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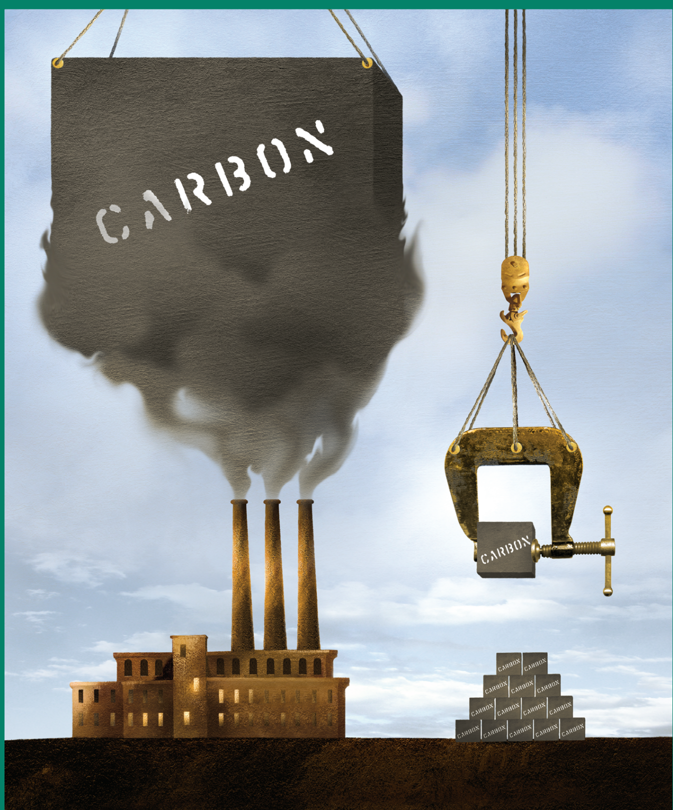
Carbon Capture and Storage

A Solution to the Problem of Carbon Emissions



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A Solution to the Problem of Carbon Emissions

Human activity generates about 28 gigatons (Gton) of carbon dioxide worldwide per year. Fossil-fuel-burning power generators, as well as industrial manufacturing facilities, are the major emitters of carbon dioxide, accounting for about 16 Gton annually. As the global demand for energy grows, fossil fuels will likely continue to meet most of that demand. Unless emissions from these stationary sources are reduced, it will be impossible to slow the increase in man-made production of atmospheric carbon dioxide—the largest contributor to global warming.

Carbon capture and storage (CCS) is a technically feasible solution for mitigating global warming. It does so by capturing carbon dioxide from large single-point sources and storing it underground rather than allowing it to be released into the atmosphere. In September 2007, The Boston Consulting Group analyzed global sources of carbon dioxide and determined that if CCS were implemented at the 250 largest stationary emitters worldwide, carbon dioxide emissions would be reduced by 4 Gton per year—25 percent of the total from all stationary sources worldwide. Implementing CCS at the 1,000 largest stationary sources would reduce emissions by 8 Gton per year—a 50 percent reduction.

Over time, the benefits of CCS would grow. By 2030, its use at the 1,000 largest stationary sources would reduce emissions by 15 Gton per year. That would represent a reduction of more than one-third of the 42 Gton of global emissions from all sources estimated for 2030—a significant contribution to solving the global warming problem.

The BCG analysis also looked at how to pay for CCS. We concluded that by 2030, assuming a stable global market price of €30 per ton, carbon trading would offset the likely cost of capturing, transporting, and storing the carbon dioxide emitted by stationary fossil-fuel-burning sources in Europe and North America.[1] (See Exhibit 1.) Today, however, it would cost a minimum of about €45 per ton to implement CCS at these facilities. Our estimates indicate that financing the technological advancements that will lower the cost of CCS to the threshold of €30 per ton will require approximately €500 billion in government subsidies and company investments through 2030, most of which could be recovered through the trading of carbon certificates. Although the required government share of subsidies is difficult to predict, we expect it to be no more than about €100 billion, or one-fifth of the total estimated cost.

