Fundamentals of Carbon Capture and Storage Technology

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Carbon capture and storage is referred to as CCS throughout this publication.
CCS is a new industry and estimates of geological storage capacity vary.

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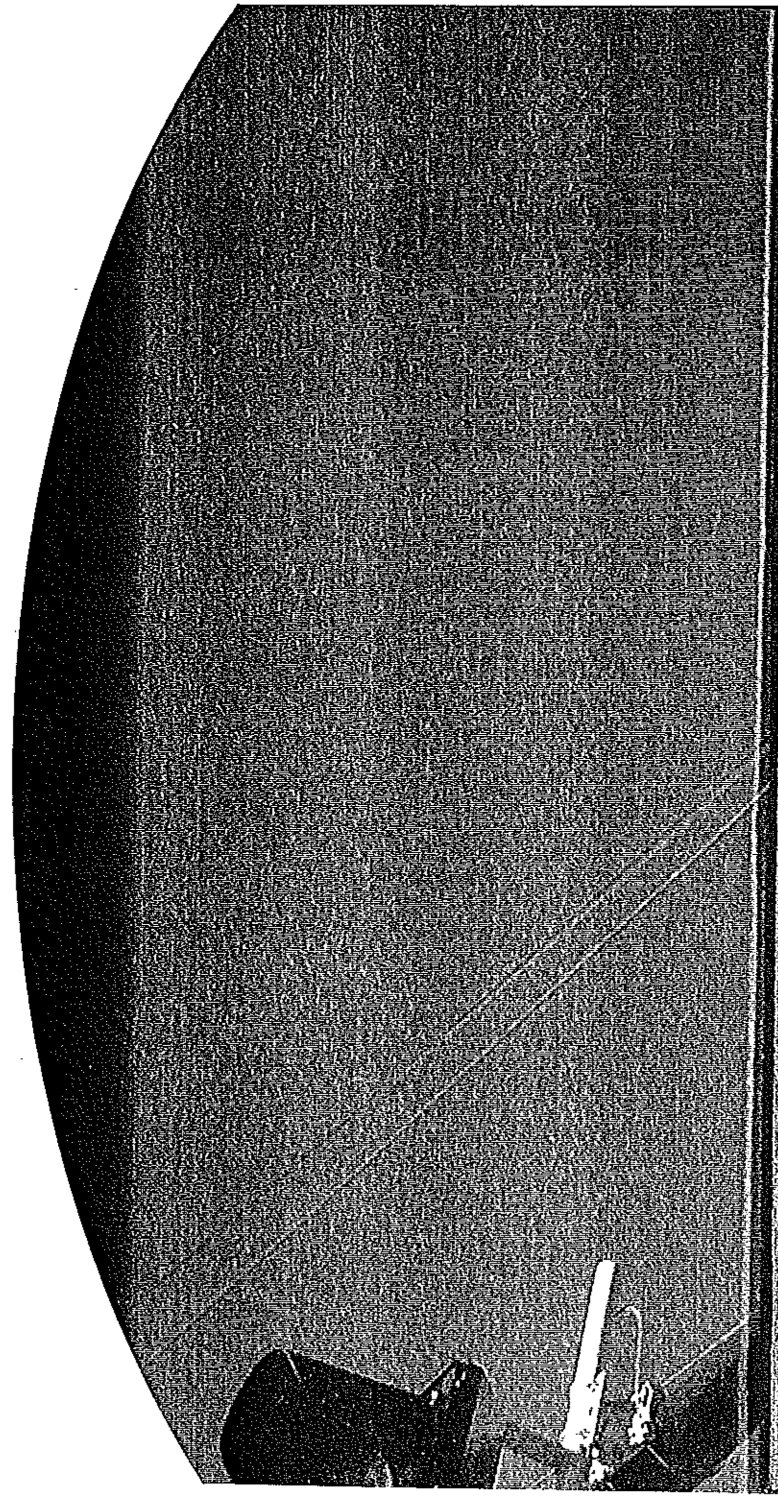
Foreword

The world has embraced the objective of dramatically reducing the risks of climate change. Only a few years ago, not many people understood the risks of climate change and most of those who did understand the risks were complacent or fatalistic. Among the factors that have changed perceptions and propelled climate-change mitigation to near the top of national political agendas are: deeper scientific insight into the carbon cycle and its potential effects; more effective communication between experts and the public; considerable resonance on the part of the public with the critique of present social values and lifestyles articulated by environmental activists; and, perhaps, a seeking of new challenges on the part of political leaders.



