CCS

inFocus Carbon Capture & Storage

Why Carbon Capture and Storage?

Climate change is a complex and challenging problem with many variables and no all-encompassing solution. That is why developing a "portfolio," or range of responses, is thought by many experts to be the best strategy for dealing with this issue. Among the most promising potential climate change solutions, especially for countries reliant on large fossil fuel reserves, is carbon dioxide (CO_2) capture and storage (CCS), also known as sequestration.

Overview

Fossil fuels — coal, oil, and natural gas — provide the vast majority of energy (particularly electricity) needed daily to power global business, industry, recreation, and general quality of life.[1] But these resources — especially coal — are also the most carbon-intensive energy options: In 2007, coal delivered a little over one-quarter of world energy to end users and nearly 42 percent of global CO_2 emissions.[2]

Complicating matters is the fact that energy from generally plentiful and affordable supplies of fossil fuels has long been considered an important factor enabling economic growth. Top coal producing nations — such as the U.S., China, India, and Russia — possess both abundant reserves and extensive infrastructures (generating plants, distribution systems, etc.) based on long-term market signals, and are unlikely to replace their reliance in the short- and intermediate-term. Meanwhile, the growing economies of developing nations are expected to require significantly more energy to meet expected future demand,[3] much of which could come from fossil fuels.

Many respected scientists agree with the idea that excessive atmospheric greenhouse gas (GHG) emissions (including CO_2) — caused by human activity — are statistically linked to the challenge of global climate change.[4] If developing nations — where

CCS is one part — not the whole — of a wider portfolio strategy for achieving significant cuts in atmospheric CO_2 emissions. It is a promising option for helping to retain coal and other essential fossil fuels as important energy contributors in a carbon-constrained world.

Did You Know?

[1] According to the International Energy Agency (IEA), fossil fuels account for more than 80 percent of present world energy consumption. OECD/IEA, "World Energy Outlook 2008: Executive Summary," 2008, 4.

[2] U.S. Energy Information Administration, "International Energy Outlook 2010," July 2010, 123–125.

[3] OECD/IEA, "World Energy Outlook 2009: Executive Summary," 2009, 4.

[4] United Nations Intergovernmental Panel on Climate Change (U.N. IPCC), "Climate Change 2007: Synthesis Report," 2007, 36.

an estimated 1.5 billion people[5] or more currently live without electricity — create and follow a coal and fossil fuel-powered grid minus a way of limiting CO_2 emissions, the worldwide buildup of this GHG would greatly increase.

The practical challenge facing developed nations is **how to continue to depend on coal as a primary electricity source while assuring this reliance is both economically and environmentally sustainable**. Of equal importance is a philosophical challenge: In an increasingly carbon-constrained world, what workable solution and example can these nations provide for developing economies to follow?

- Developing a portfolio approach is believed by many experts to be the most suitable, potentially effective and sustainable response to these questions. While energy efficiency improvements and increased use of renewable and nuclear energy are important components of this portfolio, CCS is among the most promising solutions, especially for countries reliant on large fossil fuel reserves. A key to this approach is that **it can reduce CO_2 output from present stationary sources (such as power plants) as well as help to avoid future atmospheric emissions**.

What is CCS?

CO_2 is a by-product that results when the energy of a fossil fuel is released during oxidation or combustion. The problem of control is far more difficult with CO_2 than with other air emissions, because — as a primary product of oxidation or combustion — the quantities of CO_2 that must be removed dwarf those of other coal combustion by-products, such as sulfur dioxide (SO_2) and nitrogen oxides (NO_X).

CCS is a group of technologies for effectively (1) capturing CO_2 from industrial or power plants; (2) compressing and transporting it; and, (3) storing it in geological formations by injecting it into suitable, permanent sites underground. The major application of CCS is to reduce CO_2 emissions from fossil fuel power plants, principally plants fired by coal and natural gas. However, CCS can also be applied to CO_2-intensive industries, such as cement, iron and steel, petrochemicals, and oil and gas processing.

Geologic storage is possible in a number of ways, including in:

- Depleted and declining oil fields, where it is presently used to enhance oil recovery (EOR);
- Depleted natural gas fields;
- Very deep saline formations, which underlie much of the world;
- Other significant geologic formations, such as basalts; and
- Unmineable coal seams, which may add to natural gas supply by displacing methane in the coal.

