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Technical Report

A Summary of NO_x Emissions Reduction from Biomass Cofiring

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Abstract

This report attempts to provide a summary of the NO_x emissions measured during recent biomass/coal cofiring demonstrations. These demonstrations were carried out at the commercial- and pilot-scales. Commercial-scale tests were conducted in a variety of pulverized fuel boiler types including wall-fired, T-fired, and cyclone furnaces. Biomass input ranged up to 20% on a mass basis and 10% on an energy basis. The hypothesis: "Based on published full-scale data, can cofiring be used as an effective NO_x emission reduction strategy?" The answer: sometimes.

Introduction

The threat of increased global warming has subjected the use of fossil fuels to increasing scrutiny in terms of greenhouse gas and pollutant emissions. As a result, the use of renewable and sustainable energy resources, such as biomass, for electricity production has become increasingly attractive. The use of dedicated biomass feedstocks for electricity generation could help reduce the accumulation of greenhouse gases because carbon dioxide is consumed during plant growth. The agricultural and wood products industries generate large quantities of biomass residues that could also provide fuel for electricity production. Increasing the use of such fuels could alleviate the burdens and environmental consequences of waste disposal in the agricultural and wood products industries. Landfill lifetimes could be extended and methane and CO_2 production from biomass decomposition would be avoided.

The initial capital investment to build new biomass power plants to increase the percentage of biomass power is high. Cofiring biomass with coal in coal-fired power plants is a lower capital cost option for increasing the use of biomass to produce electricity. Coal-fired power plants are used to produce most of the electricity in the United States. If biomass were cofired at low percentages in these plants, the use of biomass for power production could dramatically increase. Cofiring biomass and coal takes advantage of the high efficiencies obtainable in coal-fired power plants. Fuel diversity is another advantage of biomass/coal cofiring which reduces the need for a constant supply of biomass that would be required in a biomass power plant. Cofiring biomass and coal is also a viable way to manage the increasing emissions of greenhouse gases and other pollutants from power generating facilities.

Biomass and coal have fundamentally different fuel properties. For instance, biomass is a more volatile fuel and has higher oxygen content than coal. In general, biomass contains less sulfur than coal, which translates into lower sulfur emissions as higher blending ratios of biomass are used. Wood fuels generally contain very little ash (1% or less); consequently, increasing the ratio of wood in biomass/coal blends can reduce the amount of ash that needs to be disposed. A negative aspect of biomass (especially some grasses and straws) is that it can contain more reactive potassium and chlorine than coal. Higher fuel chlorine contents can lead to greater high temperature corrosion in boilers. Accelerated fouling and slagging can also occur when high potassium containing fuels are utilized.

Biomass cofiring is not a new technology and several utilities have taken advantage of opportunities and have or had been cofiring biomass for many years. Three examples are the AES (formerly NYSEG) Greenidge Station in Dresden, NY that began cofiring tests I October 1994. The success of these tests led to the installation of a separate biomass preparation area in the fuel yard in early 1999 to separately feed biomass into the 108 MWe tangentially fired pulverized coal unit. Steam plant #2 at Tacoma Public Utilities power plant in Tacoma, WA was reconfigured in 1991 to cofire coal, biomass, and refuse derived fuels on a continuous basis in a 50 MWe atmospheric pressure fluidized bed combustor. Northern States Power had a continuous cofiring operation from 1987 through 1997 cofiring the wood residues from the neighboring Anderson Window plant at a level of 5% (20 tons per hour) in a 550 MWe coal fired cyclone boiler at the King Station in Bayport, MN. Cofiring was suspended at the King Station because Anderson Window found a higher value application for its wood residues not for technical reasons.

Aside from these longer duration cofiring operations, several other U.S. utilities have tested biomass/coal cofiring in utility boilers for a much shorter duration with the goal of systematically trying to determine the impacts of biomass cofiring on such in-furnace parameters as boiler de-rating, boiler efficiency, emissions reductions, changes in fouling and slagging behavior, and corrosion. The USDOE Biomass Power Program is also currently funding a number of demonstration projects to add to the knowledge base of utility-scale biomass/coal cofiring.

NO_x Emissions Reductions?

Increased environmental performance at a modest cost is one of the drivers for biomass/coal cofiring in utility boilers. Biomass usually has lower sulfur content than coal so cofiring results in a reduction of SO_x emissions because of a displacement of sulfur in the fuel blend. Similar reductions are also observed for NO_x emissions because the nitrogen content of the cofired biomass fuels is generally lower than the nitrogen content of the coal. Initially, any change in NO_x emissions as a result of blending the biomass and coal can be attributed to changing the amount of nitrogen in the fuel blend.

