“ Carbon capture and storage: UK’s fourth energy pillar, or broken bridge? ”

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Carbon capture and storage: UK's fourth energy pillar, or broken bridge?
SCCS Briefing 2009-03

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Mike Stephenson (BGS) and Stuart Haszeldine (University of Edinburgh) were speaking at the "Carbon capture and storage in the north sea: a national asset in a low carbon future" session at the 2009 British Science Festival in Guildford.

Talk short summary: *CCS power is the only way to burn fossil fuel with lower emissions, and will be essential to fill in electricity generation gaps on weeks when wind does not blow across the EU. CCS is part of the UK plan for a low carbon future, but is progressing too slowly, to be commercially proven when needed. The UK is uniquely advantaged to exploit CCS, with interest from power, transport, and storage companies. Our group has made a comprehensive first evaluation of offshore UK storage, showing that 100 years of not just UK, but also European CO2, could be stored profitably. If this business charged pore space fees, that could be a revenue of £5Bn per year just from storage. Pilot injection could start immediately, and is a needed to solve longer-term capacity uncertainties.*

1. Details of your presentation Diagrams at end

CCS is seen as a critical saviour technology, which can enable industrial nations to reduce greenhouse emissions with minimal behaviour change. CCS is stated to be a 'bridge' into a more sustainable future. CCS is one of the four pillars for clean energy which the UK Government believes to be essential in its low carbon Transition Plan, and could rapidly and cheaply reduce more than one third of the UK's current CO_2 emissions. So, how will that bridge to the future be built, and will it be ready when it is needed, from 2020?

Fossil fuels are unrealistically cheap to use, because the atmosphere and oceans provide waste disposal at no charge. Emissions of CO_2 from coal and gas combustion are increasing faster than anticipated, and the effects of ocean acidification and climate change are already starting to become apparent. Carbon capture and storage is the only available remedy to make large-scale direct reductions of emissions from fossil fuel combustion. Although CO_2 capture has been undertaken at industrial scale since the 1970's, the development of CCS fitted to power plants is only currently emerging, with demonstrations being installed at 1/10 size-scale. However the UK government programme to create and develop this CCS option commercially will not produce the demonstration power plants before 2020. Our compilations of rival projects worldwide suggests that this will be too late for the UK to gain advantage in a new global industry particularly as the USA is now progressing very rapidly, and China intends to have two demonstrations operating several years before the UK. CCS is also predicted to provide a low cost remedy to electricity generation: UK citizens will be paying an increased price for CCS electricity, and a greater price for home-grown renewable electricity; both are needed for reliable electricity by 2020. CCS is not available, and needs to be accelerated.

CCS looks likely to be an essential compliment to the variable output of renewable electricity from wind power. In contradiction to initial evaluations using average windspeeds, which suggested that the wind would always blow somewhere in the UK, there appear to be infrequent troughs of wind power. Weather records show a cold week in January 2000 with no UK wind, and a hot week in June 2009 with no wind across the EU. To guarantee electricity supply to industry and the public in these periods means either developing much more energy storage, or keeping a full fleet of coal and gas power plant with CCS ready for action.

The UK has good analysis of policy needs, and has put in place the regulatory framework for CCS to operate. However, there is still no method for CCS licensing and, critically, no sense of urgency backed by government investment to make a new industry available. Historical analogies with cleanup of SOx and NOx from coal-fired power plant suggest that timespans of 10-20 years are needed to develop and fit new capture equipment, and even that needs very strong legislation; voluntary action in competitive market is insufficient. For transport, the scale of endeavour is large, but less than building the natural gas pipe network, or offshore oil pipelines. For CCS to work, large storage volumes in microscopic pores deeper than 1km below the surface need to be connected to the power plant sites of emissions. Much more effort is needed to prove the large volumes of storage which will be required. Power plants and CO2 can move; storage can not.

Our work has examined natural settings where CO2 has been retained. We can prove secure retention for tens of millions of years. Spectres of massive leakage from storage have no known validity. Our work on natural CO2 sites shows that these have securely stored CO2 for 60 Million years, and so will form excellent storage vessels for the 10,000 years needed by CCS.

