PANiC Stations

People Against New Coal Stations

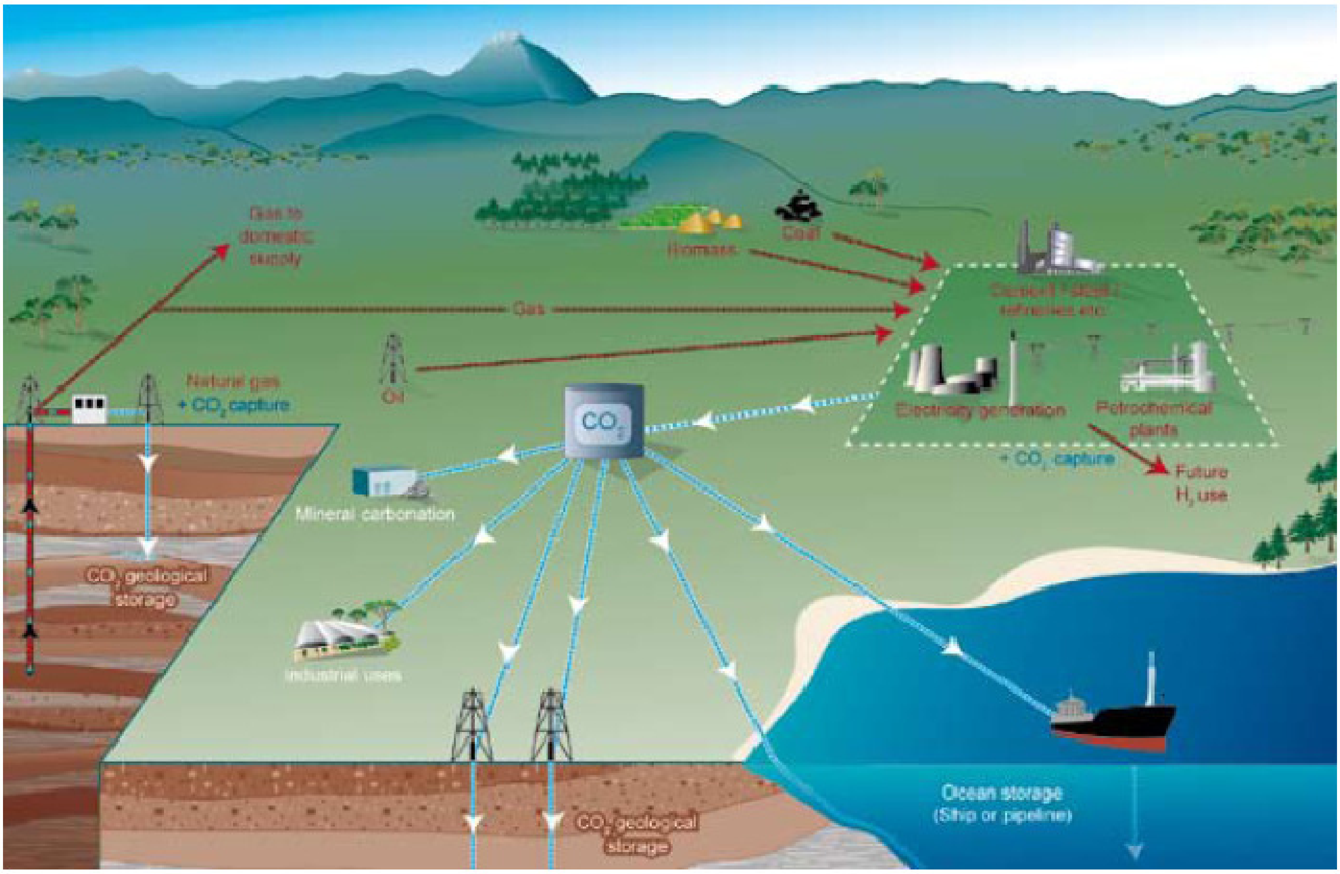
This document is based on information available from the government websites and from key industry and research organisations working on CCS. For a list of useful websites see the end of this document.

