

UK & EU CCS state of activity

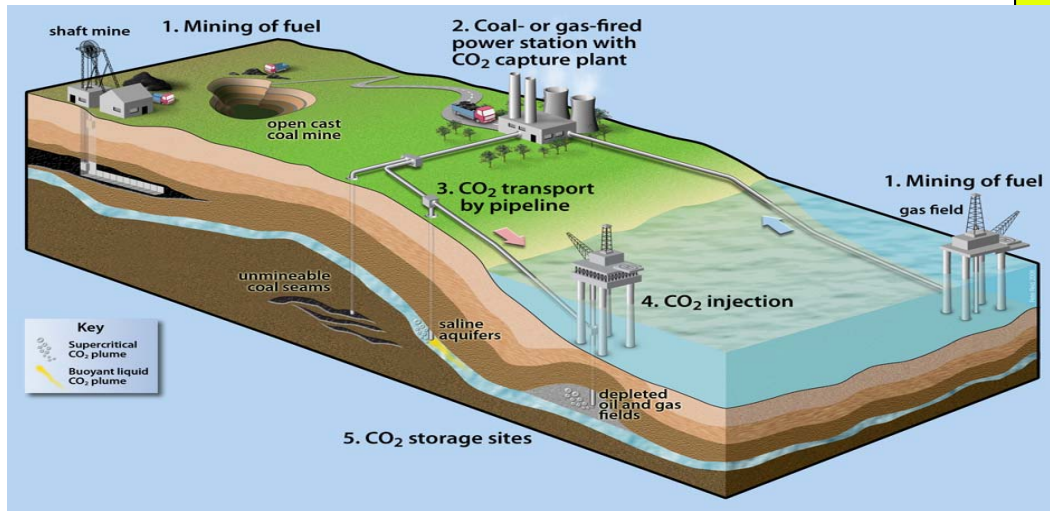


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Professor of
CCS Geology
SCOTTISHPOWER

Largest UK whole chain research group

15 CCS academics,, \$21M grants

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Projects
Storage
Problems
Outlook

EU and UK aim: 80%
CO2 reduction by 2050



Scottish Centre for Carbon Storage

www.geos.ed.ac.uk/research/sccs.html

Funded projects: Oct 2009



EU € 1.05 Bn (6 coal plant) (12)

Jaenschwalde Germany,
Rotterdam Netherlands,
Belchatow Poland,
Compostilla Spain,
Hatfield UK,
Porto Tolle Italy

Alberta \$ 2 Bn (power plant)

PIONEER ammonia retrofit 1Mt/y
QUEST - Scotford tar sands 1.2Mt/yr

Australia \$ 2 Bn (power plant)

ZeroGen 400MW; Wandoan 355MW
Gorgon offshore \$840M

UK 1 (4) £ 1-4 Bn ? (coal plant)

1 - 4 projects TBC - extra levy (tax)

USA \$ 1.4 Bn (12 industry)

Air Products Inc. steam methane reformer Port Arthur, Texas. 1Mt CO₂/yr EOR

Daniels Midland Corp amine capture CO₂ to Mt. Simon Sandstone aquifer

Memorial Institute, Pacific NW Division Fluor & Boise paper black liquor to deep basalt

C6 Resources Shell & LBNL industrial to 10,000ft saline formation 1Mt/yr

CEMEX Inc. RTI Int cement dry sorbent 1Mt

ConocoPhillips Sweeney refinery Tx, Petcoke IGCC 5Mt to oilfield

Leucadia Energy Denbury 4Mt/y co-generation petroleum coke-to- methanol project Lake Charles, La. EOR Hastings Tx