This may not be the case, however, in full-scale biomass/coal cofiring applications. Of course, in a full-scale cofiring situation many other engineering factors contribute to NO_x formation. Utility boilers are far from isothermal, and adding biomass to a pulverized coal-fired boiler can significantly change the flame structure and characteristics. The addition of biomass has been shown to reduce NO_x emissions in most commercial facilities, usually beyond the reductions expected because of a lower overall fuel-bound nitrogen content. The high volatiles content of biomass can effectively establish a fuel-rich zone early in the flame that can reduce NO_x emissions. Adding biomass can also reduce flame temperatures, leading to lower levels of thermal NO_x. The high moisture content of some biomass may also be effective for NO_x reduction at full-scale.

A summary of the measured NO_x emissions reduction as a function of the biomass cofiring percentage for a number of full-scale biomass cofiring demonstrations and pilot-scale results is plotted in Figure 1 on a % biomass cofired on a mass basis and in figure 2 on a % biomass cofired on an energy basis. Evident in Figure 1 is that in most cases, NO_x emissions decrease proportionally with an increasing amount of biomass added to the fuel blend. In many demonstrations (MG&E Blount Street Switchgrass cofiring for example) there is some degree of variability and lack of reproducibility for some measurements. This spread in the emissions measured at a given cofiring percentage can probably be attributed to other boiler factors such as load, boiler efficiency, flue gas exit temperatures, and excess air ratio.

The cofiring demonstration at TVA's Colbert plant in 1997 is somewhat of an anomaly. During these tests, 4% green (47% moisture) sawdust was cofired with eastern bituminous coal in a 190 MW_e wall-fired PC boiler. Tillman et al. attribute the increased NO_x to a variability in the coal fuel-bound nitrogen content compared to the baseline measurement. The results from the pilot plant cofiring demonstrations do not show a pronounced a decrease in NO_x emissions compared to the full-scale demonstration tests.

Figure 2 shows the NO_x emissions reduction from biomass/coal cofiring based on the percentage of energy supplied to the boiler by the biomass fuel. Similar conclusions can be drawn from this figure as were already discussed for Figure 1. Plotting the percent biomass cofired on an energy basis takes into consideration that the moisture content of biomass can be significantly greater than that of the coal used in the cofiring tests.

Issues

While numerous cofiring demonstration tests and full-scale commercial cofiring practices have been or are being conducted, several issues regarding how blending biomass and coal will affect combustion performance, emissions, fouling and slagging propensities, corrosion, and ash saleability still remain. Some of the more pertinent issues are as follows:

Boiler efficiency impacts (losses)
LOI – Carbon burnout
NOx emissions management
Environmental benefits – fossil CO_2 reduction
Mercury emissions
Trace metal partitioning
Fuel supply and logistics
Fuel handling
Ash saleability (where applicable)
Impact of biomass ash elements on SCR catalysts
Tax incentives for biomass usage

