The effect of oxy-fuel combustion with simulated flue gas recycle on NOx formation and flame stability in a 20 kW coal and coal/biomass combustor

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The adoption of renewable energy standards aimed at reducing carbon dioxide emissions and the expansion of carbon cap and trade systems are expected to have great impact on regions that are dependent upon coal for electricity generation. A retrofit technology for existing coal-fired power plants is needed in order to meet these standards and reduce CO_2 emissions while limiting the costs to be passed on to electricity consumers. It is anticipated that bioenergy resources in the form of agricultural waste or bioenergy crops grown specifically for energy production (e.g. switchgrass) could constitute the majority of the renewable energy portfolio in regions that do not have ample wind and solar resources. The cofiring of renewable biomass with coal is an attractive option for reducing the carbon footprint of a power generation plant that does not require a significant change in the power plant design. Another approach to reduce greenhouse gas emissions is to implement Carbon dioxide Capture and Storage (CCS) technology, thereby preventing the release of CO_2 into the atmosphere. The combination of cofiring of coal and biomass with CCS is potentially a carbon *negative* technology, providing energy while removing CO_2 from the atmosphere. The carbon dioxide in the flue gas can be highly concentrated by replacing combustion air with a mixture of oxygen and recycled flue gas (oxy-coal combustion) thus removing the need for CO_2 scrubbing. While there are costs associated with oxygen production, advances in air-separation technologies are being made—particularly in the area of ion-membrane separation technologies. Moreover, oxy-coal combustion has the potential to reduce the formation of nitrogen oxides (NOx) beyond the levels achievable by low NOx burners and overfire air, thereby offsetting some of the costs associated with oxygen production by reducing or eliminating the need for post combustion NOx cleanup.

The overall objective of this work is to investigate the cofiring of biomass with coal under oxy-combustion conditions, as a means of mitigating atmospheric carbon dioxide emissions while yielding burning characteristics that are similar or superior to traditional coal combustion. Experiments are performed in a 15-35 kWth, horizontally-fired laboratory combustor. The gas compositions (concentrations of O_2, N_2 and CO_2) of the primary and secondary flows are varied over a wide range of conditions and the effects of the cofiring ratio (sawdust feed rate/total fuel feed rate) and gas composition on flame stability and NOx formation are investigated. Flame stability is determined by reducing the secondary oxidizer swirl velocity until the flame is visibly detached from the fuel jet. Effects on NOx formation are determined by measuring NO in the flue gas via a ThermoFisher scientific CEM following complete char burnout.