Leucadia Energy PetCoke gasify 4Mt/yr Moss Point Miss

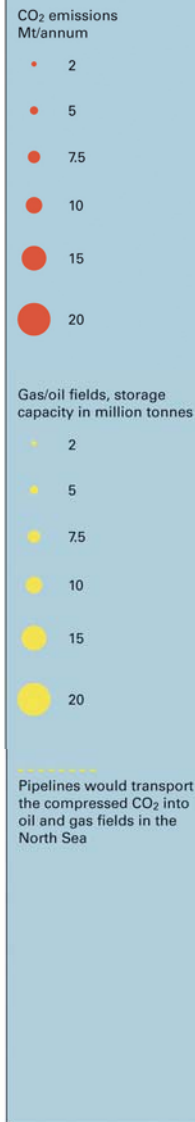
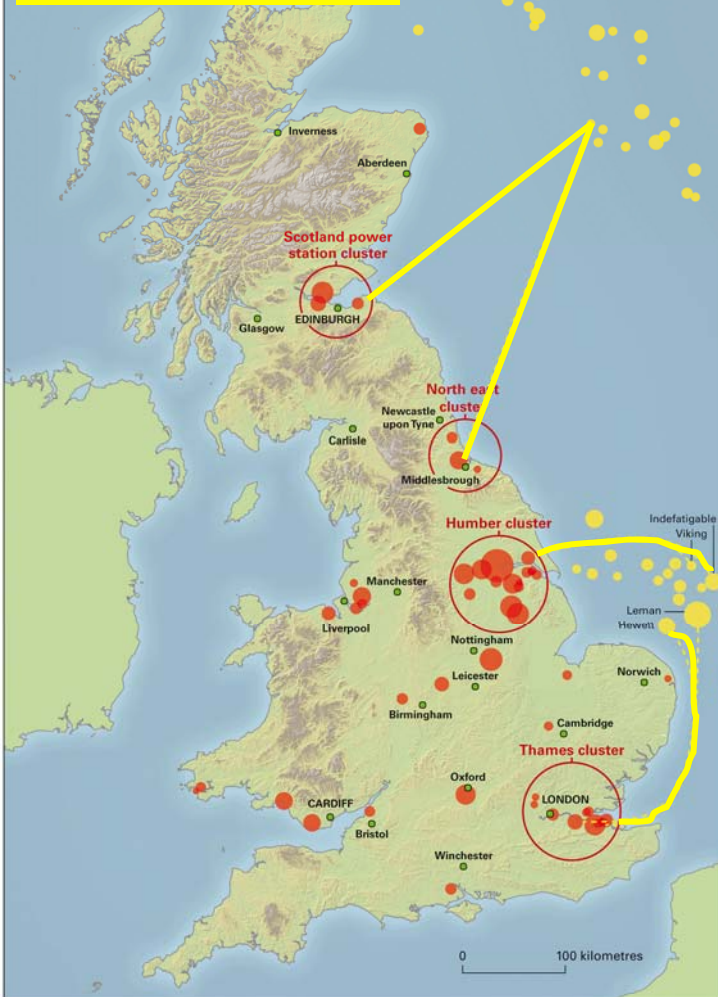
Praxair BP Denbury H₂ refinery 1Mt/yr

Shell Chemical industrials 1Mt Baton Rouge

University of Utah 1Mt/yr Kansas EOR & aquifer

Wolverine Power 300kt CFB coal

Clusters



Capture, transport

- UK Govt research councils > £ 30M on capture (efficiency, combustion)
- Worlds largest Oxyfuel test by Doosan, Renfrew
- Small slipstream amines ScottishPower
- Planned 5 MW amine slipstream on coal

From The Times
February 11, 2009

National Grid to pipe carbon dioxide emissions under North Sea

The company is planning to develop a £2bn transport and storage network so it can collect carbon and store it overseas



Coal & CO2 : Public UK, NL & D

Breaking news: Kingsnorth Six found not guilty!

Posted by bex on 10 September 2008.