Carbon Capture and Storage (CCS)

This is a very brief explanation of CCS and is intended as an introduction to issues. If you want further information on this area please feel free to contact info@panic-stns.co.uk and let us know what you want to know. We will try to find out and add more information to our site.

What is Carbon Capture and Storage (CCS)?

Carbon Capture and Storage (CCS) involves capturing the Carbon Dioxide (CO_2) produced by the burning of hydrocarbons (such as natural gas, oil and coal) before it enters the atmosphere, and storing it deep underground in rock formations (including old oil and gas fields and aquifers (natural underground reservoirs) under the ground or under the seabed) where it would remain indefinitely. CCS is most cost-effective when applied to large, stationary sources of CO_2 (such as power stations and steelworks), which account for more than half of all man-made CO_2 emissions. The CO_2 can be captured from hydrocarbons before, during or after burning and the technology to do this is already widely used in many industries (such as gas processing and fertiliser production).



Why is CCS important?

Fossil fuels are planned to continue contribute a substantial amount of the global 'energy mix' for the foreseeable future (both in the UK and internationally) with global demand for coal predicted to increase by some 70% by 2030. CCS is suggested to be the main option for achieving a reduction in CO_2 production whilst not reducing the use of fossil fuels (especially coal). In theory CCS has the potential to reduce carbon dioxide emissions from fossil fuel power stations by as much as 90%.

People working on CCS as a new technology are suggesting that it will be a major factor in reducing Climate Change as it will permit us to continue to produce electricity by burning fossil fuels while only releasing a very small proportion of the CO_2 into the air.

The Stern Review on the Economics of Climate Change highlighted the strategic role that CCS technology could play globally in lower carbon emissions, particularly in fast-growing economies with rapidly rising fossil fuel consumption, such as China and India.

Plants capture CO_2 from the atmosphere (by photosynthesis) but when they die, most of that CO_2 is returned to the atmosphere. Capturing and geologically storing the CO_2 produced from burning biomass would represent the opposite of today's fossil fuel economy – permanently removing CO_2 from the atmosphere and storing it deep underground.

A secondary reason for CCS being commercially important (and currently one of the main commercial purposes) is that it can be used as a means of getting more fossil fuel out of the ground – especially in oil wells, where the CO_2 is used to force the oil remaining in the underground reserves towards the oil well drilling head (as shown in the illustration on page 1). This is not necessarily a use that is in full accordance with the published intent of reducing CO_2 in air as the oil is then burnt in facilities that have no CCS facilities (in particular motor vehicles), so replacing coal derived CO_2 with oil derived CO_2 instead.

How does CCS work?

