the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Oxy-Combustion Boiler Development for Tangential Firing

Background

Oxy-combustion is a promising, near-term technology for carbon capture from pulverized coal (PC)-fired power plants. Oxy-combustion replaces combustion air with a mixture of oxygen and recycled flue gas, creating a high carbon dioxide (CO_2) content flue gas stream that can be more easily processed for sequestration or high purity product. For more than a decade, Alstom Power, Inc. and others have been actively working on various oxy-combustion-based CO_2 control technologies. In these projects, a large body of scientific information and knowledge has been accumulated, but product development and technology gaps exist. In particular, oxy-combustion characteristics in a tangentially-fired (T-fired) boiler are not well understood. Furnace aerodynamics and mixing with T-firing is vastly different from swirl-stabilized, wall-fired burners that require different design considerations to optimize oxy-combustion. Since T-fired boilers make up 44 percent of the world's installed base and 41 percent of that of the United States, a technology solution for T-fired boilers is important to address both existing and new units.

Description

Alstom will perform a focused research and development program to develop an oxy-combustion firing system designed for retrofit to T-fired boilers and to provide information to address the technical gaps for commercial boiler design. The project will evaluate several oxy-combustion system designs, including internal flue gas recirculation (FGR) and various oxygen injection schemes, for cost-effective, furnace design conditions in a T-fired boiler. The evaluation will use an array of tools, including Alstom's proprietary models and design codes, along with three-dimensional computational fluid dynamics (CFD) modeling. A techno-economic analysis will be performed to assess the overall viability of concepts. The effect(s) of design parameters that influence combustion and furnace heat absorption will be examined, ranging from oxygen to recycled flue gas ratio, injection of pure oxygen in various configurations, injection direction and interaction of the various streams, overfire air quantities and locations, and firing system design. A range of tests with different emissions profiles will be performed, because different potential flue gas cleanup schemes have different optimum flue gas constituents from the boiler.

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PERIOD OF PERFORMANCE

10/1/2008 to 9/30/2009

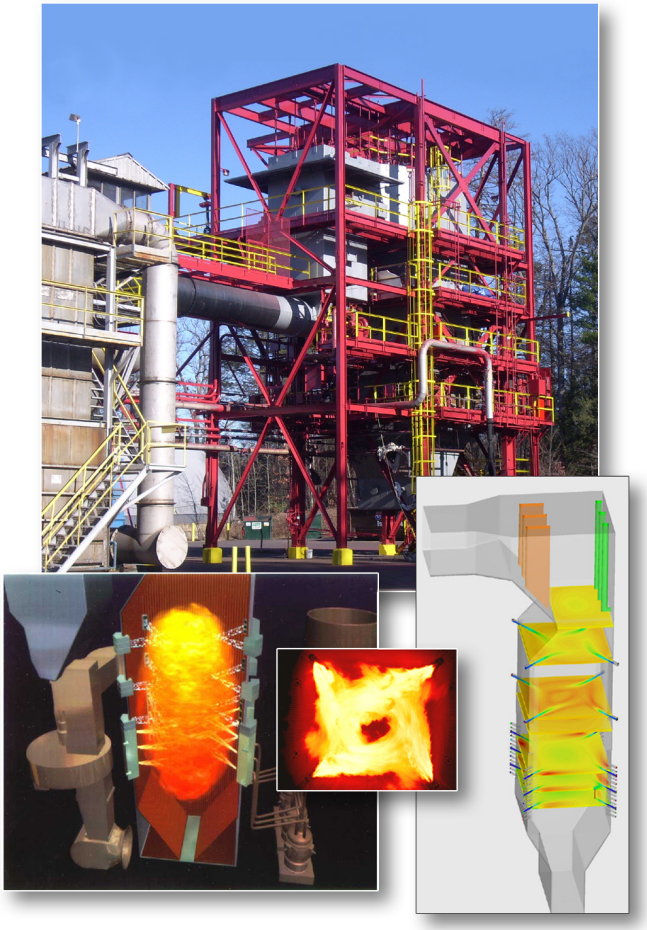
COST

Total Project Value
$4,243,497

DOE/Non-DOE Share
$3,090,219 / $1,153,278

Primary Project Goal

The project goal is to develop an innovative oxy-combustion system for existing T-fired boiler units that minimizes overall capital investment and operating costs by measuring the performance of these systems in pilot-scale tests and provides information to address the technical gaps for commercial design.



T-Fired Boiler Design and Boiler Simulation

Objectives

The overall objectives of the project are to:

- Design and develop an innovative oxy-combustion system for existing T-fired boiler units that minimizes overall capital investment and operating costs.
- Evaluate the performance of oxy-combustion T-fired boiler systems in pilot-scale tests at Alstom's 15-thermal megawatt (MW_{th}) T-Fired Boiler Simulation Facility (BSF) and 15-MW_{th} Industrial Scale Burner Facility (ISBF).
- Address technical gaps in design of oxy-combustion commercial utility boilers through focused testing in the BSF and the ISBF and improving engineering and CFD tools.

Benefits

This project is designed to (1) develop a better understanding of the characteristics of oxy-combustion as compared to air-fired combustion under various T-fired boiler conditions and (2) develop and test an oxy-combustion T-fired boiler concept that can be retrofitted to existing PC-fired power plants while minimizing incremental capital and operating costs. The project will include evaluation of a novel concept that could reduce FGR system costs and significantly reduce the total volume of the flue gas stream to be treated by the air pollution control devices (APCD). For new units, this will result in significant savings in incremental capital and operating costs for APCDs.

Planned Activities

The project will:

- Conduct four large, T-fired, pilot-scale test series over a range of combustion conditions. Three of the series will be performed on Alstom's T-fired BSF, which has been used for previous programs involving low NO_X firing system development and in-furnace limestone injection.
- Test a different type of U.S. coal for each test, because coal specification impacts the combustion process. Likely candidates include a subbituminous coal, a low-sulfur Eastern bituminous coal (with and without added sulfur), and a lignite.
- Examine a matrix of combustion conditions on each of the coals, including the oxygen to re-circulated flue gas ratio, effect of injecting pure oxygen in various configurations, injection direction and interaction of the oxygen and re-circulated flue gas streams, total excess oxygen, furnace staging, various air in-leakage rates, reduced loads, and comparison tests with air firing.
- Perform one series of large, pilot-scale tests at the ISBF following the BSF tests. The ISBF utilizes a single corner, single elevation section of a T-firing system. As there is only a single fuel admission point in the ISBF (versus 12 fuel admission points in the BSF) and the total firing rate is similar, the ISBF firing system component will be near full scale, allowing for an accurate evaluation of "near-field" combustion performance over a range of combustion test conditions.
- Test several proposed coal nozzle tips and compare for flame attachment, uniform heat release, emissions, etc.