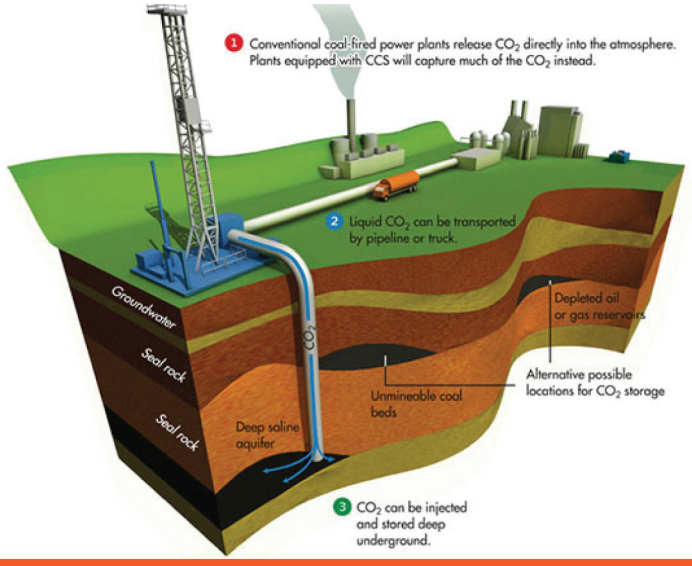
Why is CCS of interest in the climate change debate?

Carbon intensive fossil fuels, especially coal, are the primary means of worldwide energy production, a scenario many forecasts do not expect to change appreciably over the near and intermediate term. For example, the International Energy Agency (IEA) forecasts that fossil fuels will remain the dominant sources of primary energy worldwide through 2030, with coal's share of the global power sector rising 3 percent to 44 percent.[6] Much of the increase in coal use is expected to come from developing countries, particularly China and India.

CO_2 is the largest GHG in terms of quantity. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), comprising noted climate scientists from around the world, warming of the earth's climate is "unequivocal." Regarding the role attributed to anthropogenic (human-caused) emissions in the enhanced global

[5] United Nations Development Program, "The Energy Access Situation in Developing Countries," November 2009, 1.

[6] OECD/IEA, "World Energy Outlook 2008: Executive Summary," 2009, 4.



CCS is essentially a group of technologies for:

1. **Capturing CO_2 from industrial sources or power plants;**
2. **Compressing and transporting it; and,**
3. **Storing it in suitable geologic formations underground.**

Did You Know?

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greenhouse effect, the IPCC adds: "Global atmospheric concentrations of [greenhouse gases] have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years…"[7] Assessments by the IPCC and UN Environment Programme suggest the Earth's climate has already warmed as a result of these emissions over the past century and will continue to do so without a change in policy.

The scale of the problem suggests the scale of CO_2 reduction needed to address potential worldwide CO_2 emissions could be staggering. For example, the European Union (EU) has called for developed nations to reduce emissions by 20 percent from 1990 levels by 2020, and the G-8 has an 80 percent reduction goal by 2050.[8] The IPCC has said the key to preventing global warming is keeping CO_2 emissions below 450 parts per million (in 2009 the CO_2 global average concentration in the Earth's atmosphere was about 387 parts per million by volume[9]); this would require developed countries to cut their emissions by at least 25 percent below 1990 levels by 2020.[10] IEA says this 450-scenario is "achievable, but very challenging."[11] The Accord from the Conference of the Parties (COP-15) meeting in Copenhagen in 2009 recognized the scientific view that the increase in global temperature should "be below 2 degrees Celsius," and that, as a result, "deep cuts in global emissions are required."[12]

[7] U.N. IPCC, "Climate Change 2007: Synthesis Report," 2007, 36.

[8] Meagan Rowling, "G-8 Signals on Climate Change Fall Short – Experts," Reuters AlertNet, 7 July 2009.

[9] Pieter Tans, NOAA/ESRL, "Trends in Atmospheric Carbon Dioxide," n.d., http://www.esrl.noaa.gov/gmd/ccgg/trends/ and http://co2unting.com/.

[10] U.N. IPCC, "Historical Overview of Climate Change Science," "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," 105.

[11] IEA, "World Energy Outlook 2009 Fact Sheet: What Might a Low-Carbon Energy Future Look Like?," 2009, 4.