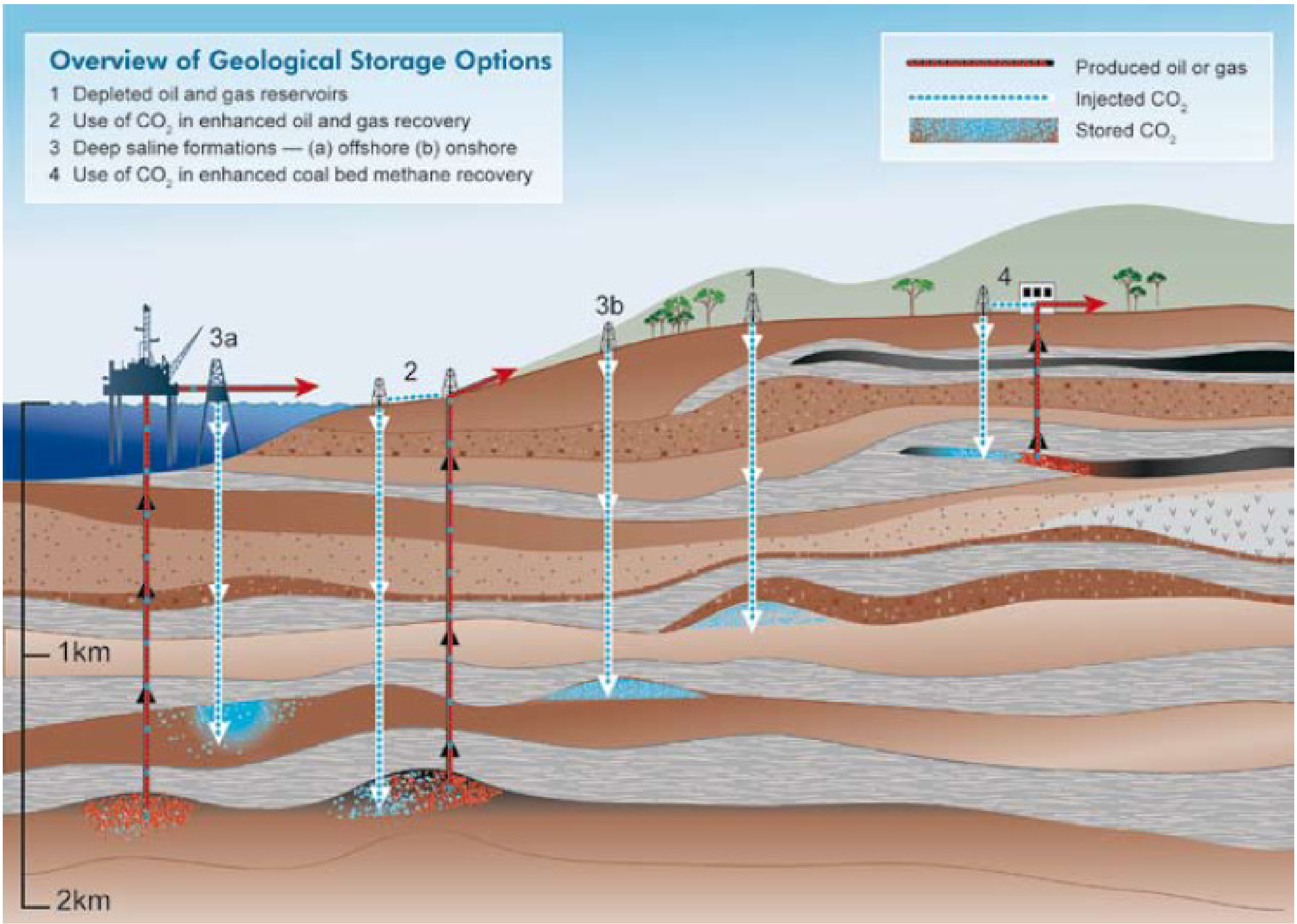
Briefly, CCS is a 3-step process which includes capturing the CO_2 from power plants and other industrial sources; transporting the CO2 (usually via pipelines) to storage facilities; and then storing the CO_2 safely in geological sites such as deep saline formations or depleted oil and gas fields.

The illustration on page 1 shows only the third stage of these processes. Stages one and two are very mundane but also very necessary to make the processes work. The largest technical problems are in the initial capture stage and this is where the scale of Power Stations really gives the most problems.

So where do we put it?

The illustration below shows the 'geological options' that are currently considered viable. This is from the IPPC study published in 2005 and is only an overview. Some other options are also now being considered, but as with nuclear waste, it is important that the locations are both stable and unlikely to be affected by any geological changes or they will leak and so completely invalidate the storage solution.

Storage of CO_2 in deep, onshore or offshore geological formations uses many of the same technologies that have been developed by the oil and gas industry and has been proven to be economically feasible under specific conditions for oil and gas fields and saline formations, but not yet for storage in unminable coal beds which has been proposed by some researchers.



What types of CCS technologies are there?

There are currently three general types of carbon dioxide (CO_2) capture systems:

Post-combustion

CO_2 is separated from flue gas before it goes up the chimney stack after the fuel is burnt in air. The preferred method to do this is to scrub the flue gas with a chemical solvent – this is an established industrial process. This therefore results in the CO_2 being dissolved in a liquid or chemically incorporated into a new material. The current industrial processes are not yet modified to cope with power station scale CO_2 production.

