Carbon capture utilisation and storage: An evolving approach to mitigating climate change

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Carbon Capture and Storage (CCS) is a set of technologies under development to reduce carbon dioxide (CO_2) emissions from large stationary sources, notably fossil energy power plants and industrial facilities. CCS involves the separation and compression of CO_2 from an exhaust stream of an industrial or power plant, its transportation to a storage site and injection into a deep geologic storage formation. The fate of the CO_2 is secure and safe disposal in that formation through various geologic trapping mechanisms. In recent years, innovative scientists and engineers have been expanding the ways to dispose of captured CO_2 to include beneficial reuse of the CO_2 for various purposes.

Carbon capture utilisation and storage (CCUS)

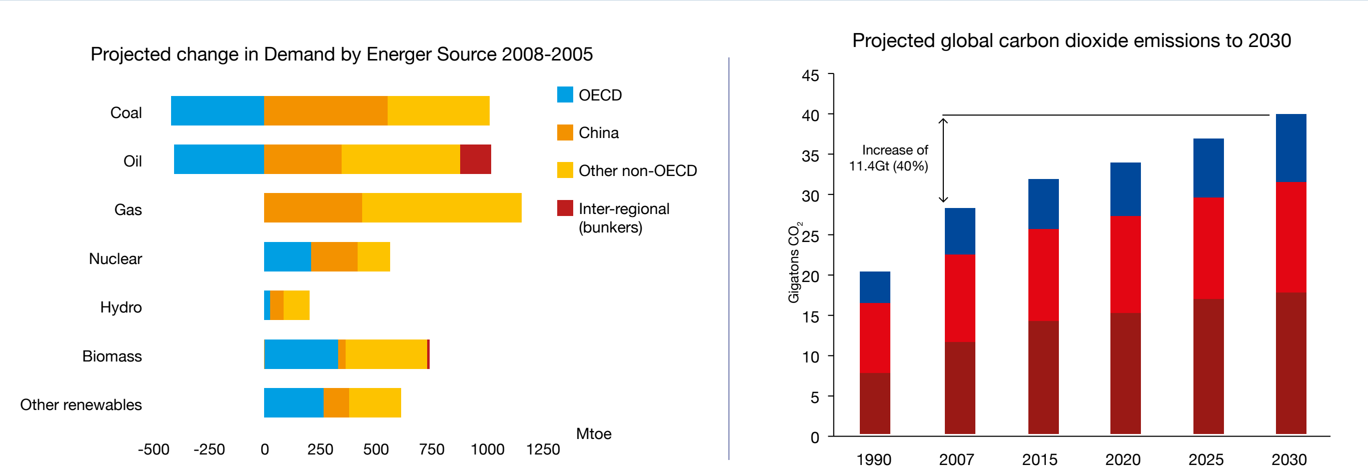
Probably the most well-developed type of reuse is Enhanced Oil Recovery (EOR). In EOR, injected CO_2 raises the pressure in reducing oil fields, increasing the production of oil. This ability to increase oil production gives the CO_2 a monetary value. Similar methods to increase natural gas production through Enhanced Gas Recovery (EGR) from decreasing natural gas fields and Enhanced Coal Bed Methane (ECBM) from deep un-mineable coal seams. Relatively small amounts of CO_2 have also already been captured from various industrial sources for decades for various high-value industrial uses such as carbonated drinks, growing flowers in greenhouses and chemical processes.

Newer beneficial reuse applications include fertiliser, cement, algae and plastics production. Most are in an early stage of development. Research into reuse applications for CO_2 has been increasing and a new term is emerging: Carbon Capture Utilisation and Storage (CCUS). While beneficial reuse is unlikely to be applied to most captured CO_2, early beneficial reuse applications can help to accelerate the use of CO_2 capture technologies, improve their economics and widen their applicability.

The Need for CCUS

CCUS is projected to play a large, critical and unique role in reducing CO_2 emissions on a significant scale to avoid climate change. There is now a broad global consensus to set a goal of making CCS widely commercial by 2020. CCUS together with nuclear hydropower is the only available large scale low carbon technology. As Figure 1 shows, CO_2 emissions, if uncontrolled, are projected to grow rapidly over the coming decades. This growth is largely driven by expected increases in global demand for fossil fuels, particularly in China and other developing (non-OECD) countries. This increase in energy demand is a natural result of the rapid economic expansion of their economies as the emerging economies strive to provide their people with the basic requirements of modern life. This creates a dilemma — reconciling that need for fossil

