## Chemical Looping Combustion Prototype - Alstom

**Project Title:**

**Alstom's Chemical Looping Combustion Prototype for $CO_2$ Capture from Existing Pulverized Coal-Fired Power Plants**

| **Technology Area:** | **Technology Maturity:** |
|---|---|
| Chemical Looping | 3-$MW_{th}$ Prototype, 1,000 lb of coal/hr |

**Primary Project Goal:**

Design, build, and test a 3-$MW_{th}$ limestone-based chemical looping combustion (CLC) prototype facility.

**Technical Goals:**

- Design a CLC prototype that consumes approximately 454 kg/hr (1,000 lb/hr) of coal and uses calcium sulfate ($CaSO_4$) as an oxygen ($O_2$) carrier.
- Test cold flow solids transport.
- Characterize the environmental performance of the CLC prototype facility.
- Develop design information for a larger-scale CLC commercial demonstration plant.

**Technical Content:**

In this project, Alstom will scale up the limestone-based CLC process from a 65-$kW_{th}$ pilot, which was successfully demonstrated in an earlier project, to a 3-$MW_{th}$ prototype facility that is expected to be operational in 2010 and 2011. CLC utilizes a metal oxide or other compound, in this case $CaSO_4$, as an $O_2$ carrier to transfer $O_2$ from the combustion air to the fuel. Since direct contact between fuel and combustion air is avoided (Figure 1), the products from combustion (carbon dioxide [$CO_2$] and water) will be kept separate from the rest of the flue gases (primarily nitrogen). CLC splits combustion into separate oxidation and reduction reactions. The $O_2$ carrier releases $O_2$ in a reducing atmosphere to react with the fuel. The carrier is then recycled back to the oxidation chamber to be regenerated by contact with air. Calcination of hot solids produced in the oxidation reactor will produce a concentrated stream of $CO_2$ in lieu of the dilute $CO_2$ stream typically found in flue gas from coal-fired power plants. This will enhance the ability to capture $CO_2$ at coal-fired power plants.

Located at Alstom's Power Plant Laboratory in Windsor, Connecticut, the prototype will include process loops to transfer solids and $O_2$ between the reducing and oxidation reactors. The facility will have the ability to combust coal, gasify coal, or produce hydrogen; however, hydrogen is not expected to be produced during this particular project. After installation and startup of the prototype, Alstom plans to conduct seven weeks of cold flow and hot flow testing, with $CO_2$ vented to the atmosphere. Information gleaned from prototype testing will be used to develop a technical plan and cost estimate for a subsequent larger-scale commercial demonstration project at a full-scale power plant.

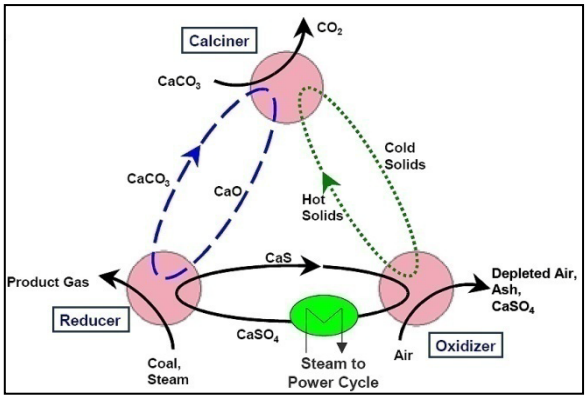


**Figure 1: Limestone-Based CLC Process**

**Technology Advantages:**

An air separation unit (ASU) is not required for $O_2$ production and $CO_2$ separation takes place during combustion. Additionally, the versatile technology can produce power, syngas, or hydrogen, while offering fuel flexibility.

**R&D Challenges:**

In addition to scaleup issues, challenges associated with the CLC process include solids handling and transport; $O_2$ carrier capacity, reactivity, and attrition; and ash management.

**Results To Date/Accomplishments:**

In an earlier project (NT41866), Alstom completed the following:

- Successful construction and testing of a 65-$kW_{th}$ pilot-scale CLC facility.
- Completion of 4.6-m (15-foot) Cold Flow Model testing.
- Successful scale up to a 12.2-m (40-foot) Cold Flow Model.
- Successful completion of internal and ASME/DOE peer reviews.

**Next Steps:**

Alstom will design and test a prototype CLC facility that consumes approximately 454 kg/hr (1,000 lb/hr) of coal and uses $CaSO_4$ as an $O_2$ carrier. While offering the flexibility to conduct testing in combustion and gasification modes, the facility will be used to test cold flow solids transport. Final test results will not be available until the March 2011 project completion date.

**Available Reports/Technical Papers/Presentations:**


Presentation: Annual NETL $CO_2$ Capture Technology for Existing Plants R&D Meeting, March 24-26, 2009, in Pittsburgh, Pennsylvania.

Andrus, H. E., Jr., et. al., Hybrid Combustion-Gasification Chemical Looping Coal Power Technology Development – Phase 1 Final Report, U.S. DOE, December, 29, 2004.

Andrus, H. E., Jr., et. al., Hybrid Combustion-Gasification Chemical Looping Coal Power Technology Development – Phase II Final Report, U.S. DOE, June, 9, 2006.

Andrus, H.E., Thibeault, P. R., Chemical Looping Spec Gate review and Peer Review Report, 22 August, 2005.

Johnson, K, et. al., Sorption-Enhanced Steam Reforming of Methane in a Fluidized Bed Reactor.

Nsakala, N. Y. and Liljedahl, G. N., Greenhouse Gas Emissions Control by Oxygen Firing in Circulating Fluidized Bed Boilers, Alstom Power – U.S. DOE Report, PPL Report No, PPL-03-CT-09, 15 May 2003.


| **Contract No.:** | **NETL Project Manager:** |
|---|---|
| DE-NT0005286 | Bruce Lani<br>Bruce.Lani@netl.doe.gov |
| **Principal Investigator:** | **Partners:** |
| Herbert E. Andrus<br>Herbert.e.andrus@power.alstom.com<br>ALSTOM Power, Inc., US Power Plant Laboratories | Dr. Jonas Beer, MIT<br>PEMM Corporation<br>University of British Columbia |