

## Carbon Capture and Storage Technologies

The importance of carbon capture and storage (CCS) technology development and deployment in addressing the climate issue—both domestically and internationally—cannot be overstated. The ability to capture carbon dioxide (CO<sub>2</sub>) emissions is inextricably linked to the advanced coal generation technology, primarily integrated gasification combined cycle (IGCC) and ultra-supercritical pulverized coal (USC/PC) and other advanced coal technologies. Efforts are underway to develop advanced coal generation technologies and to integrate capture technologies for both types of generation systems.

### Emerging technologies will be the solution for addressing concerns about carbon

- The U.S. Department of Energy (DOE) seeks 90 percent capture of CO<sub>2</sub> and 99 percent storage permanence in pilot projects by 2012; commercial units are expected to come online in the 2025-2035 timeframe.
- The process involves capturing CO<sub>2</sub> before it is emitted into the atmosphere, followed by liquid storage in saline formations, oil fields and unmineable coal seams.
  - Using CO<sub>2</sub> for enhanced oil recovery is particularly promising in the near term and could lead to production of 2-3 million barrels of oil per day. (Source: National Coal Council, *Coal: America's Energy Future*, 2006)
- CO<sub>2</sub> removal processes are equally applicable for both advanced combustion and IGCC processes.

### Ample CO<sub>2</sub> geologic storage is available in the United States and around the world

- The nation has approximately 500 of years of capacity for geologic storage, though issues relating to subsurface property rights and accessibility must be addressed. (Source: DOE)
- Technology for removing naturally occurring CO<sub>2</sub> has been used for enhanced oil recovery (EOR) for more than 30 years; however, the technology for capturing CO<sub>2</sub> from a coal-based power plant has never been demonstrated.
- After capture, CO<sub>2</sub> can be compressed to a fluid-like state that is as dense as liquid but has gas-like viscosity, making it easier and less costly to transport via pipelines. CO<sub>2</sub> also can be further cooled to liquefaction temperature and transported longer distances.

- The basic technologies for injecting CO<sub>2</sub> underground for EOR are well established; injecting the volume of CO<sub>2</sub> associated with coal-based power plants has not been done and requires multiple demonstrations at increasingly larger volumes.
- More advanced drilling and injection techniques will be needed to optimize storage on the scale required. Monitoring and validation technologies are also evolving for long-term storage to ensure permanence. Integration of advanced coal technologies with CCS in a commercially operational system will be critical.

### **Pilot- and commercial-scale technology demonstrations are underway**

- Post-combustion technologies use amine, chilled ammonia and other absorbents to remove CO<sub>2</sub> in a two-stage process. Chilled ammonia features a 9-percent loss of efficiency compared with up to 30 percent for amine.
  - Chilled ammonia is a promising technology being developed by EPRI, ALSTOM, Statoil and others, where CO<sub>2</sub> is absorbed by a solution of ammonium carbonate at low temperature forming ammonium bicarbonate.
  - ALSTOM and EPRI are conducting a 5-MW, pilot-scale test of chilled ammonia at We Energies' Pleasant Prairie Power Station in Wisconsin, and American Electric Power (AEP) is working with ALSTOM to test a 30-MW (thermal) unit at its Mountaineer Plant in West Virginia, both of which began this summer.
  - AEP also plans to test a second application of chilled ammonia at its Northeastern Station in Oklahoma on a 450-MW unit.
- Pre-combustion technology focuses on IGCC, where coal is converted using oxygen and steam under pressure to form a synthesis gas, with emissions consisting mainly of carbon monoxide and hydrogen. (Source: Electric Power Research Institute (EPRI))
  - The \$1.5-billion FutureGen project will be the world's first coal-based power plant that achieves near-zero emissions while capturing and storing CO<sub>2</sub> in deep saline formations.
  - FutureGen is completing a rigorous environmental review process and is finalizing selection of technology this year. FutureGen targets at least 90-percent capture and will sequester at least 1 million tons of CO<sub>2</sub> each year.
  - The governments of the United States, China, India and South Korea are participating in development with DOE and the FutureGen Alliance, which represents a dozen global coal companies and electric utilities.
- Oxy fuel combustion is suitable for advanced combustion and circulating fluidized bed boilers. (Source: EPRI)
  - Pilot-scale demonstrations have been announced by Babcock & Wilcox and Vattenfall in Germany at 10 MW and 30 MW, respectively, with tests beginning next year.

- Canada's SaskPower has announced a \$1.5-billion, 300-MW clean coal project with Babcock & Wilcox that would be the first of its kind in a utility-scale application, capturing 90 percent of CO<sub>2</sub> for enhanced oil recovery in the Saskatchewan oilfields.

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