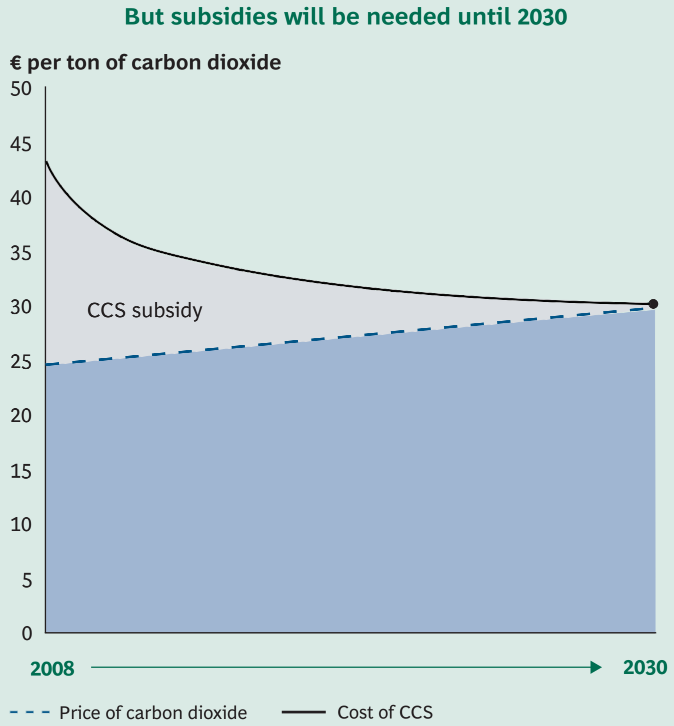
Current Efforts: Necessary but Not Sufficient

Most mitigation actions undertaken so far have focused on improving energy efficiency or deploying renewable or alternative forms of energy. Although both energy efficiency and renewable and nuclear energy must be pursued, conventional wisdom and the opinion of experts indicate that these efforts will not be sufficient to contain increasing global carbon emissions.

Incorporating energy efficiency into all human activities in all parts of the world is essential. But the success

1. Participants in carbon trading buy and sell contractual commitments or certificates representing specified amounts of carbon-related emissions that are permitted; that will be reduced through new technology, energy efficiency, or the use of renewable energy; or that can be offset through such technologies as CCS. In Europe, where prices are volatile, carbon emissions have traded in the range of €20 to €25 per ton over the past year.

Exhibit 1. The Carbon Dioxide Market Price Could Cover CCS Costs by 2030 in Europe and North America



Source: BCG analysis.

of energy efficiency initiatives depends on changes in individual behavior, which are typically driven by price changes and public pressure. Counting on behavioral change is risky, especially in developing countries, where local economic growth is likely to prevail over global environmental targets.

While renewable energy represents an interesting option for abating global warming, such power sources require further development, and current levels of adoption are not sufficient to ensure an adequate global energy supply. Nuclear power has the potential to provide a structural solution, but it is politically and socially unacceptable in many countries. Although this attitude is changing, there is still no political will to fully capitalize on nuclear power. As a result, it will not be a global solution in either the near or the medium term.

Carbon Capture and Storage: A Technically Feasible Solution

According to the European Technology Platform for Zero Emission Fossil Fuel Power Plants, a consortium formed by the European Commission, European industry, NGOs, scientists, and environmentalists committed to zero emissions from power plants, "experts agree that carbon dioxide capture and storage technology, together with improved energy conversion efficiency, is a near-term solution to reducing carbon dioxide emissions from fossil fuel power generation on a *massive* scale.... CCS could reduce carbon dioxide emissions in the European Union by over 50 percent by 2050." Similarly, in a survey of 500 key energy decision makers conducted by the ACCSEPT project (Acceptance of CO_2 Capture and Storage, Economics, Policy and Technology), which is funded by the Directorate-General for Research of the European Commission, 75 percent of respondents said they believed that the widespread use of CCS would be instrumental in achieving deep carbon reductions before 2050.

The evolution of CCS is likely to be similar to that of natural gas distribution. (See Exhibit 2.) First there will be standalone projects, with carbon dioxide capture, transport, and storage tied to a single-point source of emissions such as a power plant. Over time, more and more emission sources will connect through "trunk lines," and a grid infrastructure will develop. As with natural gas pipelines, regulation will be necessary to ensure open access to transport; in contrast, storage capacity is plentiful and likely to remain unregulated.

A variety of capture and storage technologies are currently being used. If, as most experts agree, CCS can reduce plant emissions with a 90 percent carbon-capture efficiency rate, it may be possible to upgrade rather than shut down generating facilities.

Capture technologies differ depending on the carbon dioxide source. For power plants, there are three possible technologies: postcombustion capture, precombustion capture, and Oxy-Fuel, the postcombustion capture of carbon dioxide using oxygen instead of air in the boiler.

Power plants have been experimenting with geologic sequestration of carbon dioxide since the 1970s. Typical geological storage formations include deep saline aquifers, exhausted oil and gas wells, coal seams, and saline domes. The storage potential of such formations worldwide is believed to be huge, but confirmation awaits the results of detailed studies.