In the same period, expectations about the evolution of the fossil-fuel mix have changed: there has been a rush to coal. Of the new power plants to be built in the next few decades, more are now expected to be fuelled by coal and fewer by natural gas. Coal-to-liquids technology is being taken seriously in China and the US. All this is bad news for the climate. Coal power puts twice as much CO_2 into the atmosphere per kilowatt-hour as natural-gas power.

When gasoline and diesel are made from coal, twice as much CO_2 enters the atmosphere per kilometre of driving than when the same fuels are made from crude oil.

In short, the heightened concern for climate change and the greater competitiveness of coal are on a collision course. Fortunately, there is a way greatly to reduce the effect of this collision: capture the CO_2 released

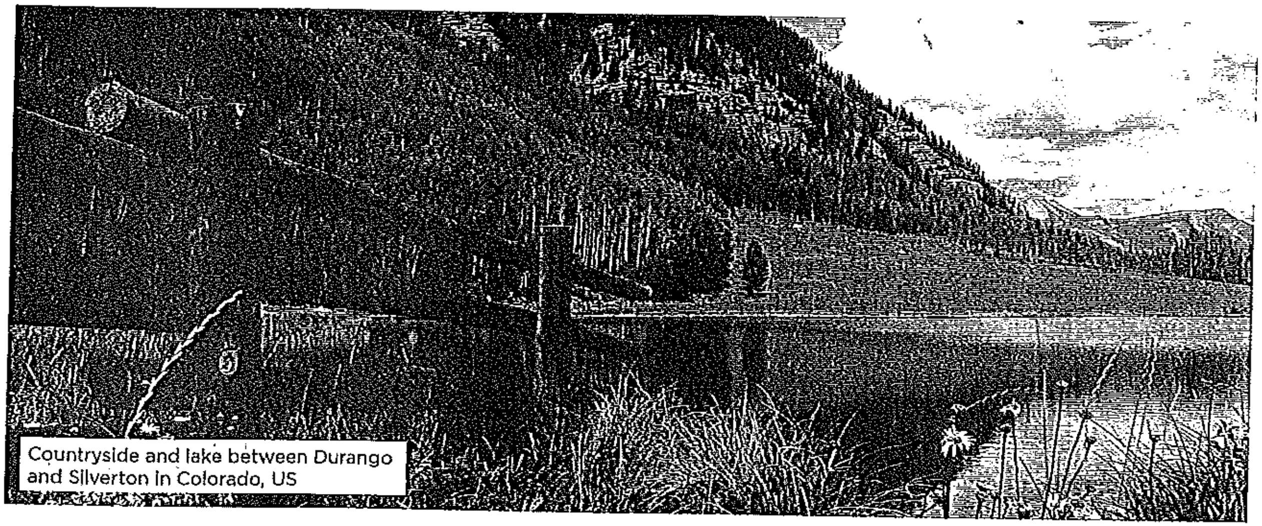


Photo: BP

Countryside and lake between Durango and Silverton in Colorado, US

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when coal is transformed into electricity or fuels and sequester the CO_2 safely in sedimentary formations deep in the Earth.

Although CCS is a relative newcomer to the energy scene, it is ready for deployment at full-scale in individual projects. Deployment at full scale is realistic because the component technologies are already deployed at full scale for other purposes. CO_2 capture technology is already tested at full scale in large ammonia plants and oil refineries where hydrogen at large scale is produced from natural gas, petroleum coke or coal; often, the byproduct CO_2 is vented at very high concentration, following hydrogen-CO_2 separation. CO_2 storage technology is already tested at full scale in association with enhanced oil recovery (EOR). Simply put, CCS deploys already commercial technologies in new combinations.

