the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Chemical Looping Combustion Prototype for CO_2 Capture from Existing Pulverized Coal-Fired Power Plants

Background

Future climate change legislation may require new and existing coal-fired power plants to decrease their carbon dioxide (CO_2) emissions. Carbon dioxide capture and storage (CCS) is one solution in reducing a coal-fired power plant's carbon footprint. The CCS process often necessitates that the dilute (10 to 15 percent) CO_2 found in the flue gas emitted by power plants be separated, concentrated to high purity (>95% purity), and compressed to supercritical conditions for pipeline transport. However, current chemical scrubbing technology is energy intensive (reducing the power plant efficiency by 30%) and expensive (increasing the cost of electricity at least 85%). One of the technologies being investigated to reduce the cost and energy consumption of CCS is the chemical looping combustion process.

Chemical looping splits combustion into separate oxidation and reduction reactions—a process designed to generate steam for power production with the byproduct of combustion being a pure stream of CO_2. A solid (e.g. calcium, iron, nickel, copper, manganese) reacts with oxygen from air and is used as an oxygen carrier. The carrier releases the oxygen in a reducing atmosphere and the oxygen reacts with the fuel. The carrier is then recycled back to the oxidation chamber where the solid oxide is regenerated by contact with air. The advantage of using two chambers for the combustion process is that the CO_2 is concentrated, once the water is removed, and not diluted with nitrogen gas. The benefit of the process is that no air separation plant or external CO_2 separation equipment is required.

Description

Alstom Power will engineer, procure, install, operate and test a 3 MW (thermal) chemical looping combustion prototype based on successful development and testing of a 65 kW (thermal) pilot-scale system under a previous Department of Energy (DOE) cooperative agreement. Alstom will install this prototype at their existing Power Plant Laboratory in Windsor, CT. The prototype will include a reducing reactor, an oxidation reactor, and process loops to transfer solids and oxygen between the two reactors with limestone used as the oxygen carrier. Calcination of hot solids produced in the oxidation reactor will produce a concentrated stream of CO_2 as opposed to the dilute CO_2 stream typically found in flue gas from coal-fired power plants. This will enhance the ability to economically capture CO_2 at coal-fired power plants. After installation and start-up of the prototype, Alstom plans to

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PERIOD OF PERFORMANCE

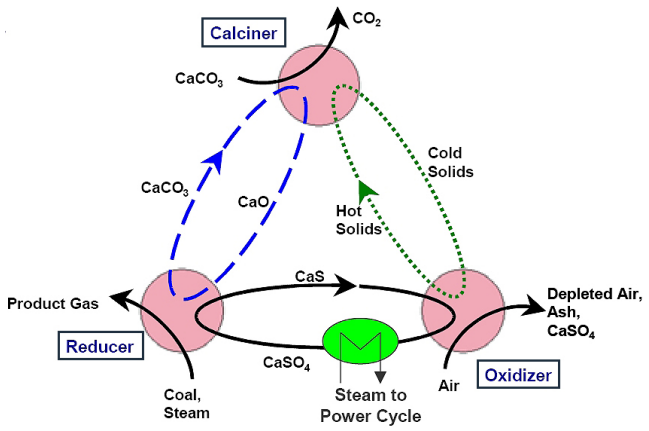
10/01/2008 to 03/31/2011

COST

Total Project Value
$6,249,518

DOE/Non-DOE Share
$4,999,614 / $1,249,904

conduct 7 weeks of cold flow and hot flow testing. The information Alstom obtains from operation and testing will be used to develop a technical plan and cost estimate for a subsequent commercial demonstration project at a U.S. power plant.



Limestone-Based Chemical Looping

Primary Project Goal

The primary goal of this project is the development of a novel chemical looping combustion process that is able to capture at least 90% of the CO_2 emitted by a coal-fired power plant, at a 35% or less increase in the cost of energy services compared to a similar plant without CO_2 capture.

Objectives

The primary objective is to advance chemical technology by designing, building, and testing a prototype facility that includes all of the equipment that is required to operate the chemical looping plant in a fully integrated manner with all major systems in service. Data from the design, construction, and testing will be used to characterize environmental performance, identify and address technical risks, reassess commercial plant economics, and develop design information for a demonstration plant planned to follow the proposed prototype. Activities in the prototype program will include operation of the prototype, testing the prototype to obtain required data, applying the lessons learned to the commercial design and economic analyses, and planning for a future demonstration plant.

Benefits

Chemical looping has the potential to generate electricity using a process that produces a concentrated stream of CO_2, which could reduce power consumption and make CCS more economical.

Upon completion, this project will benefit the Existing Plants Program's chemical looping technology development by:

- Providing experimental data for the design of future chemical looping facilities.
- Demonstrating chemical looping technology at the megawatt scale.
- Characterizing performance, risks, and economics of a prototype plant.

Accomplishments

Alstom has:

- Been awarded a cooperative agreement with the DOE's National Energy Technology Laboratory to build a prototype chemical looping plant.
- Assembled a dedicated engineering team.
- Completed definition of a preliminary prototype design.
- Submitted quote requests with steel, building, and process equipment vendors

Planned Activities

- Engineer a 3-MW prototype chemical looping plant
- Procure, install, and operate the prototype plant
- Deliver interim topical report containing results from the plant design and cost estimate
- Deliver a final topical report describing the results from the prototype testing