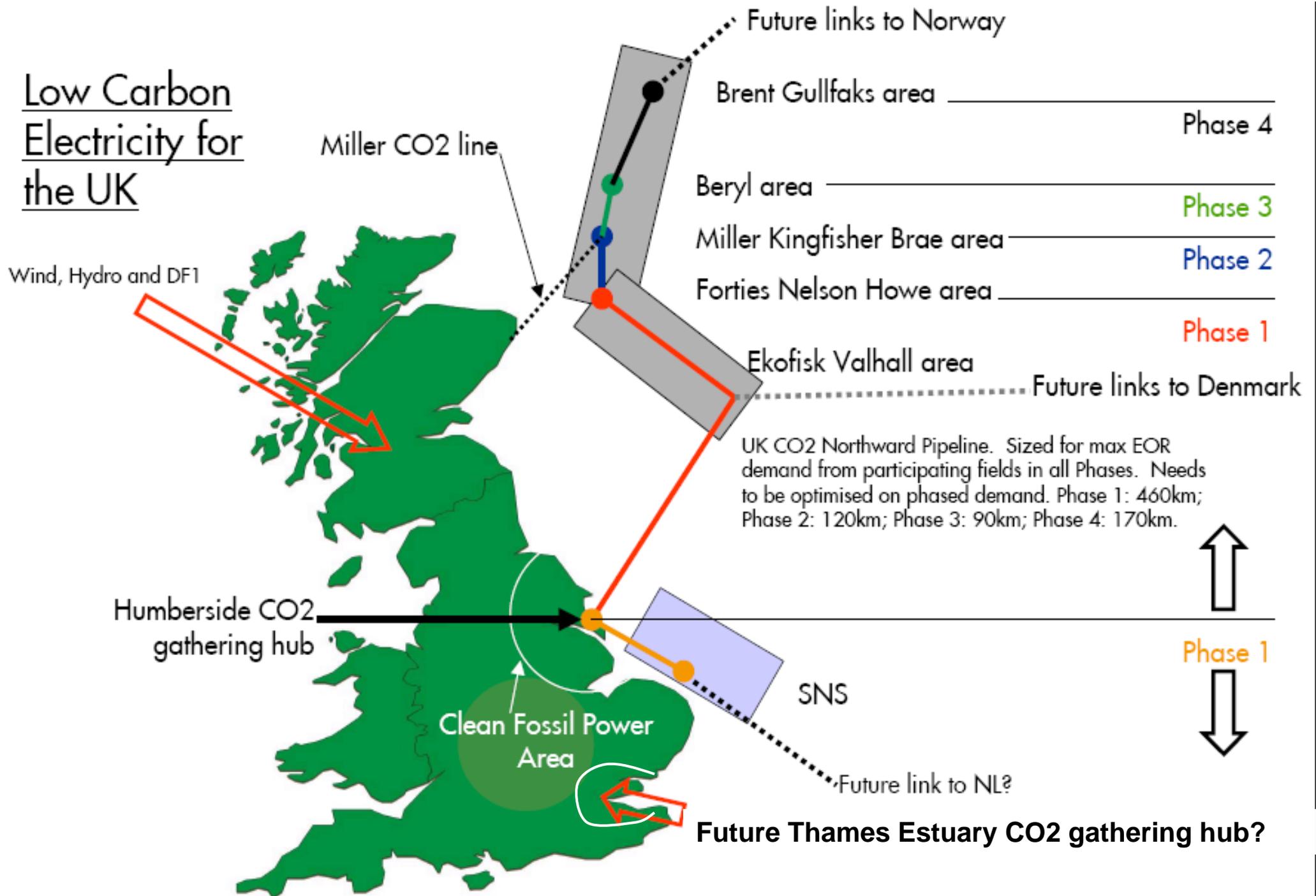
Proposed full-scale (~300 MWe and above) CCS projects - indicative only

