# Carbon Capture R&D

RTI International is actively developing technology solutions for capturing $CO_2$ from fossil fuel–based combustion and gasification power plants. These include two novel processes for post-combustion capture, the first of which is a sorbent-based technology—named the Dry Carbonate $CO_2$ Removal Process—that has been developed for $CO_2$ removal from power plant flue gases. This technology has been demonstrated in a field test and will move into the next phase of demonstration in 2009. The second process, which focuses on $CO_2$ separation based on a novel membrane technology, is in early-stage development and shows promise as a cost-effective, energy-efficient $CO_2$ separation solution. In addition, RTI is developing a pre-combustion $CO_2$ removal technology for the next generation of gasification-based power plants.

## Carbon Capture Research

Fossil fuels used for power generation, for transportation, and by industry are the primary sources of anthropogenic $CO_2$ emissions to the atmosphere. Although there are many approaches to limiting these emissions, it is increasingly clear that $CO_2$ capture and sequestration technologies will play an important role in reducing worldwide $CO_2$ emissions. Because large, stationary $CO_2$ point sources in the power and industrial sectors contribute to about half of the current $CO_2$ emissions, RTI has made these sectors primary targets for their $CO_2$ capture research. As RTI develops solutions for the power industry, we will leverage the expertise gained to offer $CO_2$ capture solutions for other industries such as cement manufacturing, petroleum refining, and natural gas processing.

## RTI Develops Novel Processes for Post-Combustion $CO_2$ Capture

### RTI's Sorbent-Based Dry Carbonate $CO_2$ Removal Process

RTI, in collaboration with several industrial partners, has developed the Dry Carbonate $CO_2$ Removal Process—a sorbent-based technology for removing $CO_2$ from power plant flue gases. This process will offer utility companies an energy-efficient and economically attractive means for removing $CO_2$ from their power plant flue gases.

The Dry Carbonate $CO_2$ Removal Process is based on a sodium carbonate ($Na_2CO_3$) sorbent that removes $CO_2$ from flue gas by reacting with carbon dioxide and water to form sodium bicarbonate ($NaHCO_3$). Upon heating (ideally with low-grade heat from the power plant), the bicarbonate decomposes and releases a $CO_2$/steam mixture that can be converted into a "sequestration-ready" $CO_2$ gas stream through steam condensation. The reversible carbonation reaction inherent to this process is

$$Na_2CO_3(s) + CO_2(g) + H_2O(g) \leftrightarrow 2NaHCO_3(s)$$

Extensive thermodynamic analysis and laboratory research was carried out to prove the feasibility of the technology and to support the design, construction, and demonstration of a bench-scale research unit. In 2007, the bench-scale Dry Carbonate $CO_2$ Removal Process was relocated to a combustion facility and tested with a slipstream of actual coal-fired flue gas. RTI's technology consistently demonstrated greater than 90% $CO_2$ removal during hundreds of hours of field testing. Extensive data were collected relating to process operating conditions, sorbent attrition, and contaminant interaction.

**The Dry Carbonate $CO_2$ Removal Process has several key features and advantages:**

- Uses a low-cost, non-toxic solid carbonate sorbent
- Sorbent is thermally regenerable at modest operating temperatures
- Applicable to fossil fuel–fired power plants
- Suitable for retrofit in existing power plants
- Less expensive and less energy-intensive than currently available technologies

Additional bench-scale R&D is being funded by the Department of Energy to resolve any remaining process challenges of the Dry Carbonate $CO_2$ Removal Process. RTI has improved upon reactor designs and the $CO_2$ capture capacity of its sorbents. RTI is using the data collected during bench-scale testing to build and evaluate a pilot-scale prototype capable of capturing 1 ton of $CO_2$ per day at a coal combustion facility. Upon successful completion of this pilot phase, RTI will move to a demonstration phase that will involve the construction and extended operation of a $5MW_e$ equivalent (100 tons $CO_2$ per day) system at an actual power plant site.

Preliminary economic and thermal analyses indicate that RTI's Dry Carbonate $CO_2$ Removal Process is potentially less expensive and more efficient than commercial amine-based $CO_2$ capture systems.

### Membrane-Based $CO_2$ Separation

Membrane processes are attractive because they are generally energy-efficient (i.e., no phase changes occur), require minimal operator attention and maintenance, and are modular and scalable. Membrane-based $CO_2$ separation systems have the potential to greatly expand the options of utility companies producing electrical power in a carbon-constrained world.

RTI and a team of industrial partners are working together to develop and demonstrate novel fluorinated polymer membranes for separating $CO_2$ from post-combustion flue gas with a focus on total process design and process integration. RTI's research is focused on three areas: new high-performance membrane materials, improved hollow-fiber membrane module design, and cost- and energy-efficient integration into existing coal-fired power plants. RTI will evaluate new materials and process designs in the laboratory, followed by bench-scale evaluation at a coal combustion facility.

## Pre-Combustion $CO_2$ Separation Targets Next Generation of Gasification Plants

Modern gasification technology provides an efficient means of producing power from carbonaceous fuels. $CO_2$ capture in gasification-based systems can be conducted before complete combustion (i.e., at elevated process temperatures and pressures). This can significantly reduce the parasitic power load necessary for $CO_2$ compression before sequestration. RTI is currently developing a pre-combustion $CO_2$ removal technology for the next generation of gasification-based power plants.

RTI's bench-scale Dry Carbonate $CO_2$ Removal Process

RTI researchers have made considerable progress in developing a high-temperature, regenerable, mixed oxide–based sorbent technology that can be integrated into advanced gasification systems. We anticipate that this technology will avoid the significant thermal penalty associated with existing $CO_2$ removal technologies. Our researchers are actively involved in the synthesis, development, scale-up, and testing of both fixed- and fluidized-bed high-temperature $CO_2$ sorbents. RTI is also investigating the use of these sorbents with water-gas shift catalysts to achieve in situ water-gas shift and $CO_2$ removal, thereby increasing the effectiveness of $CO_2$ capture and the generation of a hydrogen-rich product gas.

**More Information**

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