We have also made a first systematic evaluation of CO2 storage deep beneath the central and northern North Sea. We find that there is potentially a massive capacity, enough to store industrial CO2 from the UK from hundreds of years of emissions. Some of the best-known sites are in gas or oil fields which have had their hydrocarbons produced. Most of the North Sea capacity is in formations filled with saline water. There is certain storage for several industrial size tests from full power plants. More research, including test injection of CO2, is urgently needed to be undertaken during the next 2-10 years to refine and confirm the long-term capacity of these stores. If our initial findings are confirmed, the UK could then commercially offer safe and environmentally acceptable storage sites to accept 100 years of European Union CO2, by means of continental scale pipelines similar to those with established operational records onshore in the USA. This will be very important for CCS operations in Germany, Poland, or Netherlands – where public education about onshore storage is lagging behind development proposals.

The next stages of storage investigation are to undertake computer simulations of CO2 injection into saline formations, followed by injection of realistic test volumes of CO2. Work is already underway to develop the procedures to efficiently evaluate and predict storage volumes in candidate sites using existing information. This is adapting techniques established and proven in hydrocarbon exploitation. Test injections of CO2 must start within 2-5 years to test the predictions and test the techniques which can detect and monitoring CO2 offshore in the decades after injection. A subsea laboratory is proposed in the Firth of Forth, and test injection could occur at several offshore sites in the North North Sea and southern north sea where oilfield or gas fields are coming to the end of their first phase of utilization during the next few years. Much more funding needs to be committed to early experiments, by actually using the existing and planned green taxes on electricity prices to fund green developments.

2. What is the key finding of the work/research described in your presentation?

- CCS will be required on power plant fuelled by fossil coal and gas, if the UK is to meet its carbon reduction commitments in the most cost-effective and rapid way. CCS is cheaper than offshore wind.
- CCS enables flexibility of electricity generation to meet demand
- 100% backup for variable renewable power will be needed because there are periods of zero wind across Europe, of several days duration
- Long-term CO_2 storage can be proved secure, by comparison with natural sites, spectres of catastrophic leaks are unfounded
- The UK has massive storage capacity in microscopic pores of sedimentary rocks offshore, mostly in saline water, not oilfields
- More accurate evaluation of storage capacity is urgently needed.
- UK Government support needs to be even more energetic, so that CCS is commercially available by 2020, at present this will fail.

3. What is new and interesting about your work?

- Fossil fuel power backup, and payment, will be required to ensure reliable electricity during week long periods of zero wind.
- CO_2 has been naturally stored for tens of millions of years, a secure method is by dissolving CO_2 into underground salty water.
- The UK, especially Scotland, has exceptionally large storage capacity for CO_2, and test injections should start immediately, using oilfield technology, into rocks deep beneath the North Sea.
- The UK should plan to offer CO_2 storage commercially to the EU, and not just plan for limited domestic use.
- Although the UK has made enormous progress in CCS, the speed of testing is far too slow to make CCS commercially available by 2020. Analogies with cleanup of other power plant pollutants show that very strong rules and 10-20 years are needed. At present, the UK will be beaten by the USA, Australia, Canada and China

4. What is the relevance of your work to a general audience?

- CCS seems likely to provide direct clean up of electricity generation, using the existing national grid.
- CCS is likely to be cheaper and quicker than building onshore and offshore wind. All are needed to meet the legal climate change Act. No CCS equals more pollution and more expense.
- CCS enables clean electricity, which is needed to power electric cars and trains, home heat and power
- The UK can make CCS into a large business, by investing now. UK Government (DECC) estimate about £3-5 Bn per year value in CCS by 2030. I consider that to be

an under-estimate which could be exceeded if the North Sea and associated industries are developed as a European storage resource. More than 570 million tonnes of CO2 per ear can be derived from power plant in NW Europe and the UK, at a pore space fee of GBP£ 10 per tonne, that is an additional £5 Bn per year just from storage.

5. What is the next step for your work/research?

- Learning from history to prescribe the rules and incentives to move from experiments, to develop real commercial CCS rapidly.
- Economics of CCS mixed with wind-supplied electricity
- Computer simulation of CO2 injection capacity into saline formations offshore
- Direct injection tests of commercial CO2 capacity into different settings: disused gas fields, and multiple styles of saline formations

6. Details of relevant publications

downloads at http://www.geos.ed.ac.uk/research/subsurface/diagenesis/publications.html

