New clean coal technology reaches milestone and moves to large-scale testing

Doctoral student Elena Chung (left) and master's student Samuel Ayham (right) display chunks of coal along with pulverized coal and the iron oxide beads that enable the chemical reaction. Photo by Jo McCulty, courtesy of Ohio State University

A new clean coal technology that harnesses coal's energy without burning it will move to large-scale testing after an Ohio State University research-scale system reached 203 continuous hours of no-burn combustion. The pilot-scale demonstration is being constructed at the Department of Energy's National Carbon Capture Center in Wilsonville, Ala.

The technology has the potential to be one of the lowest cost and most efficient ways to produce affordable, pure hydrogen while attaining nearly 100 percent carbon dioxide control and complying with all environmental regulations, the university said.

The pilot plant is set to begin operations in late 2013 and will produce 250 thermal kilowatts using syngas made from coal. The unit can also be retrofitted to existing coal-fired power plants or used for new fleet installations, the university said.

Liang-Shih Fan, professor of chemical and biomolecular engineering and director of OSU's Clean Coal Research Laboratory, pioneered the technology, known as coal-direct chemical looping (CDCL).

"In the simplest sense, combustion is a chemical reaction that consumes oxygen and produces heat," Fan said. "Unfortunately, it also produces carbon dioxide, which is difficult to capture and bad for the environment. So we found a way to release the heat without burning. We carefully control the chemical reaction so that the coal never burns—it is consumed chemically, and the carbon dioxide is entirely contained inside the reactor."

According to the university, the pursuit of converting coal directly into electricity is being tried in laboratories around the world, but Fan's lab is unique in that it studies coal in two forms that are already commonly available to the power industry: crushed coal feedstock and coal-derived syngas.

"Commercial-scale clean coal technologies such as chemical looping will be the game changer that will lay the foundation for a more sustainable future," Fan said.

One of the goals set by the DOE for clean energy development includes capturing more than 90 percent of resulting carbon dioxide without raising the cost of electricity by more than 35 percent. With CDCL, Fan and his team believe they can meet or exceed that requirement, the university said.

Researchers at the university harnessed the 203 hours of heat from coal while capturing 99 percent of the carbon dioxide produced in the reaction. No other lab has continuously operated a coal-direct chemical looping unit as long as the Ohio State lab accomplished, the university said. And it could have continued even further.

"We voluntarily chose to stop the unit," said Elena Chung, an OSU doctoral student. "We actually could have run longer, but honestly, it was a mutual decision by Dr. Fan and the students. It was a long and tiring week where we all shared shifts."

The key to the technology is the chemical reaction, spurred by using tiny metal beads made of iron oxide composites that carry oxygen to the coal, the university said. The coal and iron oxide are heated to high temperatures where the materials react with each other. Carbon from the coal binds with the oxygen from the iron oxide and creates carbon dioxide, which rises into a chamber where it is captured. Hot iron and coal ash are left behind. Because the iron

beads are so much bigger than the coal ash (1.5 to 2 millimeters across, compared to coal particles 100 micrometers across), they are easily separated out of the ash and delivered to a chamber where the heat energy would normally be harnessed for electricity. The coal ash is removed from the system. The carbon dioxide is separated and can be recycled or sequestered for storage. The iron beads are exposed to air inside the reactor, so they become re-oxidized to be used again or recycled.

"The commercial-scale CDCL plant could really promote our energy independence," said Dawei Wang, a research associate and one of the group's leaders. "Not only can we use America's natural resources such as Ohio coal, but we can keep our air clean and spur the economy with jobs."

The Department of Energy funded the research. Collaborating companies include: Babcock & Wilcox Power Generation Group, Inc.; CONSOL Energy, Inc.; and Clear Skies Consulting, LLC. —FALLON FORBUSH