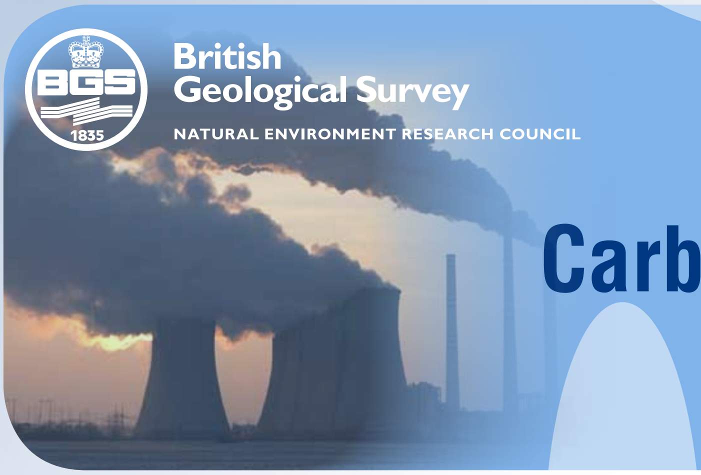

British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

SCIENCE BRIEFING 2011

Carbon capture storage: BGS research

BGS research is contributing to the siting and design of long-term storage facilities

What is climate change?

The term climate change refers to long term changes in regional or global weather patterns that can be felt or experienced or can be identified by statistical tests on meteorological records. Such changes may persist for long periods, typically decades, centuries or even longer.

Climate change can be caused by natural processes such as variation in solar radiation, cyclic changes in the tilt of the Earth's axis, interactions between the atmosphere and the oceans, volcanic activity and natural changes in the atmospheric concentration of 'greenhouse gases' such as carbon dioxide. Human activity also has the potential to cause significant climate change, principally by increasing greenhouse gases concentrations through industrialisation, changes in agricultural practice and deforestation.

What influence have humans had on climate change?

Since the start of the industrial revolution in the mid-eighteenth century, human activities have greatly increased the concentrations of greenhouse gases in the atmosphere.

Consequently, measured atmospheric concentrations of carbon dioxide are currently around 40% higher than pre-industrial levels and global temperatures about 0.8°C higher.

The main sources of greenhouse gases due to human activity are:

- burning fossil fuels — leading to higher carbon dioxide concentrations
- farming and forestry — including land use change via agriculture and livestock
- cement manufacture and oil refining
- aerosols manufacture — chlorofluorocarbons (CFCs)

What is Carbon Capture and Storage (CCS)?

CCS involves capturing carbon dioxide (CO_2) from large industrial emission sources, and then transporting it and storing it in a suitable underground geological formation.

Globally, emissions of CO_2 from fossil-fuel use in the year 2000 totalled about 24 billion tonnes with 60% attributed to large stationary emission sources such as power stations, cement factories and oil refineries.

Particulate rocks, such as sandstones, act like a sponge. The spaces between particles in a saline aquifer, like the spaces in between oranges in a box, are filled with brine.

Clusters of these sources are found around the world, notably in North America, Europe, East Asia and South Asia. Various approaches to reducing overall CO_2 emissions are now being investigated, but the main way to reduce CO_2 emissions from these large sources is CCS.

How do power stations capture CO_2?

Where fossil fuels are burnt for electricity, there are three techniques to remove the CO_2 — post-combustion capture, pre-combustion capture and oxyfuel combustion.

Post-combustion capture is the method that would be applied to most conventional power plants. Here the CO_2 is removed after burning the fossil fuel by capturing or 'scrubbing' it from the exhaust or 'flue' gases. The technology is well understood and is currently used in other industrial applications, but not at the same scale as would be required in a commercial-scale CCS power station.

Pre-combustion and oxyfuel combustion are less mature technologies. The former involves gasifying the fossil fuel (reacting it at high temperatures with oxygen creating a synthetic gas) and separating the CO_2 before the gas is burned. Oxyfuel combustion involves burning the fossil fuel in pure oxygen to produce a near pure CO_2 flue gas which doesn't require scrubbing.

> "The burning of fossil fuels will continue for decades to come. CCS is the only technology that can prevent associated CO_2 emissions from reaching the atmosphere."
> Andrew Chadwick, BGS

How can CO_2 be stored?

CO_2 can be stored in three main ways:

- in deep geological formations
- in deep ocean water — ocean storage
- in the form of mineral carbonates — mineral storage

Storage in geological formations is currently considered the most technically viable and environmentally secure option.

How does this work?

In CCS, carbon dioxide is commonly pressurised into a fluid known as 'supercritical CO_2', which has rather unfamiliar properties, being as dense as a liquid but flowing like a gas. The CO_2 is injected directly into porous (having free space) and permeable (able to let fluids flow through it) sedimentary rocks (e.g sandstone). The rocks may be in old, depleted oil fields, gas fields, or in saline aquifer formations. Unminable coal seams and basaltic volcanic rocks have also been suggested as having storage potential.

Fact file

- Depleted oil and gas reservoirs are estimated to have sufficient capacity to store around 30 years' worth of global fossil fuel emissions.
- CO_2 has been successfully and safely injected into the Utsira Sand, a major saline aquifer beneath the North Sea, for more than 14 years.
- The security of CO_2 storage sites increases with time as the CO_2 first dissolves in the formation water and then reacts to form new rock-forming minerals.
- Capture and storage applied to a power-station burning renewable biomass works as a 'carbon sink' effectively removing CO_2 from the atmosphere.

Many areas worldwide, such as the North Sea, the US Gulf Coast and offshore Australia are believed to contain huge amounts of geological storage space.

What scientific challenges are there?

One main challenge facing CO_2 storage is to accurately estimate the amount of useful storage space in a given region. We also need to be able to reliably predict and model the behaviour of the CO_2 in the storage reservoir in the short, medium and long term. It will be necessary to develop effective monitoring systems to monitor storage security (such as potential leakage) and to provide us with more data to enhance predictive models.

How can BGS help with CO2 storage?

BGS is active in most areas of CO_2 storage research. We are collaborating with other research partners to develop new methods for storage capacity assessment. Working at a number of large storage sites we are developing and refining sophisticated monitoring technologies to image and measure CO_2 in the storage reservoir. This data is being used to calibrate predictive flow models of future behaviour. We are also developing systems for detecting small amounts of CO_2 at the surface to measure any leaks that may develop. In our laboratories we are running long-term experiments to better understand the key stabilisation processes which are vital to ensuring long-term storage security.

More information: www.bgs.ac.uk/ccs

Contact Andrew Chadwick, CO_2 Storage Science Team Leader: rach@bgs.ac.uk

www.bgs.ac.uk