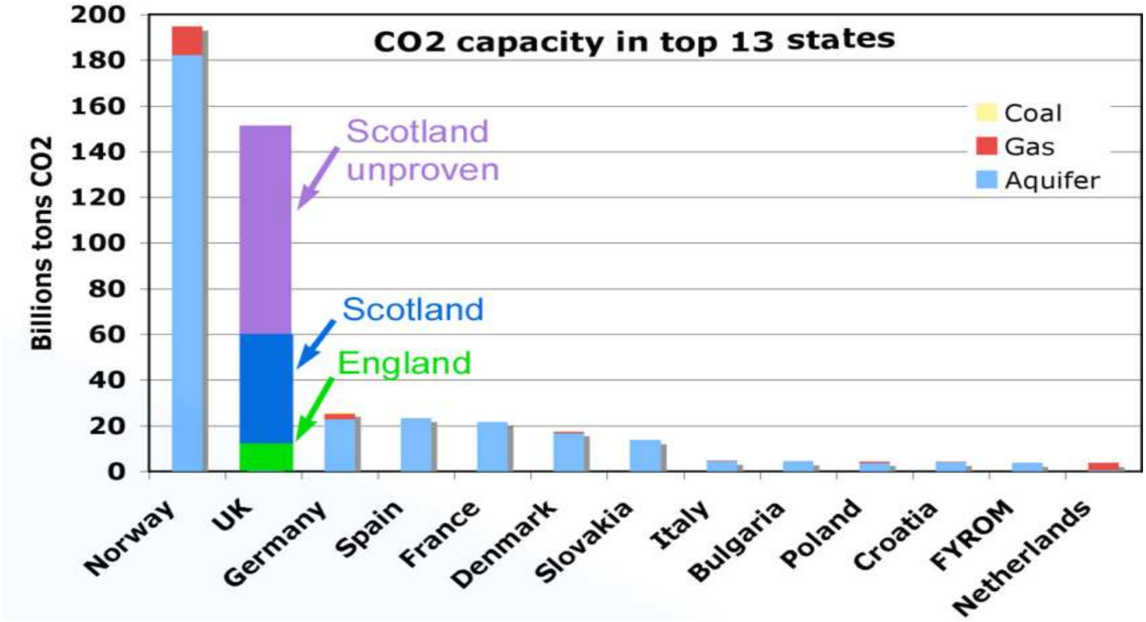
Long-term performance of a mudrock seal in natural CO2 storage Lu J, Wilkinson M , Haszeldine RS, Fallick AE. Geology 2009, v37; no. 1; p. 35–38; doi: 10.1130/G25412A.1; www.geos.ed.ac.uk/research/subsurface/diagenesis/publications.html

CO2–Mineral Reaction in a Natural Analogue for CO2 Storage—Implications for Modeling Mark Wilkinson, Sturat Haszeldine, Journal of Sedimentary Research, v79, p. 486–494. www.geos.ed.ac.uk/research/subsurface/diagenesis/publications.html

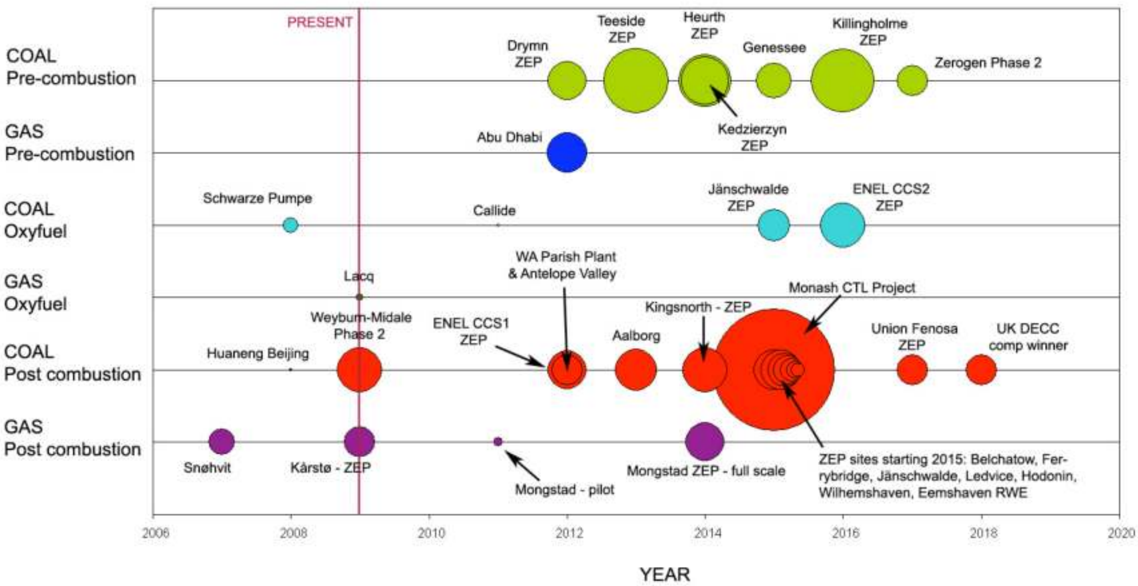
Solubility trapping in formation water as dominant CO2 sink in natural gas fields Stuart Gilfillan Nature 458, 614-618 (2 April 2009) | doi:10.1038/nature07852

