R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Carbon Sequestration

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Oxy-Fuel Combustion

Objective

The overall objective of this project is to assist in improving and validating modeling tools for designing and improving oxy-combustion systems for new plants and retrofitting existing power plants. The result of this project will be that NETL has the capability to analyze retrofit and new oxy-combustion plants, to predict performance, and to recommend measures to improve performance.

Background

Oxy-fuel combustion is being developed for both turbine power cycles, and for pulverized coal plants. The products of oxy-fuel combustion are just carbon dioxide, and water. The water is easily separated, producing a stream of CO_2 ready for sequestration.

Pulverized coal oxy-fuel combustion burns fossil fuels in a mixture of recirculated flue gas and oxygen, rather than in air. The remainder of the flue gas, that is not recirculated, is rich in carbon dioxide and water vapor, and is a good candidate for treatment to condense the water vapor and capture the CO_2. An optimized oxy-combustion power plant will have ultra-low emissions.

Oxy-fuel power cycles can use coal syngas containing both CO and H_2 for combustion in a turbine cycle. Temperatures are controlled by recycled water (or CO_2) in a complete power system.

In both pulverized coal and power cycle applications, the current state of art is such that a greenfield oxy-combustion plant could be built or an existing plant retrofitted using existing technologies. However, such plants would not be optimized due to a lack of data or proven computer models of oxy-fuel combustors, boiler systems or carbon dioxide recovery systems. Multiple oxy-combustion facilities at various scales are being constructed or are in operation around the world. NETL is currently commissioning a lab scale burner suitable to study basic features of oxy-fuel combustion. These facilities are generating data that could be paired with NETL's expertise in the application of computer modeling. An objective of this project will be to develop cooperative relationships with the entities operating these facilities and to obtain data on oxy-combustion systems to supplement the NETL computational efforts.

Prior research on PC oxy-fuel has shown that, in order to maintain the oxygen/recirculated flue gas flame so that the oxy-combustion system has heat transfer characteristics similar to that of an air-fired system, an oxygen level of about 30-35% is required in the gas entering the boiler. Plants that are retrofit to oxy-combustion

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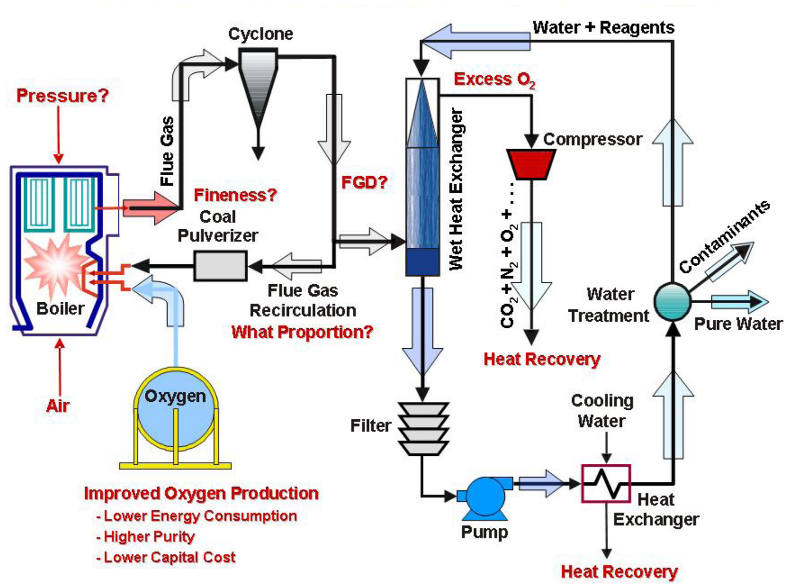
would likely operate within the range of oxygen levels that will maintain combustion conditions near those of air-fired systems. New oxy-combustion plants or repowered plants will not necessarily be constrained to be like air-fired systems, and more efficient designs will undoubtedly be conceived. The critical parameter of oxygen content may, for example, be adjusted to increase radiative heat transfer at the expense of convective heat transfer in zones further from the flame. In both retrofit and new systems, the changes inherent in oxy-combustion affect flame behavior; heat transfer; mass transfer; combustion gas chemistry and behavior; char burnout; slag development, chemistry, and deposition; and many other characteristics of fossil fuel combustion systems.

In a prior in-house project, heat recovery was identified as significant to improving efficiency of PC oxy-combustion systems. During processing of the combustion gas for carbon capture, sensible and latent heat in the exhaust gas and heat of compression can be partially recovered and returned to the plant via feed water. However, the changes in heat balance can lead to out-of-design conditions and the potential for failure. The low-pressure turbine was specifically identified as a vulnerable point. Also in prior projects, it has been shown that oxy-fuel power cycles would benefit from fundamental data on oxy-fuel gas-phase flame properties, such as flame speeds and radiant heat transfer.

As a result of the challenges identified by earlier NETL efforts in the oxy-fuel/ CO_2 - capture environment, other objectives of this project are to: 1) develop a better understanding of the oxy-combustion flame, and of heat and mass transfer in oxy-combustion systems; 2) develop an understanding of the character and distribution of ash and slag in PC oxy-combustion systems; 3) develop solutions for the potential low-pressure steam turbine imbalance in PC retrofit applications; and 4) support development of improved systems and CFD models and modeling tools.

An approach combining modeling, lab tests, and field work will be utilized. Development of relationships with other research entities will provide opportunities to conduct field evaluations of oxy-combustion test systems, which will positively impact all of the tasks of this project.



Gas path processes and areas for analysis.