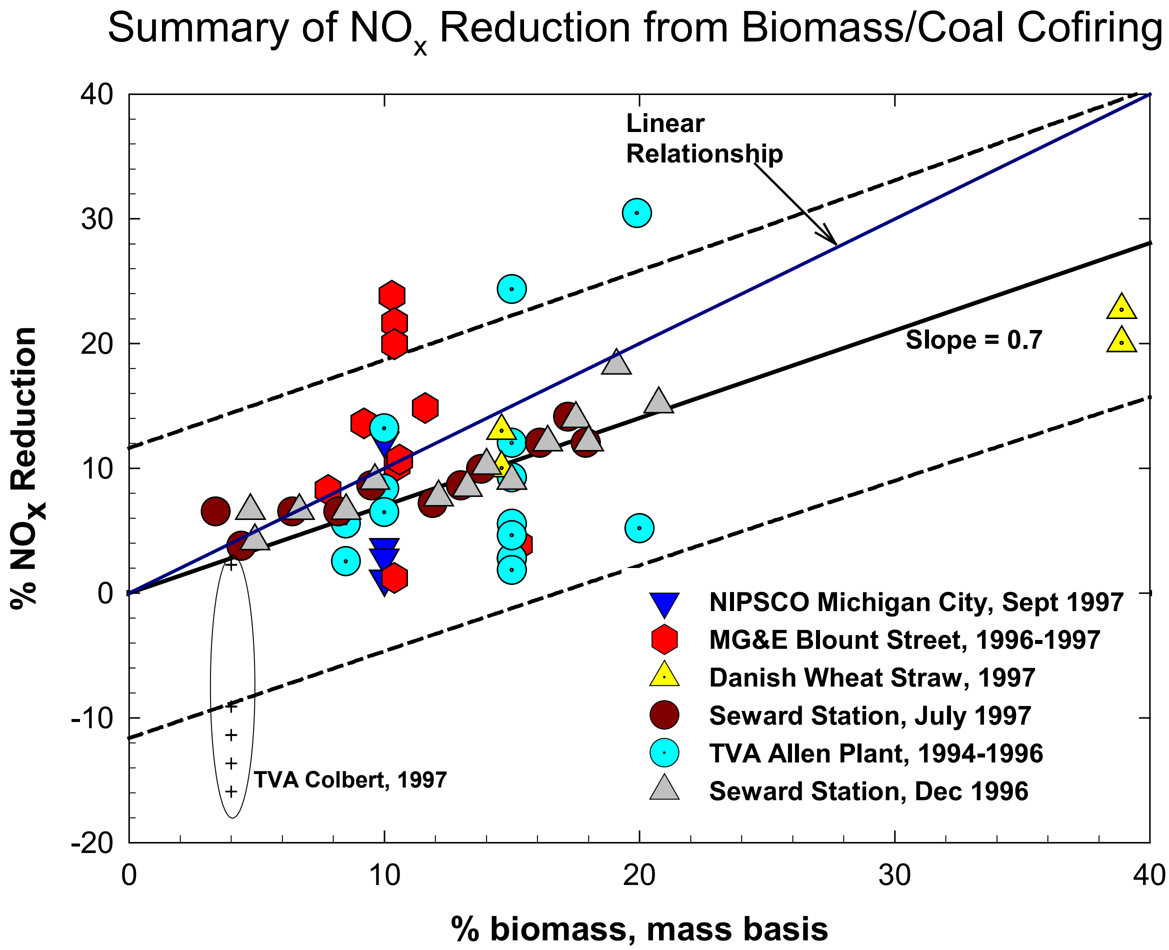

Figure 1: **A summary of NOx reduction from a number of biomass/coal cofiring full-scale and pilot-scale demonstration tests, based on the mass input of biomass. Dashed lines are 95% prediction limits that encompass the range of variability in the measured data.**

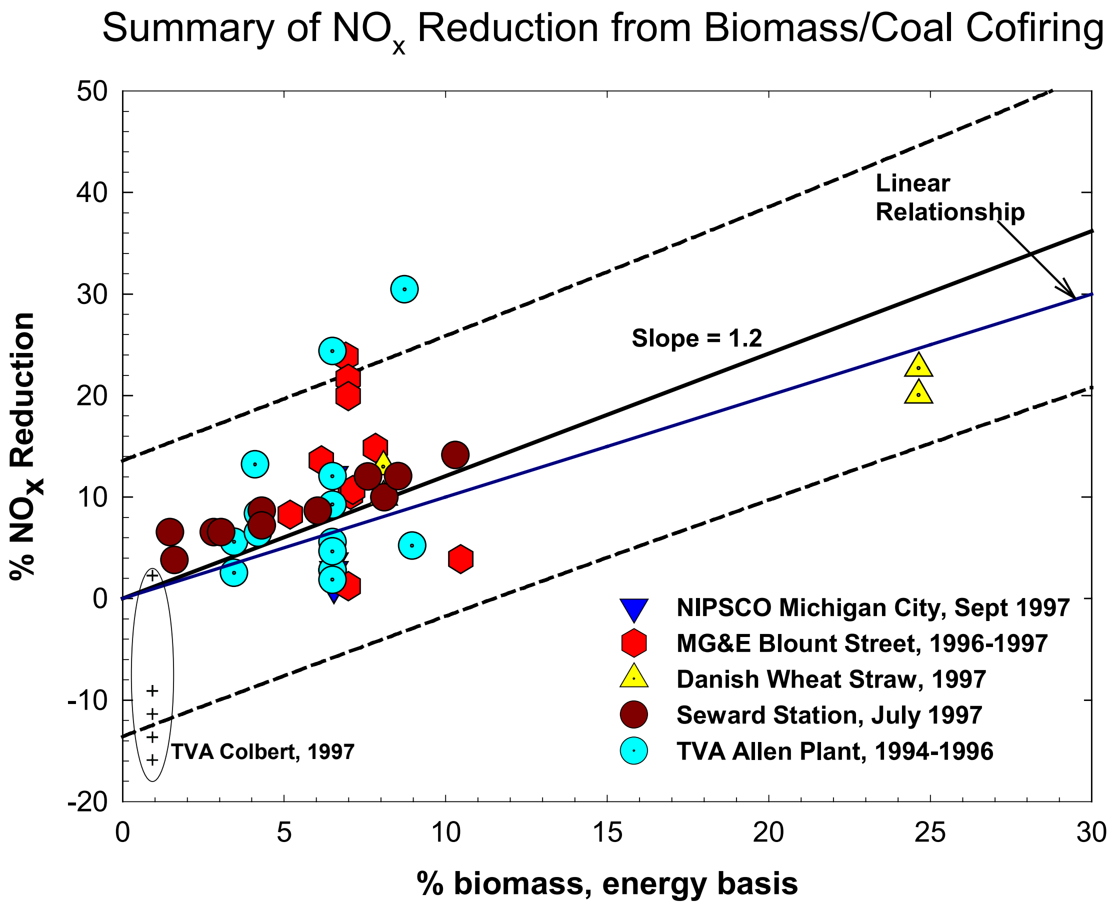

Figure 2: **A summary of NOx reduction from a number of biomass/coal cofiring full-scale and pilot-scale demonstration tests, based on the energy input of biomass. Dashed lines are 95% prediction limits that encompass the range of variability in the measured data.**

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