GREENPEACE

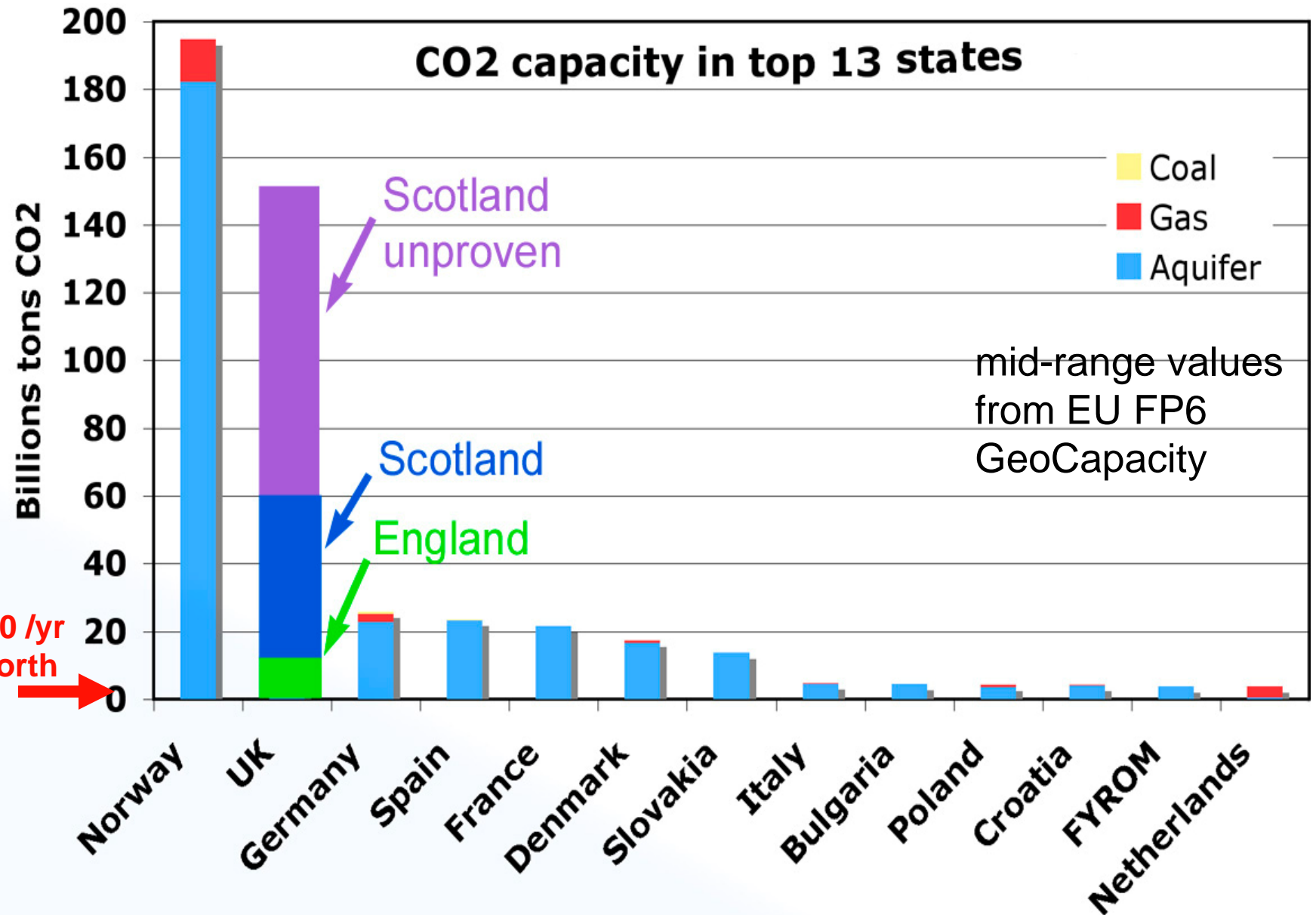


Five of the 'Kingsnorth Six' at the top of the 200m chimney

[See all trial updates.](http://www.greenpeace.org.uk/blog/climate/kingsnorth-trial-breaking-news-verdict-20080910) <http://www.greenpeace.org.uk/blog/climate/kingsnorth-trial-breaking-news-verdict-20080910>