Pre-combustion

This is a particular technique intended for use with IGCC power plants (IGCC stands for Integrated Gasification Combined Cycle). Involves reacting fuel (but not burning it) with oxygen or air, to produce a gas consisting mainly of carbon monoxide and hydrogen (rather like the old Town Gas that was used before Natural Gas was supplied in the mains). The carbon monoxide is then reacted with steam to produce hydrogen and CO_2, which is separated. In short this is a process that separates the stages of burning fuel and uses chemical steps to strip the oxygen out of water (H_2O) and then releases hydrogen gas (H_2) to be used as a fuel later on (either in a power station or in vehicles).

Basically this technique separates hydrogen from hydrocarbon fuels (and is therefore mainly used with natural gas not coal). Hydrogen is a 'clean' fuel, producing only water when burned. Another possibility is to use CCS with biomass fuels (such as crop residues) which can be processed to form a gas idealfor the process.

Oxy-fuel

Uses high purity oxygen in combustion resulting in high carbon dioxide concentrations in the gas stream and therefore its easier separation. The problem with this approach is that you have to get the high purity oxygen in the first place – which is a very energy consuming process. This is the basis of one of the current power stations pilots being tested in Germany.

The main advantage of Oxy-fuel process is that all the gasses from the combustion can be compressed and sent to storage as there is no nitrogen etc. present. Because about 80% of air is Nitrogen gas other methods of combustion have a huge potential for waste because there is no need to store the Nitrogen gas. Putting this underground would cost a lot (compressing and piping the gas) and it would also result in the reservoirs being used up five times faster. Therefore it does not need a separation process making the whole system simpler.

Has CCS been done before?

The individual processes involved in CCS are not novel, but the full chain of technologies (capture, transport, and storage) have yet to be demonstrated together at commercial scale. There are numerous experimental and pilot plant projects round the world but the largest of these can only deal with 5% (one twentieth) of the predicted output of the Blyth Power station.

There are no plans to build CCS at the Blyth/Cambois Power Station.

In the 2006 Energy Review it was outlined that the next step for CCS would be to build a full-scale demonstration plant. The Pre-Budget Report in December 2006 announced the appointment of consulting engineers "to ensure that our understanding of the costs of a CCS plant based in the UK is robust", and the 2007 Energy white paper: meeting the energy challenge subsequently announced that a UK CCS Demonstration Competition would be launched in November 2007 to build the world's first full scale CCS power plant in the UK. The site for the proposed plant has not yet been formally announced but it is widely assumed to be at the Kingsnorth Power Station. However, the latest information is that the plant will only be planned to deal with a fraction (understood to be a small fraction) of the output of the power station if it is given planning approval to be built.

One side effect of looking for places to store CO_2 underground is that old oil and gas wells will suddenly have value as a 'natural resource'. This is also the case for large underground reservoirs into which the CO_2 can be dissolved (just like in a fizzy drink). These are likely to become scarce resources and not all the old oil and gas wells will be usable because of the damage done to them during extraction. Places to hide CO_2 underground are not infinite.

So how much CO_2 does a power station generate?

The largest current CCS facilities are only capable of placing 1,000,000 Tonnes of CO_2 underground into long term storage per year. This sounds a lot but is actually only a small fraction of the amount of CO_2 generated by a modern power station. The following shows this with some very simple maths and physics but in summary every tonne of pure carbon burnt will generate about 3.6 tonnes of CO_2 gas.

Carbon has an atomic weight of 12. This means that every atom of carbon has 12 times as much weight as a Hydrogen atom. Oxygen atoms have an atomic weight of 16. One molecule of CO_2 contains one carbon and two oxygen atoms and so has a weight of 44 times that of a hydrogen atom. Therefore changing one atom of carbon (the main component of coal) into a molecule of CO_2 increases the weight from 12 to 44 – an increase of 3.66. times the starting weight.