StatoilHydro, an integrated oil-and-gas company, operates the largest saline-aquifer storage project in the world—the Sleipner injection project in Norway's North Sea, which was stimulated by the Norwegian government's carbon-dioxide tax and by corporate environmental goals. Operating since 1996, the Sleipner project has stored 8 million tons of carbon dioxide in a geological formation above a gas-producing reservoir. The project has proved the viability of CCS, but as of today there is no commercial incentive to store carbon dioxide, because the cost is higher than the alternative of direct emission into the air. Estimated storage costs vary significantly depending on the type of storage site and whether it is located onshore or offshore. For example, storing carbon dioxide in exhausted oil and gas wells is among the most cost-competitive options.

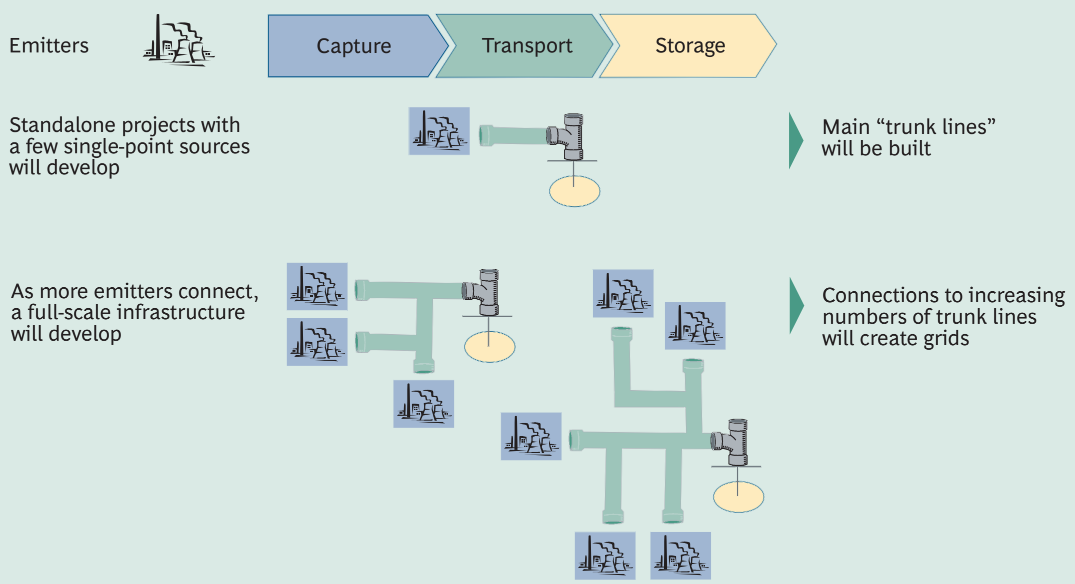
The Outlook for CCS Worldwide

Many projects and market developments now under way around the world point to progress toward a CCS solution and the likelihood that carbon markets will become available to offset its cost.

Europe. The European Union has strengthened the region's commitment to support 10 to 20 CCS projects. For the EU GeoCapacity Project, to be launched in 2009, carbon dioxide point sources and sedimentary basins in about 20 European countries are currently being assessed. An additional priority is to develop innovative methods of capacity assessment, economic modeling, and site selection. Project managers also intend to initiate scientific collaboration with their counterparts in China and possibly with other members of the Carbon Sequestration Leadership Forum (CSLF).[2]

2. The Carbon Sequestration Leadership Forum is a consortium created to foster international cooperation in research and development of carbon dioxide separation, capture, transport, and storage.

Exhibit 2. The Capture, Transport, and Storage of Carbon Dioxide Will Likely Follow a Path Similar to That of Natural Gas



Source: BCG analysis.

North America. Several initiatives could boost CCS in North America. In the United States, NRG and Powerspan are developing a large-scale pilot plant in Texas that is expected to be operational in 2012.[3] In California the Climate Action Registry and the Global Warming Bill aim to impose caps on carbon dioxide emissions from 2012 onward. The Regional Greenhouse Gas Initiative in the 11 eastern states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont would levy a tax on carbon dioxide emissions starting in 2009.