UK storage very large



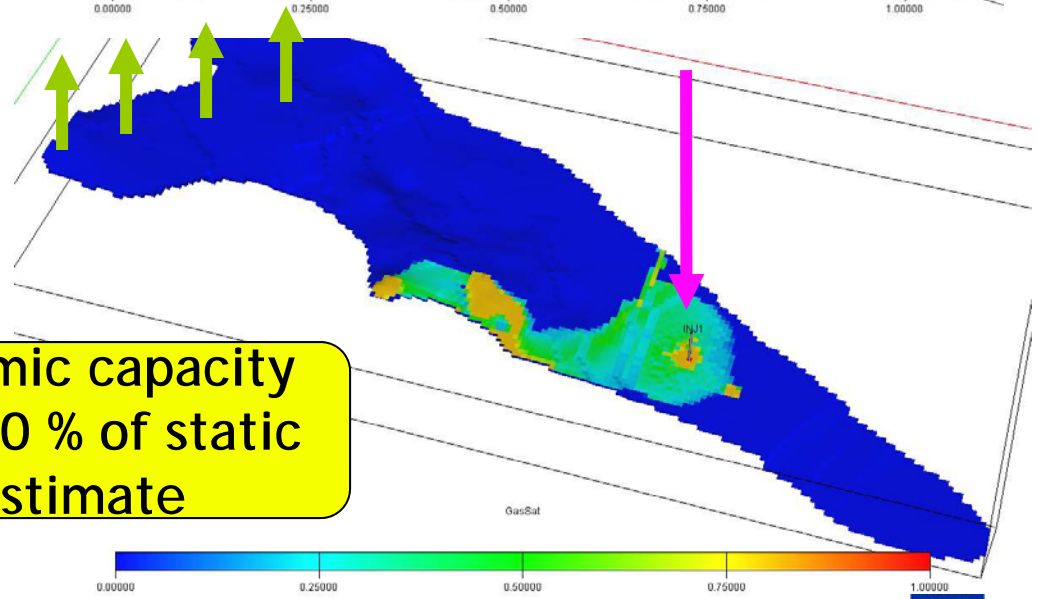
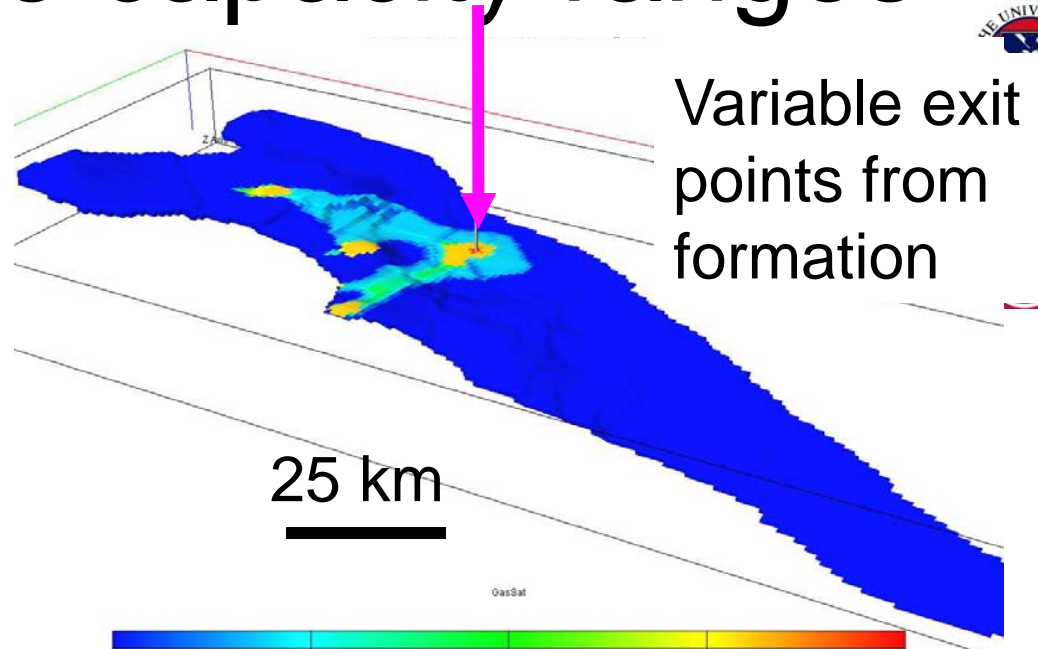
Storage capacity ranges

