Carbon Capture & Storage Technologies

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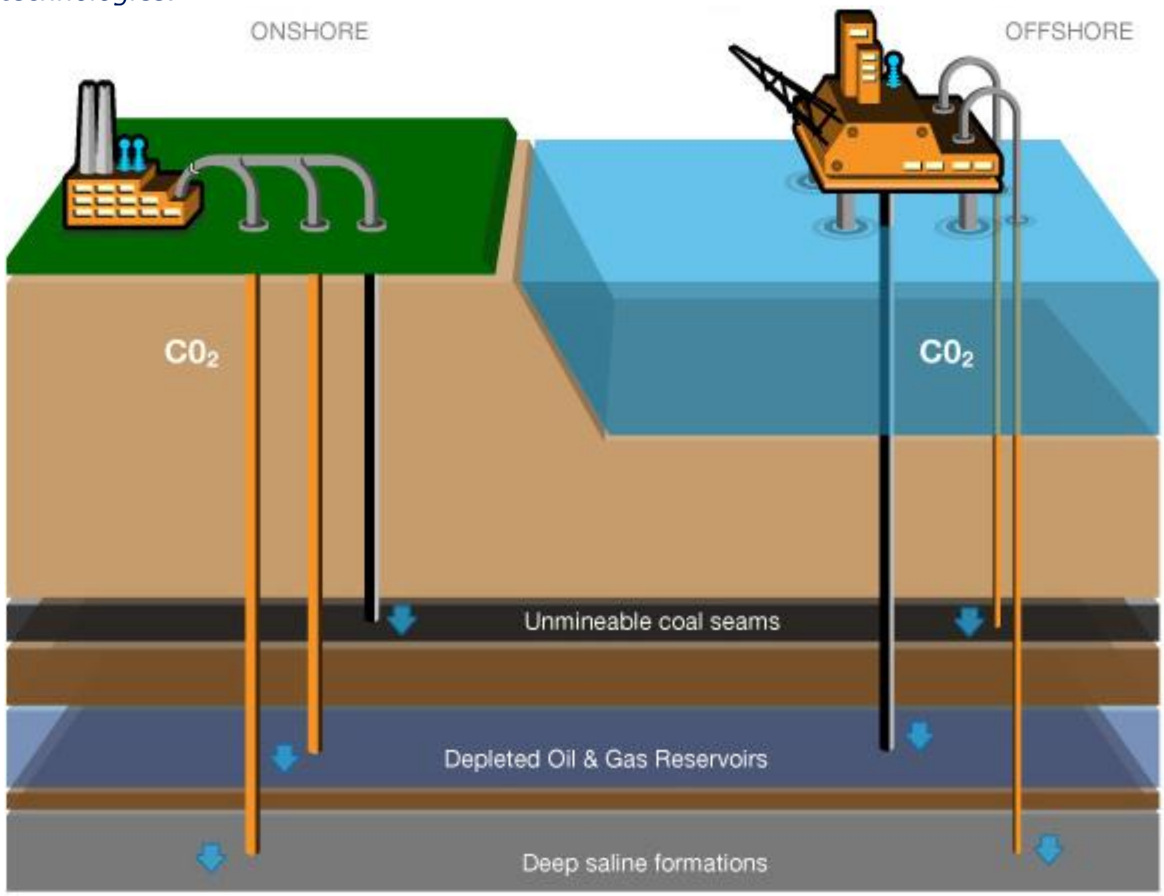

Addressing the challenge of climate change, while meeting the need for affordable energy, will require access to and deployment of the full range of energy efficient and low carbon technologies. Capturing carbon dioxide that would otherwise be emitted to the atmosphere and injecting it to be stored in deep geological formations (CCS) is the only technology currently available to make deep cuts in greenhouse gas emissions from fossil fuel use while allowing energy needs to be met securely and affordably.

CCS is not a replacement for taking actions which increase energy efficiency or maximising the use of renewables or other less carbon-intensive forms of energy. A portfolio approach taking every opportunity to reduce emissions will be required to meet the challenge of climate change.

Is CCS a proven technology?

All the elements of CCS have been separately proven and deployed in various fields of commercial activity. In fact, around 1 million tonnes of CO_2 has been stored each year at the Sleipner projectsince it started operating in 1996.