Perhaps most encouraging is the Chicago Climate Exchange (CCX). Launched in 2003, CCX is the world's first and North America's only trading system designed to reduce emissions of all major greenhouse gases with offset projects worldwide. Exchange members make a voluntary but legally binding commitment to meet annual emission-reduction targets. Those that reduce emissions below the targets have surplus allowances to sell or bank; those that emit more than the target amounts comply with the agreement by purchasing CCX carbon financial instruments, which are the commodity traded on the exchange. These contracts comprise exchange allowances and offsets (such as tree planting and other mitigation efforts) representing 100 metric tons of carbon dioxide apiece.

Asia and the Middle East. Although no common policy has been adopted in Asia, the will to reduce carbon emissions exists. Japan aims to reduce emissions by 200 megatons (0.2 Gton) through CCS, and the Australian government is supporting a CCS pilot. China is also considering CCS as a potentially significant way to reduce carbon dioxide emissions. One of the first members of the CSLF, China has integrated CCS into its science and technology development plan as well as its Eleventh Five-Year Plan (2006–2010). In addition, China has embarked on several CCS pilots involving enhanced oil recovery, enhanced coal-bed methane recovery, and an integrated gasification combined-cycle demonstration power plant. In the Middle East, the Abu Dhabi government in 2007 launched a €15 billion clean-energy fund, a portion of which is committed to developing CCS.

Over the long term, the technology would pay for itself at a stable carbon price of €30 per ton.

Challenges to Implementing CCS

Although CCS offers one of the best solutions available for mitigating carbon dioxide emissions by 2030, there are still challenges to be met, specifically the uncertainty of carbon dioxide prices and the need for transport networks to move the captured carbon.

The uncertainty and volatility of carbon dioxide prices are a disincentive to developing CCS at a pace fast enough to respond to the emission reduction challenges established for 2020 to 2050 by the Directorate-General for Research of the European Commission. According to BCG's analysis, as long as carbon prices are below €30 per ton, CCS for coal-burning power plants is not economically feasible in Europe or the United States. Over the long term, however, the technology would pay for itself at a stable carbon price of €30 per ton. Furthermore, CCS costs are expected to decrease significantly by 2030 as experience with the technology grows. (See Exhibit 3.)

Although capture and storage technologies are well understood and are beginning to be implemented in pilot projects, transport networks to move captured carbon from emission sources to confinement sites, such as depleted oil and gas fields, have yet to be deployed. Transport and storage costs are quite low compared with the cost of capture. Whereas it costs €25 to capture a ton of carbon dioxide, it costs €2 to €3 to transport it and €4 to €5 to store it. For CCS to take off on a large scale, an infrastructure similar to the pipeline networks used for natural gas needs to be put in place. It will require investments that over time will have to be backed by regulatory mechanisms that guarantee specific returns.

Making the Right Decision

To launch CCS successfully, oil companies, utilities, and other industry participants must develop a disciplined approach that incorpo-

3. "NRG and Powerspan Announce Large-Scale Demonstration of Carbon Capture and Sequestration (CCS) for Coal-Fueled Power Plants: Demonstration to Be Among Largest CCS Projects in the World," company press release, November 2, 2007.

