What is carbon dioxide capture and storage?

In the face of mounting atmospheric carbon dioxide (CO_2) levels resulting from anthropogenic emissions and their environmental and economic consequences, various mitigation strategies are under consideration. One strategy considered to have potential is carbon dioxide capture and storage (CCS).

The problem

CO_2 is an essential and natural component of our atmosphere, supporting all life on Earth. It drives plant growth through photosynthesis, which underpins most terrestrial and marine food webs, forms the basis of human food production and provides around half of the oxygen we breathe. Under natural circumstances the amount of CO_2 in the atmosphere remains more or less in balance, but since the industrial revolution (c.1860) human activities - various industrial and commercial processes, the use of fossil fuels and changes in land use - have led to increasing amounts of CO_2 entering the atmosphere. CO_2 is a potent greenhouse gas, so this 'extra' anthropogenic CO_2 has led to global warming, climate change and, when it enters seawater, ocean acidification.

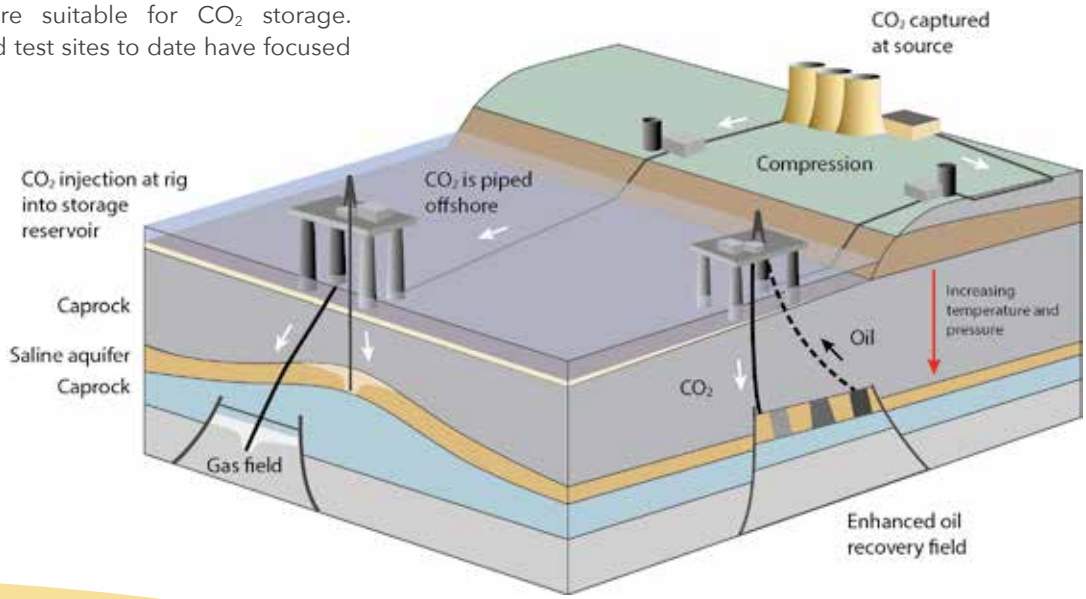
One solution?

CCS, often called carbon capture and storage, is the process whereby CO_2 is captured at production sources such as industrial plants or power stations, and transported via pipelines, road and/or sea to a storage location. Here it is pumped into geological strata deep below ground or beneath the seabed for long-term isolation from the atmosphere.

However, not all strata are suitable for CO_2 storage. Investigations, field trials and test sites to date have focused on depleted oil and gas reservoirs, saline aquifers that have potential to hold CO_2 within their pore fluids, and unmineable coal seams where the CO_2 is adsorbed into the permeable coal.

Costs

The costs involved in CCS include the CO_2 capture process, transportation infrastructure, ensuring any site is suitably sealed to prevent escape, and investing in the necessary technology to inject the CO_2 into the storage reservoir. Existing oil and gas reservoirs are often favoured because they may already satisfy some of these criteria, which can help keep costs to a minimum. In fact, injection of CO_2 into economically unviable oil and gas reservoirs can result in further recovery of hydrocarbons, a technique known as Enhanced Oil/Gas recovery (EOG/EGR) which has been used by the oil industry since the 1970s. Likewise, injecting CO_2 into suitable coal seams may result in the displacement of methane, which can be collected and used to offset the cost of CO_2 injection. The financial bonus of obtaining further hydrocarbons as a side-effect of CO_2 injection is a significant factor in making CCS economically viable.