Opportunities for CO2 Storage around Scotland 2009 Scottish Centre for Carbon Storage http://www.geos.ed.ac.uk/sccs/regional-study/

CO2 projects worldwide 2009 http://www.geos.ed.ac.uk/sccs/storage/storageSitesFree.html

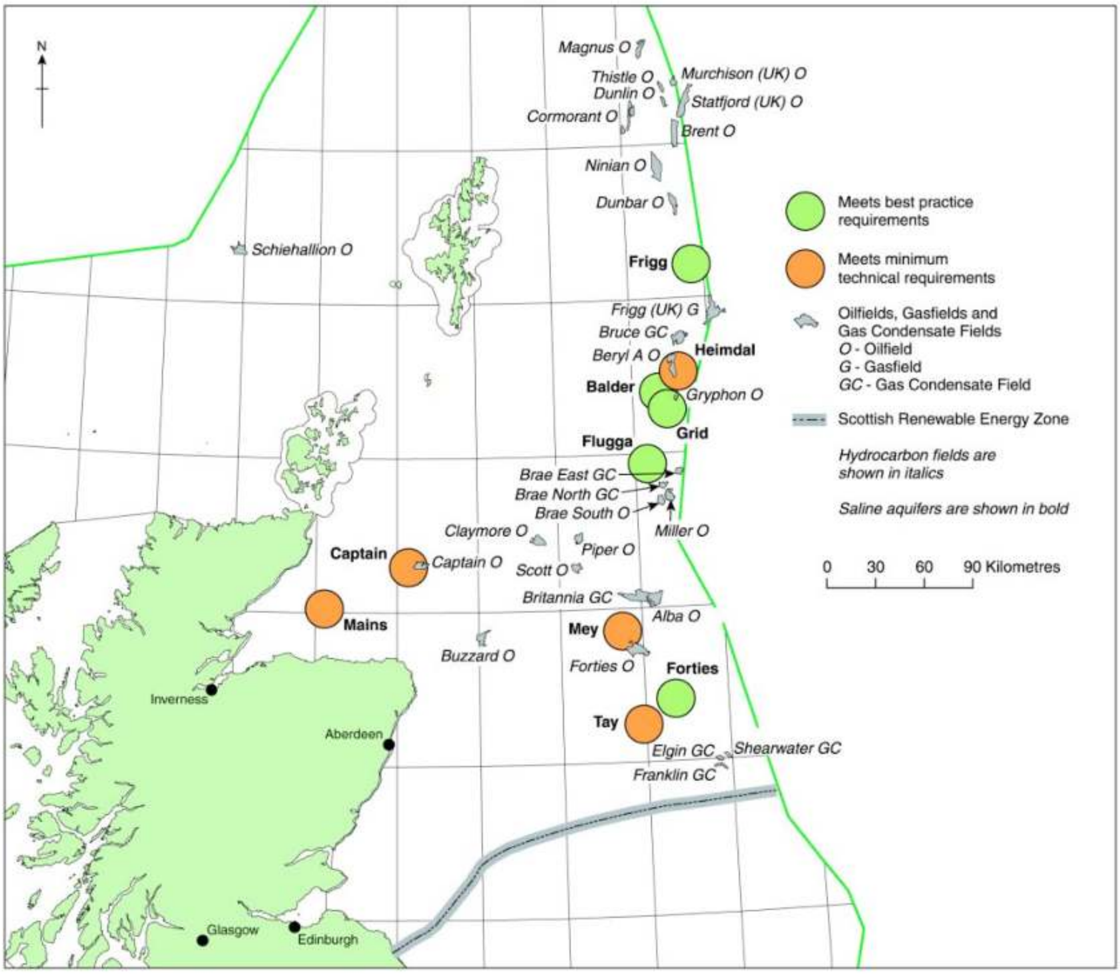


CO2 storage in EU and nearby – the UK is highly ranked.
Data from SCCCS study "opportunities for CO2 storage around Scotland" and EU Geocapacity study. Central case values used, assuming 2% efficiency of aquifers.