The vital next stage – which is where we are right now – is the successful demonstration of fully integrated, large-scale CCS systems fitted to commercial-scale power stations. Failure to deploy CCS will seriously hamper international efforts to address climate change. TheIntergovernmental Panel on Climate Change (IPCC) (link opens PDF of IPCC 2005 Special Report on CCS) has identified CCS as a critical technology to stabilise atmospheric greenhouse gas concentrations in an economically efficient manner. The IPCC has concluded that by 2100, CCS could contribute up to 55% of the cumulative mitigation effort whilst reducing the costs of stabilisation to society by 30% or more.

How is CO_2 Captured?

While CO_2 capture technologies are new to the power industry, they have been deployed for the past sixty years by the oil, gas and chemical industries. They are an integral component of natural gas processing and of many coal gasification processes used for the production of syngas, chemicals and liquid fuels. There are three main CO_2 capture processes for power generation.

- *post-combustion*
- *pre-combustion*
- *oxyfuel*
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'Post-combustion' capture *involves separating the CO_2 from other exhaust gases after combustion of the fossil fuel. Post-combustion capture systems are similar to those that already remove pollutants such as particulates, sulphur oxides and nitrogen oxides from many power plants.*
The most commonly used process for post-combustion CO_2 capture is made possible through special chemicals called amines. A CO_2 rich gas stream, such as a power plant's flue gas, is "bubbled" through an amine solution. The CO_2 bonds with the amines as it passes through the solution while other gases continue up through the flue. The CO_2 in the resulting CO_2-saturated amine solution is then removed from the amines, "captured" and is ready for carbon storage. The amines themselves can be recycled and re-used.
Whilst post-combustion CO_2 capture is technically available now for coal-based power plants, it has not yet been used commercially for large-scale CO_2 removal.
'Pre-combustion' capture *involves separating CO_2 before the fuel is burned. Solid or liquid fuels such as coal, biomass or petroleum products are first gasified in a chemical*

reaction at very high temperatures with a controlled amount of oxygen. Gasification produces two gases, hydrogen and carbon monoxide (CO). The CO is converted to CO_2 and removed, leaving pure hydrogen to be burned to produce electricity or used for another purpose. The CO_2 is then compressed into a supercritical fluid for transport and geological storage. The hydrogen can be used to generate power in an advanced gas turbine and steam cycle or in fuels cells – or a combination of both.

Oxyfuel combustion *(also called oxyfiring) involves the combustion of coal in pure oxygen, rather than air, to fuel a conventional steam generator. By avoiding the introduction of nitrogen into the combustion chamber, the amount of CO_2 in the power station exhaust stream is greatly concentrated, making it easier to capture and compress. Oxyfuel combustion with CO_2 storage is currently at the demonstration phase.*

Each of these capture options has its particular benefits. Post-combustion capture and oxyfuel have the potential to be retrofitted to existing coal-fired power stations and new plants constructed over the next 10-20 years. Pre-combustion capture utilising IGCC is potentially more flexible, opening up a wider range of possibilities for coal, including a major role in a future hydrogen economy.

All the options for capturing CO_2 from power generation have higher capital and operating costs as well as lower efficiencies then conventional power plants without capture. Capture is typically the most expensive part of the CCS chain. Costs are higher than for plants without CCS because more equipment must be built and operated. Around 10-40% more energy is required with CCS than without [IEA GHG]. Energy is required mostly to separate the CO_2 from other gases and to compress it, but some is also used to transport the CO_2 to the injection site and inject it underground.

As CCS and power generation technology become more efficient and better integrated, the increased energy use is likely to fall significantly below early levels. Much of the work on capture is focused on lowering costs and improving efficiency as well as improving the integration of the capture and power generation components. These improvements will reduce energy requirements.

Transportation

The technology for CO_2 transportation and its environmental safety are well-established. CO_2 is largely inert and easily handled and is already transported in high pressure pipelines.In the USA, $CO_2$is already transported by pipeline for use in Enhanced Oil Recovery (EOR).

The means of transport depends on the quantity of CO_2 to be transported, the terrain and the distance between the capture plant and storage site. In general, pipelines are used for large volumes over shorter distances. In some situations or locations, transport of CO_2 by ship may be more economic, particularly when the CO_2 has to be moved over large distances or overseas.