- Static formation 2% effective
1328 Mt CO₂

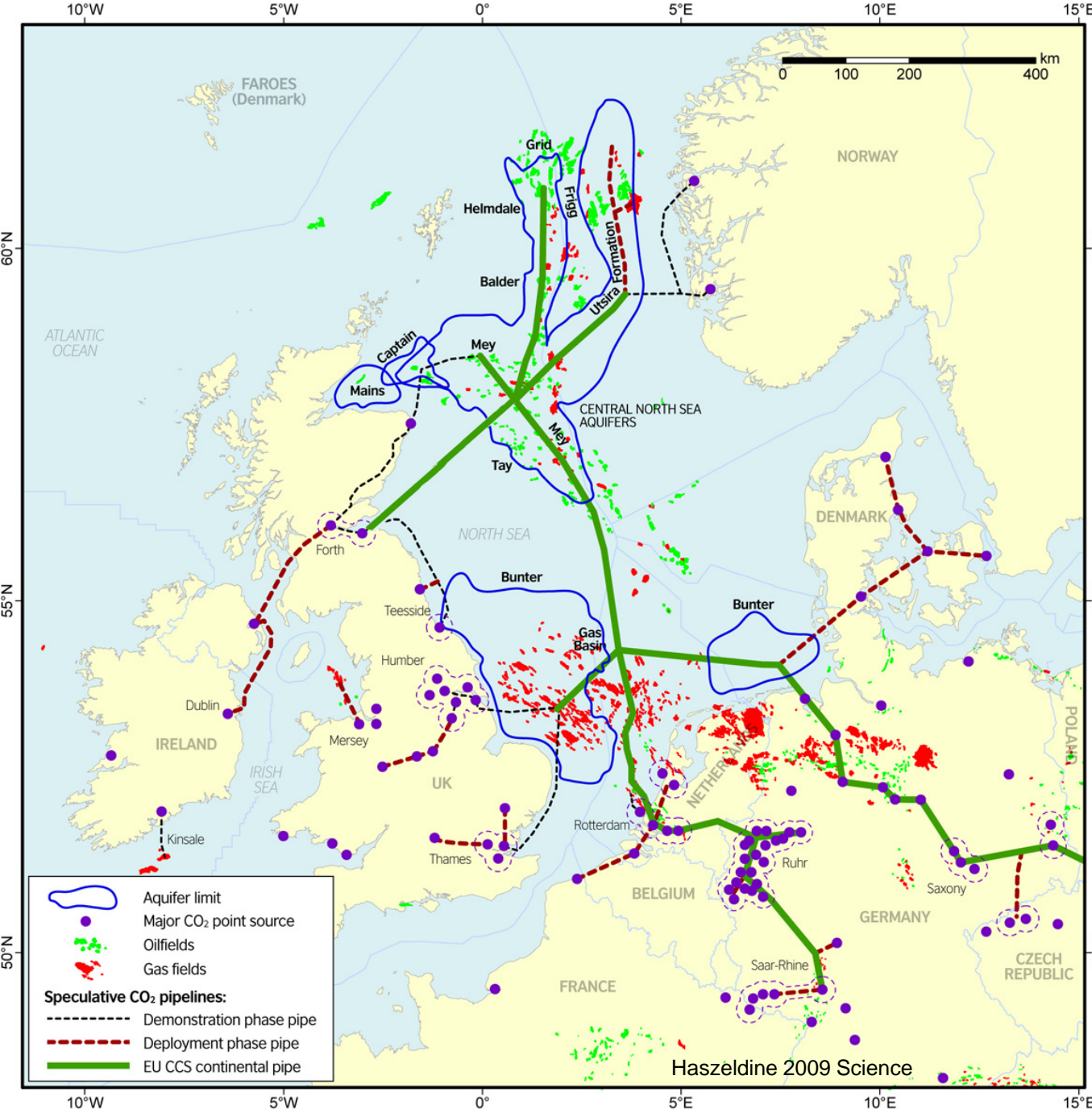
- Open formation with heterogeneity 0.56 % effective store 375 Mt CO₂

- Closed formation, with pressure limit 0.2 % effective
155 Mt CO₂

- Closed formation with water production stores 375 Mt CO₂



**Dynamic capacity
10 - 30 % of static
estimate**



Few large, or many small stores ?

Continental pipes to offshore \$8 Bn/yr income?

