PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Carbon Sequestration

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PILOT-SCALE DEMONSTRATION OF A NOVEL, LOW-COST OXYGEN SUPPLY PROCESS AND ITS INTEGRATION WITH OXY-FUEL COAL-FIRED BOILERS

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Background

It is widely accepted that global climate change is due, in large part, to the emissions of greenhouse gases such as CO_2. Since fossil fuels will remain the primary energy source for some time, coal-fired power plants of the future will need to incorporate processes that can cost-effectively capture and sequester their CO_2 emissions. One of the promising CO_2 capture technologies is oxy-combustion with flue gas recycle. In this process, the combustion air is replaced with a mixture of oxygen and recycled flue gas to produce a CO_2 - flue gas, which can be conditioned and delivered to a CO_2 sequestration site. Recycled flue gas moderates temperatures and maintains heat transfer characteristics in the boiler, enabling the technique to be easily applied to existing coal-fired power plants. However, the biggest barrier to implementation of this technology is the cost of producing the oxygen. The standard oxygen production method for applications of this scale is the relatively costly cryogenic air separation process. The development of cost effective alternative technologies for oxygen production is extremely important to make oxy-fuel coal fired power plants with CO_2 capture viable and attractive.

One alternative to cryogenic air separation being investigated by BOC is the Ceramic Autothermal Recovery (CAR) oxygen production process. BOC, the world's second largest industrial gas company, has developed a novel high-temperature sorption-based technology for oxygen production and supply to oxygen-fired boilers with flue gas recycle.

Description

The process utilizes the oxygen storage capacity of Perovskite materials at high temperatures, and involves cyclic operation with conventional fixed bed vessels that contain the material in granular form. This process consists of two main steps: (1) oxygen sorption and (2) oxygen release. In step 1, air is passed through one bed to allow sorption and storage of oxygen, while in Step 2, a sweep gas such as flue gas or steam is passed through the other bed to release the stored oxygen. The process operation is made continuous by operating two beds in a cyclic mode. The air and purge steps are carried out counter-currently in order to achieve higher oxygen concentrations in the product mixture as well as to effectively recover the heat in the gas streams leaving the bed. Since oxygen sorption on Perovskites is exothermic while oxygen release is endothermic, the process operates autothermally with little heat input.

PARTNERS

Alstom Power Plant Laboratories

Western Research Institute

COST

Total Project Value
$6,132,613

DOE/Non-DOE Share
$4,906,089 / $1,226,524

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Primary Project Goal

The overall goal of the project is to conduct pilot-scale testing of BOC's Ceramic Autothermal Recovery (CAR) oxygen generation process, when integrated with a coal-fired combustor to produce a CO_2 - rich flue gas. This includes integrated testing of a 0.7 ton oxygen per day unit at WRI and scale up to a 10 ton oxygen per day unit and integrated testing at Alstom.

Objectives

- Determine the ability of CAR materials to handle the contaminants in the recycled flue gas stream including SO_2, NO_x and particulates at the levels present after processing in the scrubber and barrier filters.
- Determine the ability of the CAR test unit to operate at performance levels indicated as acceptable according to a systems and economic analysis.
- Assess the performance of the CAR test unit through an updated process and economic systems analysis to determine the ability to achieve economic and DOE goals.

Accomplishments

- The 0.7 ton oxygen per day CAR unit was operated at the Combustion Test Facility (CTF) of the Western Research Institute (WRI) that demonstrated that researchers were able to maintain operation of the CAR unit at the desired operational temperature range. This was accomplished by switching the feed gas to the bed from air to carbon dioxide.
- Subsequent testing at WRI demonstrated the ability to operate the CAR unit in dual bed cyclic mode.
- Conducted preliminary evaluations of CAR performance in the presence of recycled flue gas contaminants.
- Completed baseline oxycombustion tests for the CTF facility.

Planned Activities

- Complete integration of CAR unit dual bed system with the CTF facility at WRI to conduct integrated oxycombustion testing.
- Design and construct 10 ton oxygen/day CAR unit
- Integrate 10 ton oxygen/day CAR unit with Alstom's Multi-use Test Facility (MTF) in Winsor, CT.
- Test integrated CAR-MTF system in both pulverized coal and circulating fluidized bed combustion configurations.