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Carbon Capture and Sequestration

OVERWHELMING SCIENTIFIC EVIDENCE SHOWS THAT CO₂ EMISSIONS FROM FOSSIL FUELS HAVE caused the climate to change, and a dramatic reduction of these emissions is essential to reduce the risk of future devastating effects. On the other hand, access to energy is the basis of much of the current and future prosperity of the world. Eighty percent of this energy is derived from fossil fuel. The world has abundant fossil fuel reserves, particularly coal. The United States possesses one-quarter of the known coal supply, and the United States, Russia, China, and India account for two-thirds of the reserves. Coal accounts for roughly 25% of the world energy supply and 40% of the carbon emissions.* It is highly unlikely that any of these countries will turn their back on coal any time soon, and for this reason, the capture and storage of CO₂ emissions from fossil fuel power plants must be aggressively pursued.

This special issue of *Science* discusses the potential role of carbon capture and sequestration (CCS) in reducing CO₂ emissions. The scale of CCS needed to make a significant dent in worldwide carbon emissions is staggering. Roughly 6 billion metric tons of coal are used each year, producing 18 billion tons of CO₂. In contrast, we now sequester a few million metric tons of CO₂ per year. At geological storage densities of CO₂ (~0.6 kg/m³), underground sequestration will require a storage volume of 30,000 km³/year. This may be sufficient storage capacity, but more testing is required to demonstrate such capacity and integrity.

We should pursue a range of options for new coal-fired power plants (such as coal gasification, burning coal in an oxygen atmosphere, or postcombustion capture) to determine the most cost-effective approach to burn fuel and reduce the total amount of CO₂ emitted. No matter which technology ultimately proves best for new plants, we will still need to retrofit existing plants and new plants that will be built before CCS is routinely deployed. Each new 1-gigawatt coal plant is a billion-dollar investment and, once built, will be used for decades.

Estimates of CCS costs vary considerably, but experience with other pollution control technologies such as the scrubbing of SO₂ and NO_x show that costs can be considerably lower than initial estimates. Furthermore, new ideas are now being explored, such as more efficient, lower-temperature catalytic conversion of coal to hydrogen and methane, CO₂ capture based on phase separation, and polygeneration (production of variable mixtures of electricity, methane, liquid fuel, and ammonia). In the natural world, sequestration of CO₂ occurs through photosynthesis, calcification of CO₂ by phytoplankton, and mineralization in ground root systems. Can we enhance natural processes (“reforestation plus”) or draw inspiration from nature as a starting point for artificial capture? Similarly, nature provides proof that the energy penalty for releasing adsorbed CO₂ in postcombustion capture can be decreased: Through carbonic anhydrases, our blood captures CO₂ created by cell metabolism and releases it in the lungs with no enthalpic energy penalty.

Public support of CCS R&D is essential, and for this reason, \$3.4 billion of American Recovery and Reinvestment Act money is being invested by the U.S. Department of Energy (DOE) in CCS R&D. The DOE is also supporting the testing of CO₂ sequestration in seven different U.S. geologic formations. To accelerate global dissemination of CCS technology and expertise, international collaborations are essential. The G-8 leaders called for at least 20 CCS projects by 2010. In July, I announced a new U.S.–China Clean Energy Research Center that will facilitate joint research in several areas, including CCS. Intellectual property developed jointly will be shared between our countries.

There are many hurdles to making CCS a reality, but none appear insurmountable. The DOE goal is to support R&D, as well as pilot CCS projects so that widespread deployment of CCS can begin in 8 to 10 years. This is an aggressive goal, but the climate problem compels us to act with fierce urgency.

– Steven Chu

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*<http://energy.gov/carbongraph>