MAJOR RISK Needs REAL TESTS



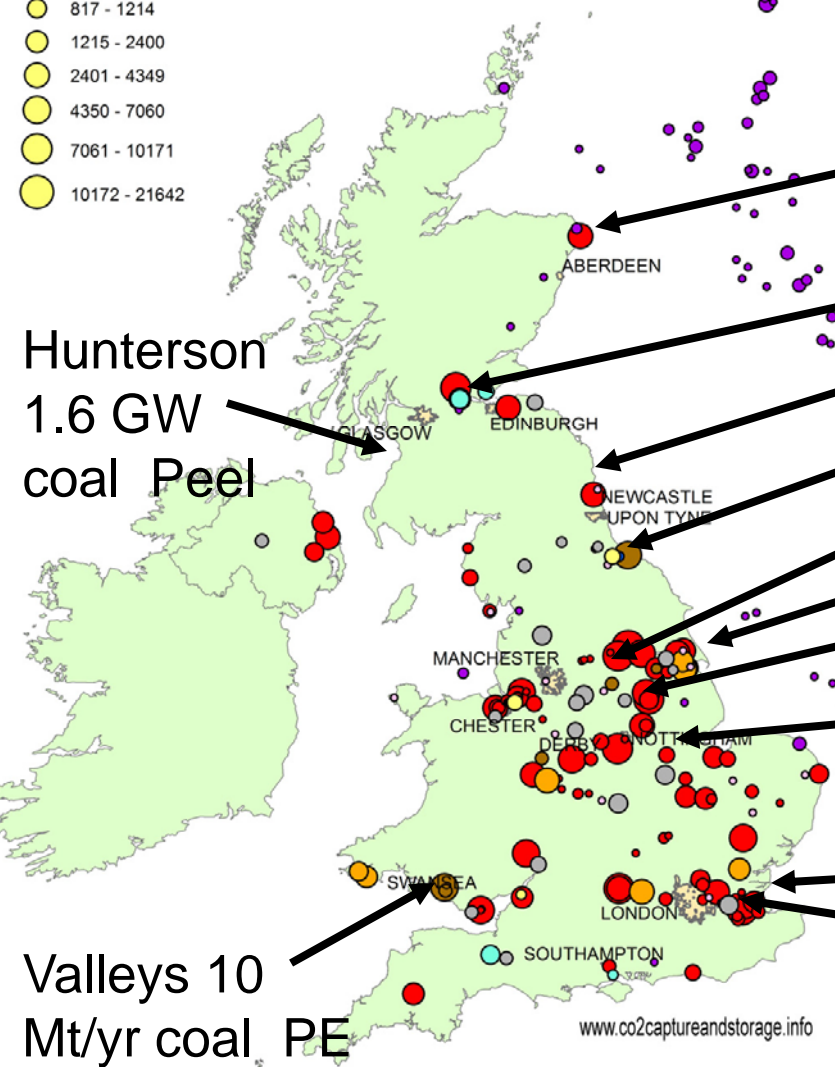
IEA Greenhouse Gas R & D Programme

Legend

CO2 (Kt)

- 0 - 183
- 184 - 300
- 301 - 557
- 558 - 816
- 817 - 1214
- 1215 - 2400
- 2401 - 4349
- 4350 - 7060
- 7061 - 10171
- 10172 - 21642

- Ammonia
- Cement
- Ethylene
- Ethylene Oxide
- Hydrogen
- Iron & Steel
- Oil & Gas Processing
- Other Sources
- Power
- Refineries



Hunterson
1.6 GW
coal Peel

Valleys 10
Mt/yr coal, PE

UK CO₂ capture proposals 2007

12.9 GW, 20% UK baseload

- Peterhead 1.5 Mt/yr gas SSE/BP
- Longannet 10 Mt/yr coal SP
- Cockenzie 4.1 Mt/yr coal SP
- Blyth 2.4 GW coal RWE
- Tees-side 10 Mt/yr coal PE
- Ferry Bridge 10 Mt/yr coal SSE
- Immingham 1.2 GW CHP Conoco

Hatfield 900 MW Powerfuel

Killingholme 900MW coal E.ON

Kingsnorth 1.6 GW coal E.ON

Tilbury 1.4GW coal RWE

Before BERR clarification



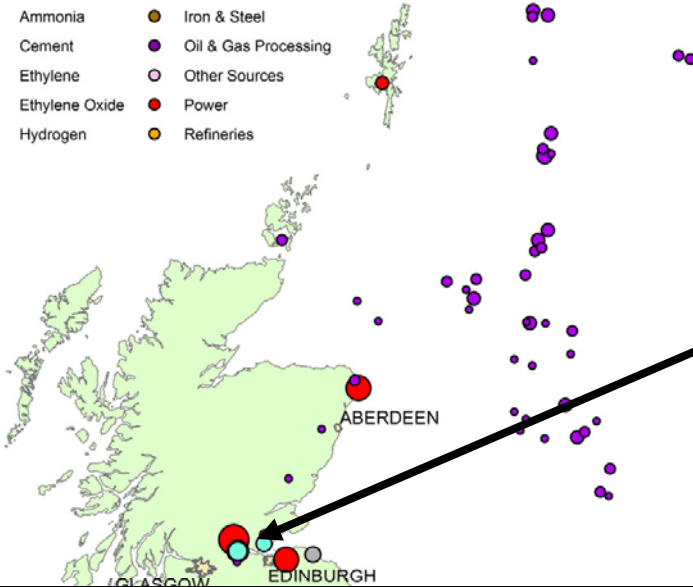
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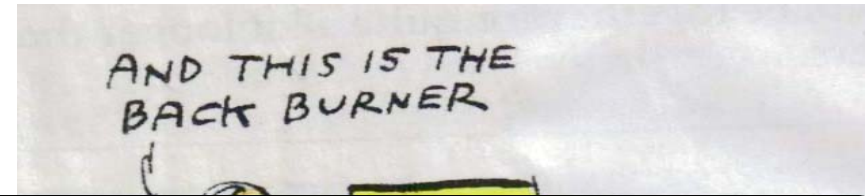
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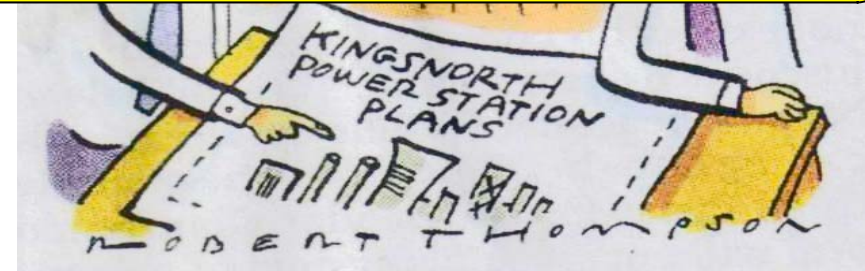
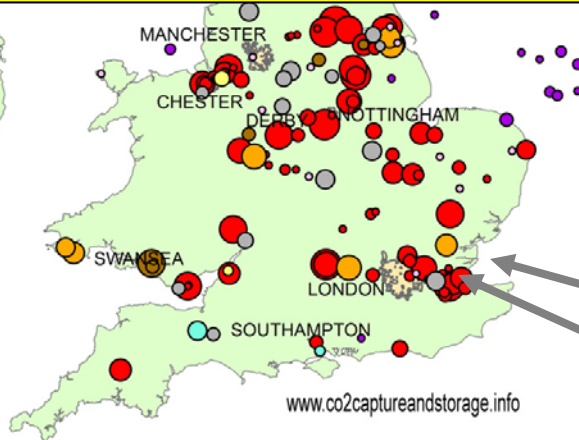
UK competition CCS Oct 2009