Since coal varies in purity depending on the source and type of the coal there will be a different amount of CO_2 produced per tonne of coal burnt. The other things in coal include various organic chemicals (from tar to a wide range of toxic chemicals) and other minerals including uranium, sand, limestone etc. (for further information you could try the Mineral Information Institute www.mii.org or the Wikipedia website at http://en.wikipedia.org/wiki/Anthracite). Therefore for the following calculation I have assumed that only 90% of the weight of coal burnt is available carbon.

A power station uses millions of tonnes of coal per year. The planned power station for Blyth/Cambois is predicted to use 6 million tonnes of coal a year. Therefore 90% of this multiplied by 3.66 to convert the carbon to CO_2 means that the power station will produce about 20 million tonnes of CO_2 per year, for an estimated life of 50 years, that is 1,000,000,000 tonnes, i.e. one billion tonnes of CO_2.

The Blyth/Cambois power station may generate 1 billion tonnes of CO_2 in its planned life.

Data published in 2005 by the IPCC stated that world power generation was responsible for 10,539 M Tonnes of CO_2 per year, making the Blyth/Cambois power station represent about 0.2% of world pollution by CO_2 from power stations. The same data also states that there are 4942 power stations included making the Blyth/Cambois station nearly 10 times the average size of the power stations identified in the study.

What other support is there for CCS?

The Government has supported smaller scale demonstration of the component parts of CCS. This was formally through the Hydrogen Fuel Cells and Carbon Abatement Technologies Demonstration Programme (HFCATT) scheme. This scheme is now supported through the Environmental Transformation Fund (ETF).

Additionally, the UK Energy Technologies Institute (ETI) considers CCS one of its future technology themes. With a potential billion pound budget for investment across a broad range of low carbon technologies, the ETI is bringing together government and some of the world's biggest companies with a view to accelerating the development of low-carbon energy technologies towards commercial deployment.

All of this support has still failed to provide a viable plan for a scheme capable of working at a full sized power station site.

Information sources

IPCC

The illustration on page 1 has been taken from the Intergovernmental Panel on Climate Change (IPPC) publication "IPCC Special Report Carbon Dioxide Capture and Storage – Summary for Policymakers" website www.ipcc.ch for the main site and www.ipcc.ch/ipccreports/special-reports.htm for special reports.

CCSA website

CCSA government list of sites where CCS is proposed for new build projects
http://ccsassociation.org.uk/ccs_projects/uk_projects.html#

World Coal Institute

CCS website www.worldcoal.org/pages/content/index.asp?PageID=414
The World Coal Institute describes its self as
"a non-profit, non-governmental association of coal enterprises and stakeholders – the only international body working on a worldwide basis on behalf of the coal industry. WCI has strong contacts and relationships with important international agencies, including the International Energy Agency and the World Bank, and has accredited consultative status with the United Nations."

BERR Government Website

What is CCS – BERR website
www.berr.gov.uk/whatwedo/energy/sources/sustainable/ccs/page42320.html

The 2006 Energy Review
www.berr.gov.uk/whatwedo/energy/whitepaper/review/page31995.html

The 2007 Energy white paper: meeting the energy challenge
www.berr.gov.uk/whatwedo/energy/whitepaper/page39534.html

The UK CCS Demonstration Competition
www.berr.gov.uk/whatwedo/energy/sources/sustainable/ccs/ccs-demo/page40961.html

The Hydrogen Fuel Cells and Carbon Abatement Technologies Demonstration Programme (HFCATT) scheme.
www.berr.gov.uk/whatwedo/energy/environment/etf/hfccat/page45482.html

The Environmental Transformation Fund (ETF).
www.berr.gov.uk/whatwedo/energy/environment/etf/page41652.html

Treasury Website

The Stern Review on the Economics of Climate Change
www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

Scottish Centre for Carbon Storage

Part of a research institute at Edinburgh University
World map of CCS projects
www.geos.ed.ac.uk/sccs/storage/storageSites.html