Project	Fuel	Plant output	Capture technology
Progressive Energy /Centrica, Teeside	Coal (petcoke)	800 MW	IGCC + shift + precombustion
Powerfuel/ Kuzbassrazrezugol Hatfield Colliery	Coal	~900 MW	IGCC + shift + precombustion Shell gasifier
Conoco-Phillips, Immingham	Coal (+petcoke?)	450 MW (or more, with retrofit)	IGCC+CCS addition to planned NGCC CHP plant
E.ON, Killingholme, Lincolnshire coast	Coal (+petcoke?)	450 MW	IGCC + shift + precombustion
RWE, Tilbury	Coal	2 x 800 MW	PC, CR, new supercritical, post-com
SSE, Ferrybridge	Coal	1 or 2 x 500MW	PC, CR, supercritical retrofit, oxyfuel
E.ON, Kingsnorth	Coal	2 x 800MW	PC, CR, new supercritical, post-com
RWE, Blyth	Coal	3 x 800MW	PC, CR, new supercritical
Scottish Power, Longannet	Coal	~ 2400 MW	PC, CR, supercritical retrofit, (oxyfuel?)
Scottish Power, Cockerzie	Coal	~ 1200 MW	PC, CR, supercritical retrofit, (oxyfuel?)

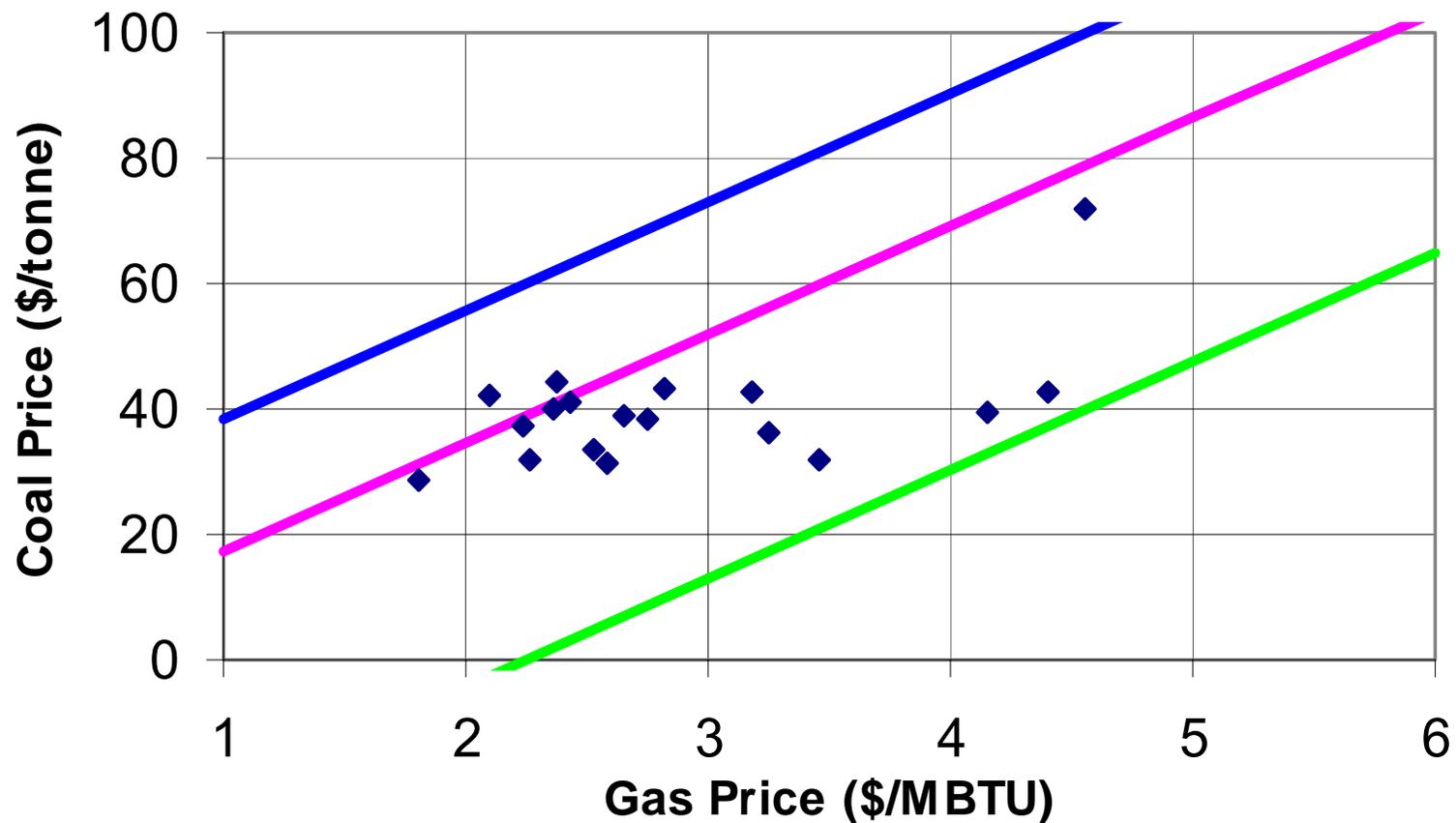
*Any possibility of Peterhead/Miller?*

*~ 13 GW – not including capture-ready NGCC*

# Low Carbon Electricity for the UK



**Coal + CCS has LOW marginal costs compared to high cost LNG. Having a coal option, with an option for CCS, is a great way to negotiate reasonable LNG contracts**



# Distributed vs Central Generation

kWh in gas LHV		kWh out heat	kWh out electricity	kg CO <sub>2</sub>	
100	Condensing boiler (100% LHV)	100	0	20	
100	CHP with local networks (90% LHV)	55	35	20	
63.6	NGCC + trans. Loss (55% LHV)		35	12.7	
55	Condensing boiler (100% LHV)	55	0	11.0	
118.6				23.7	
72.9	NGCC + CCS (48% LHV - 80% CO <sub>2</sub> reduction)		35	2.9	30% lower CO <sub>2</sub> than CHP
55	Condensing boiler (100% LHV)	55	0	11.0	
127.9				13.9	
