

Oxy-Combustion CO₂ Capture

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Research Objective

This project brings together flagship projects in the United States with centers of excellence in both China and the United States, with the goal of achieving cost and performance improvements through small pilot and large at-scale validation projects. For example, strategic introduction of oxygen into proper flame zones can enable low-volatile pulverized coal to burn in a wall-firing configuration and avoid the complexities associated with the down-shot boiler design. All work is expected to continually feed and update robust simulation programs. The work examines opportunities for oxyfiring with both U.S. and Chinese coals (solid fuels) by accomplishing the following:

- Understand the fundamental and pilot-scale combustion and emission characteristics of indigenous Chinese and U.S. coals (solid fuels) of different ranks under oxy-fuel conditions
- Create a model for oxy-fired burner design, pilot-scale oxy-combustion evaluation and optimization, and full system modeling
- Conduct a commercial-scale engineering feasibility study for an oxy-fuel-combustion reference plant as a new build, retrofit, or repowering
- Develop the plant simulation and modeling to accelerate further design improvements, applications, and performance. This is key in order to quickly measure the value of the costs and benefits of proposed improvements discovered in the laboratory.

Technical Approach

Both China and the United States have large coal reserves including lignite, bituminous, and anthracite coal. With the existing experience from previous U.S. work, along with the development of new research pilots in China, an opportunity exists to accelerate the path to commercialization and broaden the application across regions and fuel types. The primary approach focuses on expanding the experience of oxy-combustion into broader applications in the United States and China. The technical approach comprises four main activities:

Fuel Characterization and Hazardous Air Pollution Emission Study under Oxy-fuel Conditions

- Conduct analysis of representative samples of different ranks of Chinese and U.S. coals
- Conduct experiments on characteristics of coal pyrolysis, ignition, combustion, burn off, dust stratification, slagging, and deposition in bench-scale facilities. Also, conduct tests on NO_x formation and destruction, PM_{2.5} emission and control.
- Develop and implement reaction chemistry sub-models on combustion and NO_x formation under oxy-combustion conditions to provide a tool for burner design and oxygen injection optimization (FURN, HUST, COMO, B&W)

Pilot-Scale Oxy-fuel Combustion Evaluation and Optimization

- Carry out pilot-scale tests in research facilities at B&W and HUST using selected Chinese and U.S. coals
- Configure the research facilities at B&W and HUST for the optimum oxy-combustion flue gas recycling process (e.g., warm-recycle, cool-recycle, or cold-recycle) using a new burner design
- Collect performance data on combustion, heat transfer, furnace exit gas temperature, and emissions over a wide range of practical operating conditions



- Select the most promising design based on modeling predictions and performance criteria for further demonstration
- *Steady-State and Dynamic Process Modeling Simulations*
- Compare Aspen Plus static predictions with pilot-scale data
- Use Aspen Plus Dynamics to simulate transient oxy-combustion processes
- Validate and tune the dynamic process model toward developing a control strategy for start-up, shutdown, modulations, and unit trips (e.g., boiler, air separation unit, compression and purification unit, etc.)
- *Feasibility Study for Large-Scale Deployment*
- Design a larger boiler unit at near-commercial scale
- Conduct an engineering study of a reference wall-fired pulverized coal burning unit for oxy-combustion
- Perform unit and process design of the air separation unit, boiler island, compression and purification unit, and the balance of plant

Recent Progress

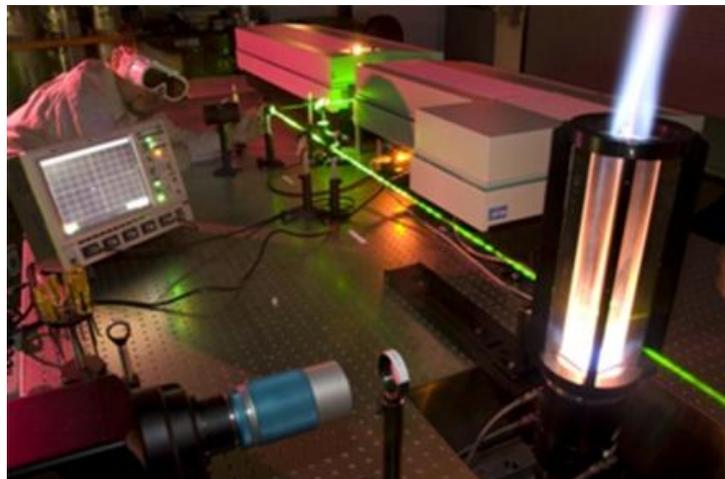
Several large oxy-combustion plant analyses and configurations have been completed (B&W). The flue gas conditions and a base configuration for the plant environmental equipment will be determined (WVU). Initial laboratory combustion tests of three Chinese coals have been completed (B&W). The results are being used to update combustion models for oxy-combustion processes and will be correlated to U.S. coals to evaluate and process differences in collaboration with HUST.

Recent meetings have been held both in the United States, where HUST was able to review the B&W 1.8 MWt pilot plant and discuss operating and performance characteristics, and in China, where B&W was able to review the design of the new 3 MWt pilot under construction by HUST and provide input on design, functionality, and controls. Discussions continue on large-scale demonstrations and effective collaboration on key opportunities, such as the sub-critical repowering in the United States at 200 MWe (B&W), sub-critical retrofit in China at 100 MWe (HUST), and super-critical new build in China at 350 MWe (B&W).

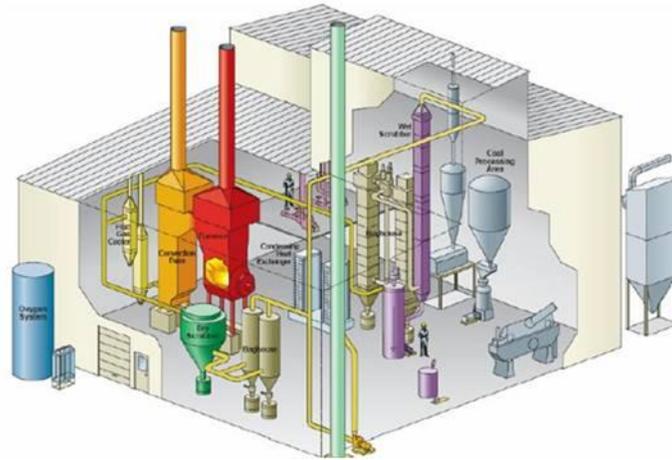
Expected Outcomes

This project will lead to cost and performance improvements in the laboratory and in the field. Ultimately, the economic and environmental potential of oxy-firing combustion will be attributable to a wider range of solid fuels and at a commercially viable scale.

Combustion laser diagnostics for fuel characterization and oxy-combustion



Oxycombustion pilot facility diagram



1.8 MWth oxycombustion pilot facility