0.4 GW, soon after 2014

Longannet 2.4 GW coal SP
(10 Mt CO₂/yr)



FEED study 2 x £45M in January. Award contract late 2010
Operational end 2014, 400MW. **ELECTION 2010 ==> 5GW?**



Kingsnorth 1.6 GW coal E.ON

Tilbury 1.4GW coal RWE



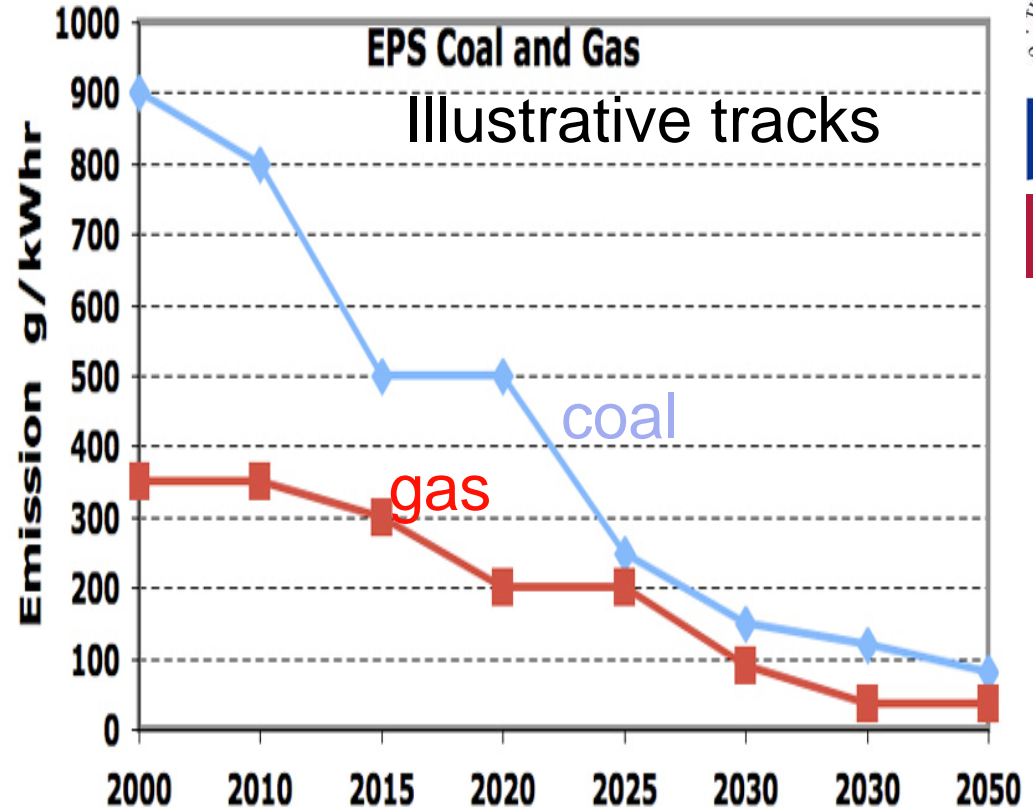


Future outlook

Emissions Performance Standards

- **Direct focus on CO2**
- Places the problem with generators (like EU)
- **Needs less government time and expertise**
- Old coal will close by LCPD 2015, IED 2022
- Separate track for gas
- **Coal and gas EB2010**