72.9	NGCC + CCS (48% LHV - 80% CO <sub>2</sub> reduction)		35	2.9	
57.3	NGCC + CCS (48% LHV) + heat pump (COP=2)	55	0	2.3	74% lower CO <sub>2</sub>
130.2				5.2	
72.9	NGCC + CCS (48% LHV - 80% CO <sub>2</sub> reduction)		35	2.9	
38.2	NGCC + CCS (48% LHV) + heat pump (COP=3)	55	0	1.5	78% lower CO <sub>2</sub>
111.1				4.4	

16% less gas use and 16% lower CO<sub>2</sub> emissions with CHP

## CONCLUSIONS – THE COMPETITION IS CENTRAL

- No practical experience = No meaningful CCS options
- Plenty of serious UK players
- Costs probably less than offshore wind
- Three types of things to do – not a straight competition :
  - IGCC (3 types or more?) on Teeside or Humberside
  - Commercial post-com  $\sim 1000$  tCO<sub>2</sub>/day on coal next
  - EOR scheme – Peterhead only existing pipeline
- Canada, Norway, NL all going slow on early demo projects
- Maybe one or two plants in Australia – but LNG & CTL?
- Maybe the USA will start moving after the election?
- Maybe we'll save wasting 2-5 years?

## CONCLUSIONS – THE COMPETITION IS CENTRAL

- No
- Pl
- Co
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- 
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- 
- Car
- May
- May
- May

*Candidate Berr knows all the material but still hasn't answered the main question yet – probably distracted by other students playing about so deserves another chance – hard worker too - recommend allow re-examination end of next year under first-time rules.*

*Agree, but needs to take it seriously this time, can't afford to see 2-5 years wasted, and can we rely on USA anyway?*

CCS options

competition :

Humberstone

on coal next

pipeline

/ demo projects

ING & CTL?

ection?