One key question must be answered before CCS can be judged to be able to make a material difference to climate-change mitigation: is there sufficient storage capacity below ground? The answer appears to be yes. The Intergovernmental Panel on Climate Change (IPCC) estimated in its 2005 report that worldwide geological CO_2-storage capacity is "likely" to exceed 2 trillion tonnes – more than 60 times total global annual emissions and equivalent to the lifetime output of about 4,000 large (1 gigawatt) coal plants. The same IPCC report explains that the storage sites being included in this estimate would retain their CO_2 for very long periods.

Such estimates of storage capacity are, of course, preliminary and lack a cost component. Eventually, such estimates will be replaced by the kinds of estimates that accompany statements of available hydrocarbons or available metals, inasmuch as storage capacity is just another resource-to-reserve problem. Estimates of storage capacity are estimates of secure and economic pore space for CO_2 below ground and pore space so defined reflects both the technology and the costs of the day, as well as the details of societal definition of secure. The amount of such pore space can be expected to expand over time with technological innovation and experience.

This is a dynamic technological frontier. There will be new engineering approaches to CO_2 capture during energy conversion and extensions of CCS capture to low-rank coals, to biomass and probably to natural gas. New gasifiers, new gas-separation strategies and new systems approaches that reduce CO_2 compression requirement, are examples of areas for innovation in capture technology.

"TO HAVE A MATERIAL EFFECT, MANY HUNDREDS OF PROJECTS WILL BE NECESSARY"

There will also be new strategies for inserting CO_2 efficiently into a sedimentary formation and new techniques for monitoring its subsequent fate as the CO_2 migrates through the formation and gradually dissolves in brine, combines chemically with formation minerals and becomes trapped by capillary forces as a pure phase in the formation's pores. In short, with learning-by-doing, costs will come down for both capture and storage.

The many individual full-scale projects now being planned for deployment in the next decade around the world, during the period of first steps towards national, regional and global carbon policy, will provide both private and public benefits. The private benefit is first-mover advantage. The public benefit is pre-competitive global learning.

But to have a material effect on climate-change mitigation, not a few tens but many hundreds of projects will be necessary, affecting virtually every new coal power plant and coal-to-liquids plant and many of the coal power plants already built. This effusion of CO_2 projects will require the phased development of a favourable public-policy environment for CCS, because almost always, it will be cheaper to vent CO_2 than to store it. (The exceptions are the special situations where CO_2 is assigned significant value – notably, when CO_2 is used for EOR.) The commercialisation of CCS requires climate policy that puts a significant price on CO_2 emissions, whether through a CO_2 emissions tax or through trading under a quantity cap.

It will take a decade or so for various regions of the world not only to develop a durable CO_2 policy, but also to become comfortable that the ground rules for the permitting of CCS storage sites are right for the long haul. It will be important, during the transition decade, to maintain a spirit of experimentation, not just with regards to technology, but also to the enabling policies themselves. It is too soon, for example, to decide the final requirements for CO_2 retention in storage reservoirs and the degree of surveillance required at each storage site. Preliminary guidelines are needed, not the locking in stone of untested regulations.

Although CCS technology is already adequate and will steadily improve, the public is not on board – indeed, for the most part, it is scarcely aware of the concept. Of paramount importance is that CCS be conducted by industry over the next decade in a way that gains the public's confidence that the challenges are being fully and fairly presented and the inevitable complications are not being hidden from view. Public acceptance must be won, not presumed.

Fossil fuels have acquired, with a concern for climate change, entirely new connotations. The initial public reaction is understandably a negative one: the burning of fossil fuels is the culprit. CCS offers the opportunity to transform this view. Especially if, as many think, the promise of non-fossil energy in either renewable or nuclear form is limited and the competitiveness of fossil fuels is robust, making CCS a commercial reality is not only beneficial to the oil and gas industry, but also essential for good stewardship of the planet. ❖


Photo: BP

Portal glacier in Alaska