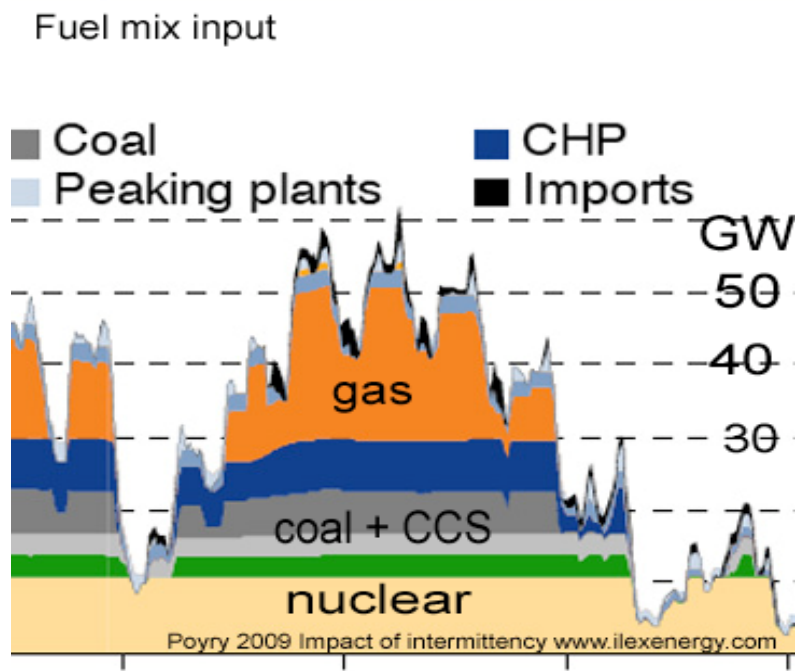
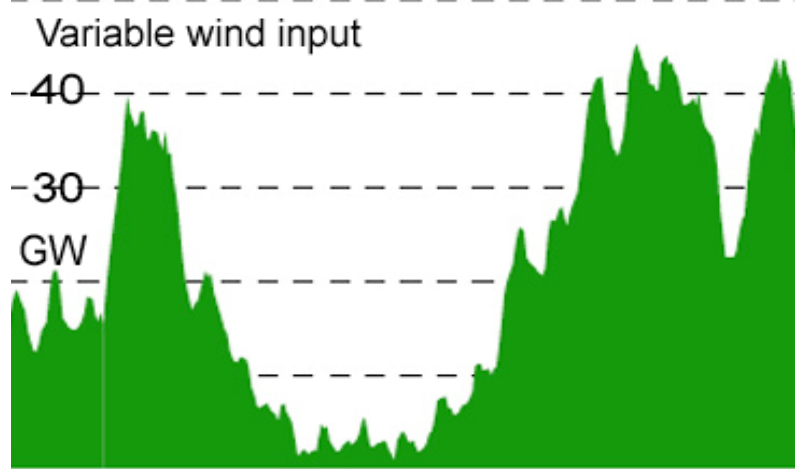
Need DESIGN to keep coal in the mix - cheap security
Separate coal and gas standards



Stick

Future: system demand variability

Based on history, projected to 2030



Renewables (wind) are variable. Very cold or very hot ==> no wind for a week

Either: disconnect / manage demand (for several days)

Either: build electricity / heat / potential energy storage

Or: build 100% backup fossil plant. Variable operation, less efficient CCS, more g/kWhr

Payment for on-call capacity. More CCS may be 'cheaper' capex than more renewables

Technical

- **Dynamic storage** capacity - volumes / **pressure**
- Injection **hydrates** in pressure depleted gasfields
- **Density inversion** of scCO₂ relative to saline water
- Accessing **compartmentalised** aquifers
- Any role for **EOR** offshore ?
- Designing capture clusters **transport** to large stores
- Improved **monitoring** for offshore storage > 1km



Summary

- **CCS projects are emerging, slowly, mostly coal power**
- **TWO UK coal projects in the frame (Longannet, Hatfield)**
- **Commercial enticements, for CCS, for EOR**
- **Minimum will enable learning - but needs sharing**
- **Capture >> storage research - public perception**
- **Dealbreakers - Capacity, Basin pressure, no EOR ...**
- **EPS ramping, Operation in renewables grid un-solved**