Figure 1: projected energy demand and CO_2 emissions under current polices

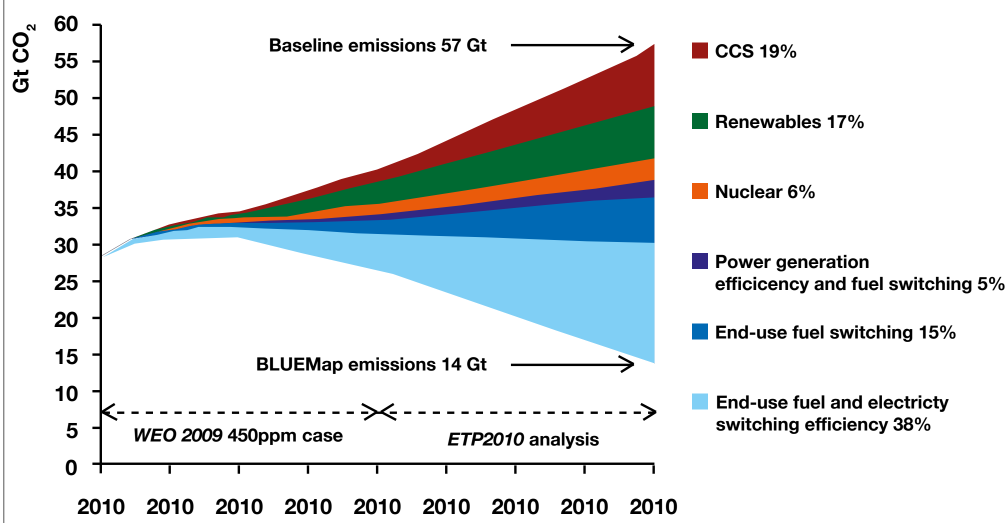


Source: International Energy Agency, World Energy Outlook 2010, November 2010 energy with the necessity to reduce CO_2 emissions. CCUS will be vital to resolving that dilemma because it enables fossil energy use without the corresponding emissions.

Role of CCUS in Reducing Global CO2 Emissions

The International Energy Agency recently conducted what is probably the most thorough and detailed analysis of how CO_2 emissions can be cut in half by 2050, which is the minimum reduction the UN Intergovernmental Panel on Climate Change (IPCC) estimates is necessary to prevent most of the damage resulting from climate change. The results are shown in Figure 2.

Figure 2: Key technologies for reducing C0$_2$ emmissions



Source: International Energy Agency, World Energy Outlook 2010, November 2010

While this study focused on the subset of CCUS applications that can be termed CCS, several conclusions can be drawn from this figure:

- A wide range of technologies will be necessary to achieve the 50 per cent emissions reduction goal.
- The largest opportunity to reduce emissions is to improve energy efficiency.
- CCUS can achieve the second largest emission reductions, even greater than renewable energy.

The conclusion about the large potential for CCUS is not widely known. It is based on the large number of potential cost-effective applications worldwide in both power generation and industry. This conclusion would be even more strongly supported had the full range of potential applications for beneficial reuse been considered.

Progress on CCUS

Engineers and scientists have been developing CCS for nearly twenty years and have made substantial progress. Work to develop CCS technologies and practices, in particular, has been ramping up considerably throughout the world over the last decade. Once just the exotic dream of a few scientists, CCS is now well on its way to becoming a commercial reality. This work is now expanding to cover CCUS.

Capture technologies can be used for the full range of CCUS applications. Several pilot-scale capture projects are currently in operation and numerous tests of geologic storage have been undertaken and are proving successful in demonstrating safe and secure long-term storage. A wide range of capture technologies for power generation have been developed and are currently being refined, with costs of capture now starting to come down. Millions of tons of CO_2 have now been injected into diverse geologic formations around the world. Much has been learned about how to inject CO_2 safely, how to monitor it underground, and what happens to the CO_2 in the geologic formations into which it has been injected.

Several large-scale commercial projects are now reliably in operation, some for over a decade. These include the Great Plains Gasification/Weyburn-Midale project in the United States and Canada (an example of CCUS), the Sleipner and Snøhvit projects offshore from Norway, In Salah in Algeria, and the Gorgon Project in Australia.

The Great Plains/Weyburn-Midale project is a particularly interesting example of CCUS because it is fully commercial and involves the capture of CO_2 from a coal gasification plant in the US state of North Dakota and its storage and use for EOR in depleting oil fields in the Canadian province of Saskatchewan. The CO_2 is carried by pipeline about 200 miles to the oil fields.

The capture technology at the Great Plains Gasification Plant (shown in Figure 4) is pre-combustion capture, one of several approaches to capture. The Weyburn-Midale CO_2 storage component of this project in Saskatchewan also hosts a major international research project led by the IEA Greenhouse Gas R&D Programme to monitor what happens to the injected CO_2. The results of over a decade show that the CO_2 is securely trapped in formation and that the CO_2 can be reliably monitored.

Great Plains Gasification and CO_2 Capture Plant

Photo courtesy of Basin Electric Power Cooperative

Overcoming the Remaining Challenges

While progress to develop CCUS has been substantial, much more work remains to be done to make it widely commercial. Substantial challenges remain. Some are technical and others are institutional. These include:

Technical Challenges

- High capture costs and energy requirements
- Work to develop beneficial reuse applications
- Need for further storage experience
- Undeveloped CO_2 transport infrastructure in most regions
- Water requirements for capture

Institutional Challenges

- Lack of value for CO_2 emissions reductions
- Inadequate legal and regulatory frameworks
- Limited public awareness of CCS, its benefits and safety

These challenges vary by country. They are particularly severe in developing countries where CO_2 emissions are expected to increase the most. In developing countries, the highest priority is generally economic development, financial capacity is the most restricted, and capacity to implement CCUS is most limited.

Work is underway throughout the world to overcome these challenges and technical progress has been particularly great. Increasingly, progress involves global collaboration through such organisations as the Carbon Sequestration Leadership Forum and the WEC Committee on Cleaner Fossil Fuel Systems.

Legal and regulatory frameworks for CCUS are being put in place in several international, national and sub-national jurisdictions. The most fundamental challenge is that, in most places, reducing CO_2 emissions through emissions trading schemes, tax incentives, carbon taxes, or other mechanisms lacks adequate economic value to justify widespread commercial investments in CCUS. ❑