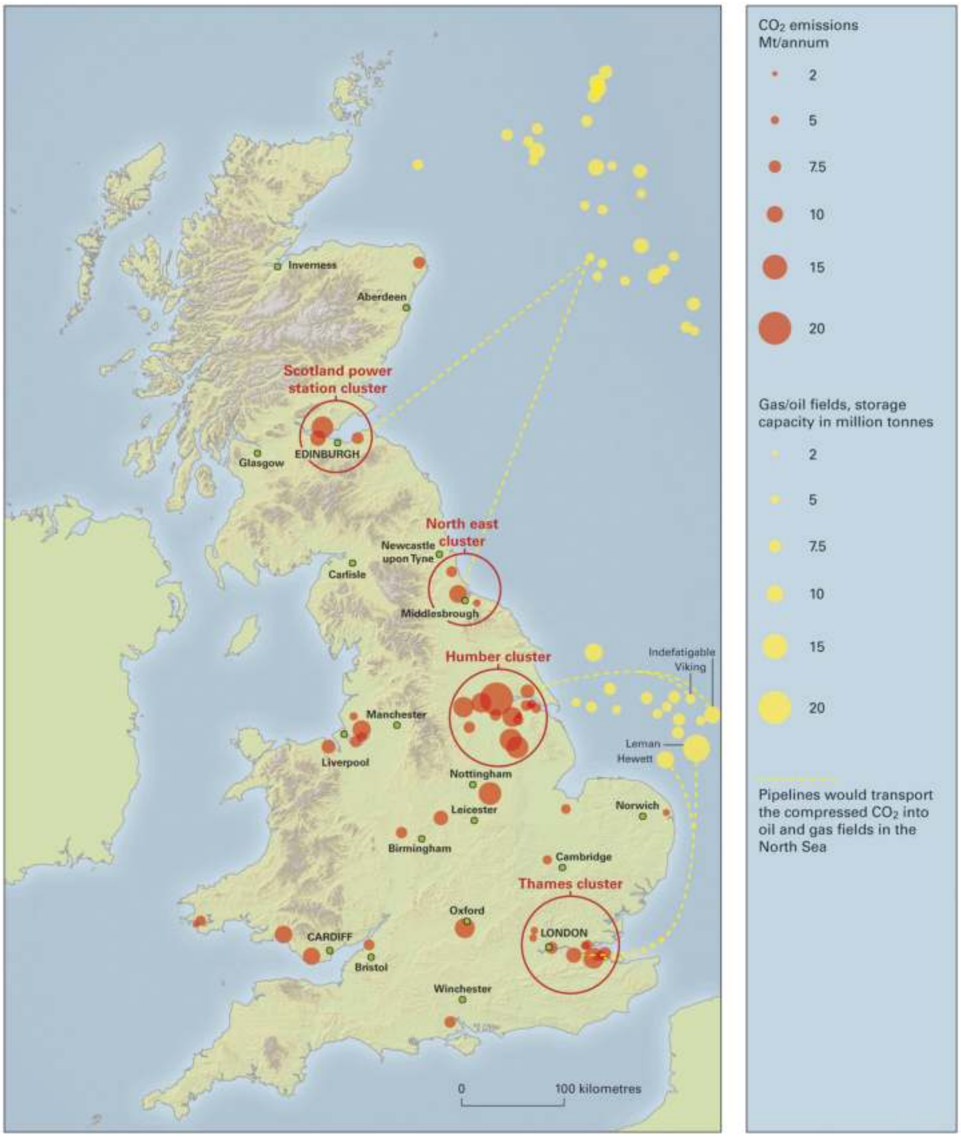


Compilation of large CCS projects worldwide. Size of bubble relates to annual tonnage of CO2 projected to be stored. UK DECC competition delivers CCS after many other countries, but is guaranteed to be funded unlike many competitors. An update will be published in "Science" 23 September 2009

Figure 13
The location of all 29 hydrocarbon fields and 10 saline aquifers identified as potential CO_2 storage sites within the Scottish offshore.



CO2 storage potential sites, North Sea
Map derived from
Opportunities for CO2 Storage around Scotland 2009 Scottish Centre for Carbon Storage http://www.geos.ed.ac.uk/sccs/regional-study/



Clusters of CCS are needed to test several storage sites – not just one plant Testing just one gas field storage site may be an easy option, but that doesn't test the large scale storage of the North Sea. Aquifers need to be tested and proved at a very early stage, to be validated and ready for use from 2020.