[12] United Nations Framework Convention on Climate Change, "Draft Decision-/CP.15, Proposal by the President, Copenhagen Accord," 18 December 2009, 1–3.

carbon sequestration leadership forum

As deeper cuts in CO_2 emissions continue to be suggested within increasingly shorter timeframes, many scientists have argued for use of a portfolio approach as the best strategy for reductions. This would include not only increased energy efficiencies and use of renewable and nuclear energy, but also advanced coal power generation including CCS as a key component. The reason: carbon capture and storage technology has the potential for large reductions in CO_2 emissions within 10 to 20 years. The IPCC has predicted CCS can achieve up to 55 percent of the reductions required to stabilize atmospheric levels of CO_2 in this century.[13] IEA has concluded that CCS will need to contribute one-fifth of the necessary emissions reductions to achieve GHG stabilization in the most efficient manner.[14] While future emissions of CO_2 can be avoided in electric power by some combination of the above options, emissions from pre-existing sources can be reduced — and future emissions avoided — using carbon capture and storage. In short, CCS appears to be a promising option for helping to retain coal and other essential fossil fuels as important contributors to the energy supply needed to sustain a globally competitive economy in a carbon-constrained world.

Why do scientists think CCS is promising?

First and foremost, numerous natural accumulations of CO_2 already exist underground in geologic reservoirs and have been stored for millions of years. Additionally, in theoretical, simulation, or laboratory bench settings, and in small-scale industrial operations, the critical elements of CCS have been separately demonstrated. For example, there is nearly a half century of experience with injecting CO_2 for EOR operations, and there are presently five fully integrated, commercial-scale CCS projects (mostly involved in natural gas production) in operation in Norway, Algeria, the United States, and Canada (see inFocus: Is Geologic CO_2 Storage Safe?). Additionally, adequate storage sites and capacities appear to exist around the globe with the caveat that these sites and their capacities need to be characterized and verified for storage suitability. Further testing of preliminary results by operating larger-scale CCS plants and storage facilities in a variety of environments and settings, as well as improving cost-effectiveness, is essential for the technology to fully realize this promise.

Are there any challenges facing CCS?

There are a number of existing challenges that ultimately must be resolved before CCS can be demonstrated and widely deployed as a CO_2 emissions control option. As important as timely technology development is to establishing CCS, having definitive standards, practices, and procedures; encouraging private-sector investment; and addressing liability and regulatory issues are also essential. Current barriers that could delay or — if not resolved — prevent the rapid deployment of CCS essentially fall into two categories: technical and non-technical. The key technical challenges to CCS include: (1) addressing the cost and energy penalty of capture; (2) proving CO_2 storage permanence; (3) verifying that sufficient storage capacity exists; and (4) developing best practices for the lifecycle of a CCS project, from site selection through to site closure and post-closure monitoring. Non-technical challenges primarily consist of: (1) the global need for significant financial investments to bring numerous commercial-scale demonstration projects on-line in the near future; (2) establishing an adequate legal and regulatory framework to support broad CCS deployment, including dealing with long-term liability, and; (3) building public understanding, awareness and acceptance.

[13] U.N. IPCC, "Special Report on Carbon Dioxide Capture and Storage," 2005, 352–358.

[14] OECD/IEA, "CCS for Power Generation and Industry," n.d.

How can these challenges be effectively addressed?

The climate change challenge has a global nature, both in terms of sustaining economic growth and in taking effective steps to reverse the increase in CO_2 and other GHG in the atmosphere. Consequently, an international effort of developed and developing countries, focused on technical, political, and scientific cooperation, is necessary to effectively address the challenges facing CCS. The Carbon Sequestration Leadership Forum (CSLF) is helping in this regard. It is a Ministerial-level organization, and an international climate change initiative focused on confronting issues and fostering the deployment of CCS technologies worldwide. Accumulating data suggest that nations will need to work collaboratively to curb CO_2 emissions within the short timeframe of 10 years or less to avoid IPCC predictions of dire consequences.[15] While research and development need to be accelerated, simultaneous progress must be made internationally on a legal and regulatory framework for CCS that deals with the varied liability issues connected to long-term CO_2 storage, and other challenges.

In the final analysis, all nations would be affected by the impacts of global climate change. But technology and energy choices like CCS may provide policymakers with the basis for balancing and meeting their national economic, energy and environmental needs in a sustainable manner.

Sources for Additional Information

- United Nations Intergovernmental Panel on Climate Change, http://www.ipcc.ch/
- International Energy Agency, http://www.iea.org/
- World Coal Institute, http://www.worldcoal.org/
- The World Bank, http://www.worldbank.org/
- European Zero Emissions Platform, http://www.zeroemissionsplatform.eu/

Other inFocus Factsheets:

- Is Geologic CO_2 Storage Safe?
- Underground CO_2 Storage: A Reality?
- CO_2 Capture — Does it Work?
- CO_2 Transportation — Is it Safe and Reliable?
- 10 Facts About CCS

[15] U.N., News Centre, "Time for the world to act collectively on climate change to avoid catastrophe, warns Ban," U.N. News Service, 1 October 2009.