Can we survive without fossil fuels — or is our survival under greater threat from rising carbon dioxide emissions? **Nick Riley** describes how BGS is helping to address this conundrum.

Emission control

World energy use threatens the core of the global ecosystem upon which human society depends. Like it or not, the world is increasingly locked into fossil fuels. They are the most energy-dense, convenient and abundant fuels available. International Energy Agency projections show that over the next four decades as much fossil fuel will be burnt as has been used throughout human history.

Against this forecast, the prospect of curtailing world carbon dioxide (CO_2) emission growth without using the emerging technology of CO_2 capture and storage (CCS) is bleak. Achieving at least a 60% CO_2 emission reduction by 2050 and staying within a 2°C rise in average global temperature above natural levels (agreed by EU member states) is a monumental and urgent challenge. For more than 15 years the BGS has led research nationally and internationally into the feasibility of capturing CO_2 emissions from large, industrial point sources (such as electricity power plants, or oil and gas facilities) and storing it underground.

Our work on CO_2 storage has several strands. Foremost is that of calculating the potential storage capacity of the porous deep saltwater-filled rocks (saline aquifers) and hydrocarbon fields considered suitable for permanently retaining CO_2. The BGS, together with international partners, has been at the forefront of developing standard methodologies to achieve this since the early 1990s. These methodologies are now adopted internationally by the Carbon Sequestration Leadership Forum. Our latest estimates for the UK's CO_2 storage capacity using these methodologies has been published by the Department for Business, Enterprise and Regulatory Reform (report URN06/2027). It demonstrates that the UK has ample capacity to store its large point-source CO_2 emissions.

Another very important aspect of our research is that of being able to monitor and model the behaviour and ultimate fate of CO_2 through the injection and post-injection period of a storage operation. This knowledge has been gained from experience with large-scale CO_2 injection operations such as that at Sleipner, in the North Sea (described in *Earthwise* issue 24). Although all storage sites have features in common, each site is also unique. To reflect this diversity we have developed an online decision-support tool which assists in selecting the monitoring technologies which best match a site's location (such as onshore or offshore) and geological characteristics. This tool is available on the International Energy Agency Greenhouse Gas R&D Programme website (**www.co2captureandstorage.info/co2tool_v2.1beta**) and is continually being updated.

CO_2 capture and storage (CCS) is the only the way to achieve near zero emissions from coal-burning power plants, such as these in the Latrobe Valley, Australia.

Emissions from aviation are growing and are difficult to reduce. One way to compensate for this is by cutting ground-based CO_2 emissions.

In order to store land-based CO_2 beneath the seabed it has been necessary to amend international conventions and protocols that concern marine environmental protection. We have been closely involved in providing geotechnical advice to the UK government since this work started in 2003. In February 2007 the London Convention and its Protocol were amended and the OSPAR Convention has since recommended that CO_2 storage should also be recognised within its agreements (**www.ospar.org**). An important aspect here has been the recognition that CO_2 emissions to the atmosphere pose a major threat to marine life especially marine organisms that have calcified skeletons. This is because the oceans are the major sink for anthropogenic CO_2 emissions. If emissions continue to rise at current rates the oceans will become more acidic. Another important international regulatory need is that of providing guidelines for CCS projects adopted in national greenhouse gas accounting inventories. We played a major role in helping formulate the guidelines published by the Intergovernmental Panel on Climate Change (IPCC).

The safety of CO_2 storage, especially the risk of leakage from storage to the surface, is a matter of concern to the public, policy makers and regulators. Storage sites are designed not to leak and are not expected to do so. Nevertheless, it is prudent to know what would be the consequences of leakage, how it might occur, and whether it could be detected. To gain this knowledge we need to study natural analogues, places where CO_2 is coming to the surface in various parts of the world, usually associated with volcanic activity (see *Earthwise* issue 24). The BGS led the world's first study of this kind, the Nascent Project (**www.bgs.ac.uk/nascent**), and has now taken this work forward with European partners through its co-ordinating role with the European Research Network of Excellence (CO2GeoNet: **www.co2geonet.com**), supported by the European Commission's Sixth Framework Programme. The BGS has played a major part in this area of research, deploying its mobile field laboratory, and the NERC's airborne facilities to study natural CO_2 seeps in Germany and Italy. One strategy has been to compare ground-based and airborne detection methods. We have also been involved, with partners, in small-scale field and laboratory experiments using marine and terrestrial sediments, exposing them to raised CO_2 levels.

The emerging economies represent the fastest growth in fossil fuel demand. It is a high priority to engage with these countries and help pave the way there for CCS. We are involved with partners in appraising the feasibility of geological storage in eastern Europe and most importantly in China and India. These two countries have a large dependency on coal-fired power generation and are set to become the dominant greenhouse gas emitters unless CCS is deployed. Of particular importance is the Near Zero Emission Coal (NZEC) initiative led by the UK, the European Commission and China. The aim of this initiative is to pave the way for the building of China's first CO_2 capture and storage operation fitted to a conventional coal-burning power plant.

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The BGS has provided the underpinning strategic science and advice to investigate the feasibility of storing CO_2 underground for many years. It is therefore particularly exciting for us to see CCS becoming a reality. The UK will have its first commercial-scale demonstration of CCS fitted to a coal-burning power plant within seven years. This is an important step forward, but we must not be complacent. Each year global CO_2 emissions are rising by around 750 million tonnes. This means that, to hold emissions at current levels, the world needs to be deploying at least the equivalent of 750 Sleipner-sized storage projects (one million tonnes of CO_2 each) every year. We still have a long way to go but it is clear that CCS is gaining momentum to play its essential part among a portfolio of technologies and strategies to reduce emissions. We will describe our activities in non-fossil-based clean energy research in a future issue of *Earthwise*.

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