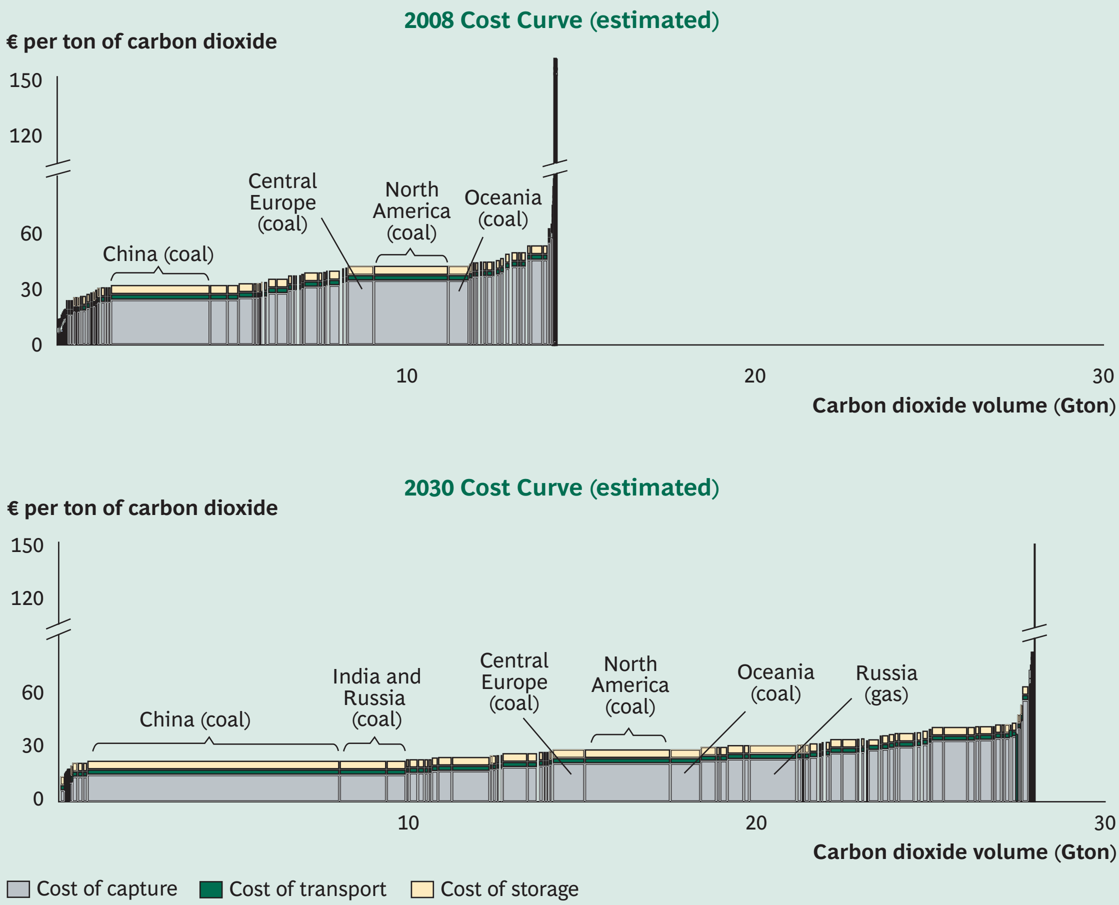
rates the lessons learned from the utilities and other industrial sectors, such as the natural gas industry in the United States.

Accurately define the business model. This is a critical first step for each player participating in the capture, transport, and storage process. Nowadays it is not clear how some steps in the value chain, such as carbon dioxide transport and storage, will be priced. Therefore, the economics of each phase need to be modeled to determine feasible approaches.

Carefully manage the regulatory process. CCS technologies should be developed with the unconditional commitment and support of national governments and supranational authorities such as the World Economic Forum and the World Business Council for Sustainable Development. CCS will be stuck in a quagmire if governments do not either implement a new regulatory scheme that supports its development or modify current regulations so that the responsibility for emissions is assigned to the actual emitters. Large investments in CCS activities cannot be allowed to be subject to volatile carbon-dioxide market prices.

Increase speed to market. Companies and governments need to speed up the development of large-scale storage technologies. If they don't, there is a substantial risk that emissions will continue to increase and global warming will reach a level at which climate change could become irreversible. On its current development path, CCS will not be commercially available until sometime between 2020 and 2030,

Exhibit 3. CCS Costs Are Expected to Decline by 2030



Source: BCG analysis.

delaying the potential for significant reductions in carbon dioxide emissions.

Leverage the experience curve. Companies need to review and evaluate the experience curve to ensure that CCS is cost competitive and will become a feasible and attractive part of the solution to the carbon emissions problem.

Until a new, completely sustainable energy source is developed, carbon capture and storage is a feasible, cost-effective near-term solution to the challenge of eliminating a considerable portion of global carbon emissions. Because this technology has a long-term payback, private companies and government authorities must begin aggressively promoting its development today in order to fully capitalize on its potential to significantly reduce carbon emissions.

To meet reduction goals worldwide, CCS technology will need to be financed initially by a combination of two levers: subsidies and carbon dioxide prices. Subsidies will be necessary to make CCS projects profitable, because the price of carbon dioxide will probably not be high enough in the near term. Worldwide subsidies of €100 billion through 2030 could mitigate global warming while developing a new and definitive sustainable technology.

About the Authors

Ramón Baeza is a senior partner and managing director in the Madrid office of The Boston Consulting Group. You may contact him by e-mail at baeza.ramon@bcg.com.

Balu Balagopal is a senior partner and managing director in BCG's Houston office. You may contact him by e-mail at balagopal.balu@bcg.com.

Eric Boudier is a partner and managing director in the firm's Oslo office. You may contact him by e-mail at boudier.eric@bcg.com.

Michael Buffet is a project leader in BCG's Oslo office. You may contact him by e-mail at buffet.michael@bcg.com.

Ingrid Velken is a consultant in the firm's Oslo office. You may contact her by e-mail at velken.ingrid@bcg.com.

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For Further Contact

BCG's Energy practice sponsored this report. For inquiries, please contact one of the authors.

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