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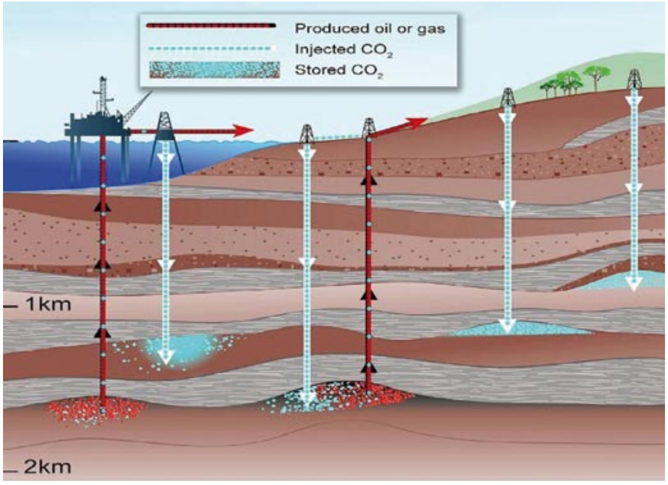
Quick Guide to Carbon Dioxide Capture and Storage



Definition

Carbon Dioxide Capture and Storage (CCS) describes a set of technologies which can be used to collect carbon dioxide (CO_2) from industrial processes and power generation, separate and purify it, transport it to a storage site, compress it to a form suitable for storage and then place it in long term storage where it will remain indefinitely. Various forms have been conceived for permanent storage of CO_2. These forms include gaseous storage in various deep geological formations (including saline formations and exhausted gas fields), liquid storage in the ocean, and solid storage by reaction of CO_2 with metal oxides to produce stable carbonates.

Shell is principally interested in geological storage, although some work is taking place in the area of mineralization. The issue with the latter is the much smaller scale on which it operates. Shell is not working on ocean storage.

Potential Use

CCS is a technology typically imagined for coal-fired power generation. A 1 GW coal fired power station emits about 8 million tonnes of CO_2 per annum, for a total of 400 million tonnes of CO_2 in its 50-year life. The construction of coal-fired power generation is accelerating, with China and India in particular utilising this technology to support their rapid development. China is building some 50 GW of new coal-fired capacity each year (IEA World Energy Outlook 2007).

CCS applied to a modern conventional power plant could reduce CO_2 emissions to the atmosphere by approximately 80-90% compared to a plant without CCS. Capturing and compressing CO_2 requires energy and would increase the fuel needs of a plant with CCS by up to 20%.

CCS is also a technology of interest to the oil industry. Most refineries operate hydrogen-manufacturing facilities that vent nearly pure CO_2 to atmosphere as a waste product. This CO_2 could be captured and stored, thus lowering the CO_2 emissions of the refinery. Future refineries upgrading bitumen products from oil sands require even more hydrogen and often have substantial electricity generating facilities associated with them. These relatively higher emitting operations could use CCS to lower their overall emissions to levels comparable with conventional refining.

Longer term, CCS could play an important role in the transport sector. Two options are possible;

- If hydrogen becomes an important transport fuel, CCS would allow this fuel to be centrally manufactured from fossil sources without CO_2 emissions.
- If bio-fuels predominate, CCS could be used to store CO_2 emitted from the fermentation step in the process of ethanol manufacture, resulting in a net CO_2 removal from the atmosphere. Such a future strategy could even be important in addressing any overshoot in atmospheric CO_2 concentrations.

Why do we need CCS?

Almost all future pathways to a 450 - 550 ppm atmospheric concentration of CO_2 require CCS. Only a high nuclear scenario can reduce it. The World Business Council for Sustainable Development report "Pathways to 2050" showed that by 2050 some 1,000 large coal fired power plants could be in operation utilising CCS, with all new facilities using CCS from 2025.

The timing of CCS deployment is also critical. A study using the Shell World Energy Model that underpins our scenarios showed that each year we delay the widespread deployment of CCS beyond 2020 would translate into a 1-ppm increase in long-term atmospheric stabilization levels of CO_2. In other words, assuming deployment by 2020 can still result in a 450 ppm stabilization, then deployment by 2021 will mean that 451 ppm is the best we can achieve, and so on.

Capturing the CO_2

There are three types of CCS technology applied to coal-fired power generation;

- Post combustion – the flue gas from a coal-fired power station is stripped of its CO_2, which is then available for storage.
- Pre combustion – the coal is gasified rather than combusted, producing syngas (CO + H2). CO_2 can be easily recovered from syngas and is then available for storage.
- Oxyfuel combustion – this is a variation of post combustion, but the fuel is burned in oxygen instead of air, such that the flue gas consists mainly of carbon dioxide and water vapour.

Storing the CO_2

As CO_2 is pumped deep underground it is compressed by the higher pressures and becomes essentially a liquid, which then becomes trapped in the pore space between the grains of rock. Typically, an impermeable layer of cap-rock, such as shale, ensures that the CO_2 does not rise back to the surface. The presence of CO_2 in geological structures is a naturally occurring phenomenon. Occasionally CO_2 wells are drilled so that the CO_2 can be used for enhanced oil or gas recovery.

Over time, depending on the geology of the storage site, the CO_2 can react with the minerals in the rock, forming new minerals and providing increased storage security.

The Future of CCS

CCS is one of the few technologies that is entirely climate change driven, which means development and deployment will not happen without policy intervention.

A market price for CO_2 emissions, such as generated by the EU Emissions Trading System, is an effective deployment tool, but CCS must first be recognised as a valid mitigation technology by such systems. A legal framework must also exist to cover storage and long-term liability. Only the EU has proposed such recognition and the necessary framework.

Given that coal-fired power generation is growing rapidly in India and China, recognition of CCS as a valid emissions reduction technology under the Clean Development Mechanism (CDM) of the Kyoto Protocol is also a priority.

But CCS is at a difficult stage in its development. Whilst all the individual technologies making up a CCS plant are in operation somewhere for some reason, a single end-to-end plant (e.g. coal-fired power station with CCS) has yet to be built. Large-scale demonstration is now essential. This remains a pressing issue due to cost. The potential for delay is high.