Right: schematic cartoon showing the priciples of offshore carbon capture and storage, including the use of CO_2 injection in Enhanced Oil Recovery (EOR). After AFP, European Commission, USGS.

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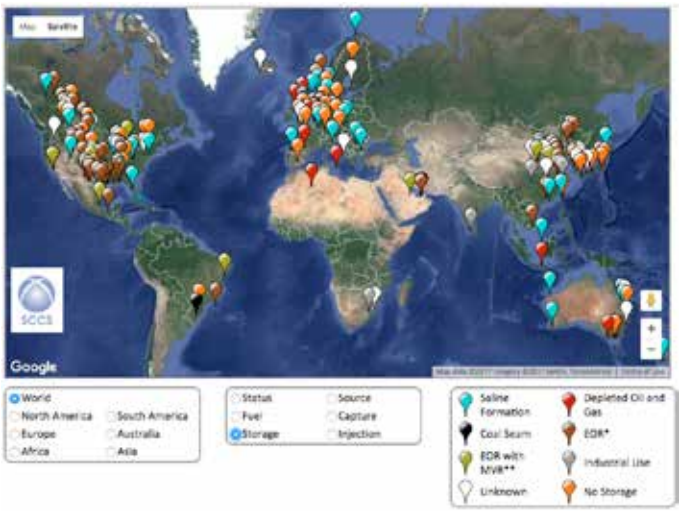
Existing CCS projects

Globally there are 22 CCS projects operating or under construction; 16 are in North America. Of the total, only 3 capture CO_2 from power stations, and 16 schemes will pump CO_2 underground to force more oil out of the wells (EOR). Another 7 projects are in an advanced stage of development, and 11 others are at an early stage. Currently the UK has no operational CCS projects although a small number are planned. In Europe, there are three operational sites located in the North and Norwegian Seas; various others are being planned while others have been cancelled or are currently dormant.



Location of large-scale CCS project workdwide. Source Scottish Carbon Capture & Storage www.sccs.org.uk/map

How much CO_2 can we expect to capture?

When all the existing CCS projects are operational they are projected to capture and store 40 million tonnes of CO_2 annually. This is the equivalent of 0.1% of current annual global CO_2 emissions. The Intergovernmental Panel on Climate Change (IPCC) expects this capacity will need to rise to 60,000 million tonnes by the end of the century - this figure is about 15 times that of the current amount of oil extracted annually so the challenge is enormous. Whilst this will not account for all of the CO_2 being produced, it will go some way to meeting internationally agreed reduction targets.

Objections to CCS

Many new technologies face resistance to their implementation, based on real and/or perceived issues. Among the objections raised against CCS is that it may detract from the need to reduce CO_2 sources by attempting to 'bury' the emitted CO_2, or that by producing more hydrocarbons through EOR/EGR the purpose of CCS is defeated. There is also the suggestion that the environmental cost of capturing, transporting and storing CO_2 does not make economic sense.

Supporters point to the fact the CO_2 problem is already here and getting worse, so rapid action is required - and CCS has the potential to have an immediate impact on preventing emissions reaching the atmosphere. Other objections concern safety aspects and focus on potential catastrophic 'blow-outs', leakage from the storage reservoir, and potential harm to the environment and humans. Safety aspects are paramount at all stages of the CCS process, and are addressed by domestic health and safety legislation and environmental guidelines, which are constantly evolving. A key part of initial surveys and monitoring is to ensure that a CO_2 storage site is safe and secure as well as technically suitable.

Monitoring a controlled seafloor CO_2 release experiment for research purposes. Image courtesy H. Stahl/SAMS.

CCS is one potential mitigation strategy to reduce the amount of CO_2 reaching the atmosphere and ocean. In combination with more efficient hydrocarbon use, development of renewable energies and an overall reduction in CO_2 emissions, CCS has the potential to be an important part of the package for alleviating climate change-related impacts on our planet.

Resources and further reading

- Maroto-Valer, M.Mercedes (Ed) Developments and innovation in carbon dioxide (CO_2) capture and storage technology, Vol 2: Carbon dioxide (CO_2) storage and utilisation. Woodhead publishing 2010.
- Global CCS projects: www.carbonbrief.org/around-the-world-in-22-carbon-capture-projects
- Scottish CCS Research Group: www.sccs.org.uk

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The STEMM-CCS consortium comprises 12 partners across Europe, coordinated by the National Oceanography Centre, UK. For more information please visit www.stemm-ccs.eu