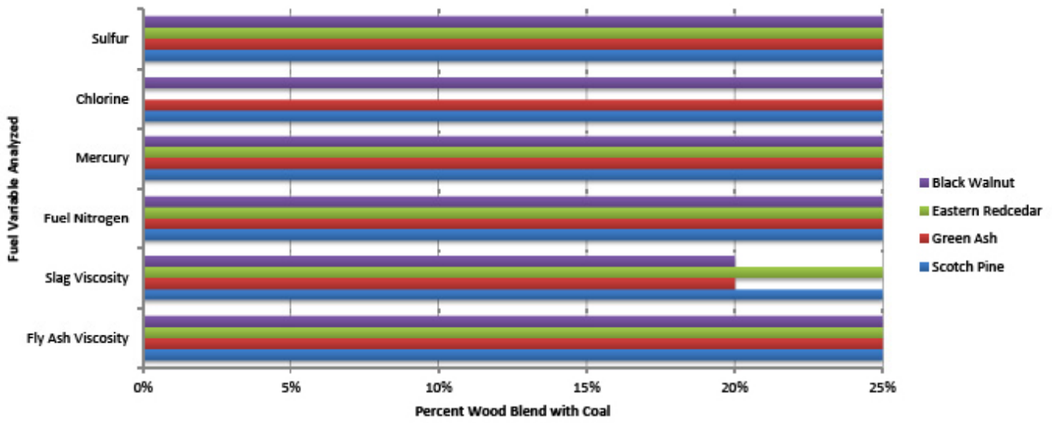
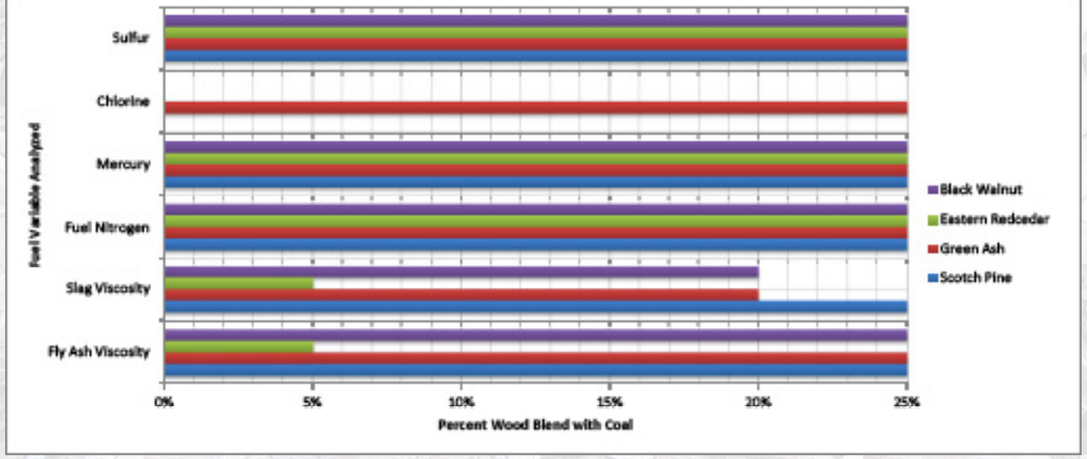
SUMMARY OF RESULTS

Suggested Wood Bland Levels with Wood Fuel Chemical Characteristics Similar/Better than Baseline Mine 1 Coal



Suggested Wood Bland Levels with Wood Fuel Chemical Characteristics Similar/Better than Baseline Mine 2 Coal



CONCLUSIONS

The black walnut, green ash and scotch pine appear generally favorable for blending, especially at lower blend levels. The performance of ERC is predicted to be more problematic. Plant specific testing must be performed as the next step in evaluating the feasibility of co-firing wood-coal

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NEBRASKA FOREST SERVICE

Woody Biomass Co-Firing

Adam Smith

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Nebraska's 1.2 million acres of forests produce 1.47 million net air-dry tons of biomass per year. Nebraska's 2 million acres of nonforestland with trees produce an estimated 590,000 net air-dry tons of biomass annually. An additional 270,000 green tons of wood waste are generated annually through timber harvests; fuels treatment projects; primary and secondary wood product processors; municipal tree removals and prunings; and forest and range improvement projects.

A perfect storm of highly destructive invasive insects and diseases, such as emerald ash borer and thousand cankers disease, threaten ash and black walnut trees in Nebraska. Combined, these threats have the potential to kill tens of millions of trees across the state, resulting in millions of additional tons of biomass.

With today's energy demands, rising fossil fuel prices and heightened regulatory concerns it will be more difficult for coal burning facilities to find ways to reduce emissions while maintaining high production output. One way to achieve the market demands for energy and reduce fossil fuel consumption is to use renewable woody biomass along with coal in coal boilers, a process also called co-firing. Co-firing allows facilities to combust fossil fuels and local renewable resources simultaneously to achieve comparable levels of boiler output. In May 2011 the Nebraska Forest Service (NFS) partnered with the Nebraska Public Power District (NPPD) to conduct a wood-coal blend chemical properties and emissions analysis. The analysis was performed to help better understand how wood-coal blends would perform in a boiler situation using various wood and coals at varying blend ratios.

A wood-fired boiler is being built at the Nebraska College of Technical Agriculture in Curtis to supplement existing natural gas boilers. The new system can be used for heating and cooling.

THE ANALYSIS

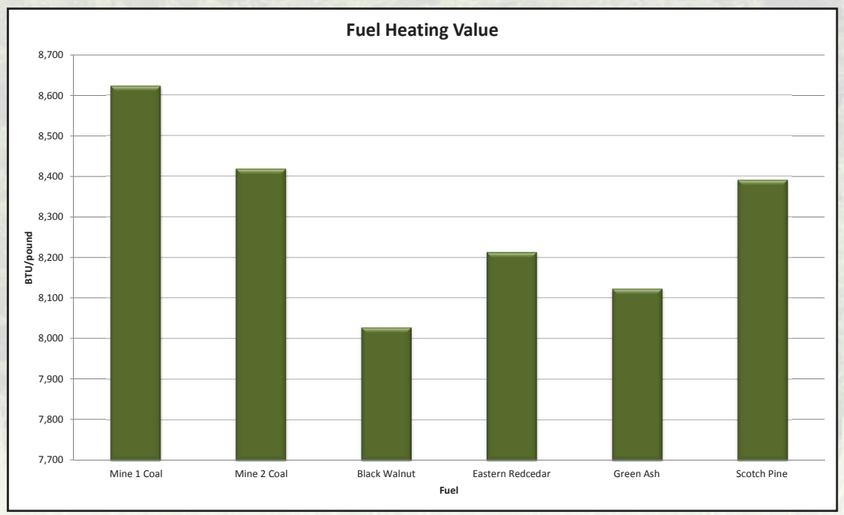
The co-firing analysis, completed by the Energy and Environmental Research Center (EERC) at the University of North Dakota, modeled the properties of co-firing at 0, 5, 10, 15, 20 and 25% wood blend with sub-bituminus Powder River Basin (PRB) coal. The EERC performed a series of equilibrium thermodynamic and viscosity calculations to estimate the anticipated effects of slag and fly ash as a function of temperature. These calculations were based on the bulk elemental analyses of the various coals and woods. Calculations were also performed focusing on sulfur, chlorine, mercury and nitrogen emissions.

For the analysis, samples of black walnut, eastern redcedar, green ash and scotch pine were provided by NFS. The PRB coal used in the analysis was provided by NPPD and came from two separate mines. The wood samples were processed down to obtain a finely ground material for the analysis.

RESULTS

Heating Value

The wood and coal have similar heat content (measured in BTUs) when combusted. Depending on its preparation, the wood feedstock is roughly half the density of coal. This physical difference in density will affect the fuel and ash material handling system.



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RESULTS

Fuel Chemicals vs. Baseline Coal

Fuel Chemical Content Compared to Baseline Mine 1 Coal

	Sulfur	Chlorine	Mercury	Nitrogen	Ash
Black Walnut					
Eastern Redcedar					
Green Ash					
Scotch Pine					

Fuel Chemical Content Compared to Baseline Mine 2 Coal

	Sulfur	Chlorine	Mercury	Nitrogen	Ash
Black Walnut					
Eastern Redcedar					
Green Ash					
Scotch Pine					

Decrease Increase

Slag viscosity

Blends of black walnut, green ash and scotch pine with either of the coals will decrease slag viscosity, but it should remain in the range of normal variability. The ERC may result in significantly lower slag viscosity and may be restricted to 5-10%

Fly ash viscosity

Other than ERC, no increase in fouling is expected for any of the woods at blend levels of 20% wood or lower.

Fly ash collectability and opacity

Other than for ERC, solid sulfates, solid phosphates, solid chlorides and liquid potassium sulfates are anticipated to have no effect on performance or opacity at blends below 20%.

Disclaimer: The results presented in this publication are from samples and may not necessarily reflect plant specific results. Predicted results are analytical estimates and do not reflect any post-combustion emission control equipment.