FETC/EPRI BIOMASS COFIRING COOPERATIVE AGREEMENT

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ABSTRACT

The FETC/EPRI Biomass Cofiring Program has accelerated the pace of cofiring development by increasing the testing activities plus the support activities for interpreting test results. Past tests conducted and analyzed include the Allen Fossil Plant and Seward Generating Station programs. On-going tests include the Colbert Fossil Plant precommercial test program, the Greenidge Station commercialization program, and the Blount St. Station switchgrass program. Tests in the formative stages included the NIPSCO cofiring test at Michigan City Generating Station.

Analytical activities included modeling and related support functions required to analyze the cofiring test results, and to place those results into context. Among these activities is the fuel availability study in the Pittsburgh, PA area. This study, conducted for Duquesne Light, supports their initial investigation into reburn technology using wood waste as a fuel.

This Quarterly Report, covering the third quarter of the FETC/EPRI Biomass Cofiring Program, highlights the progress made on the 16 projects funded under this cooperative agreement.

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EXECUTIVE SUMMARY

The FETC/EPRI Biomass Cofiring Program has capitalized upon the prior cofiring work funded by EPRI and its member utilities; and upon industrial cofiring work performed at Pulp and Paper mills throughout the country. Utilities, with the support of the FETC/EPRI cooperative agreement, have demonstrated the technical viability of cofiring low percentages of wood waste in PC boilers, and have demonstrated the impacts of that approach on pulverizer performance. Utilities, supported by the FETC/EPRI program, have also demonstrated the benefits of cofiring at moderate percentages in PC boilers using separate feeding. They have demonstrated that cyclone boilers can cofire up to 20 percent by mass, when bituminous coal is the base fuel, without capacity penalty and with moderate efficiency penalties. In all cases where cofiring is practiced at >10 percent by mass, this technology achieves significant NO_x reductions.

Demonstrations of cofiring continued during this quarter. The precommercial testing at Colbert Fossil Plant of TVA continued. Plans were initiated for a second cofiring test at the Seward Generating Station of GPU Genco. NYSEG initiated activities to upgrade its materials handling system at Greenidge Station, Fuel was procured, processed, and blended with Shoshone coal at the Michigan City Generating Station of NIPSCO.

The success of current cofiring demonstrations has led Duquesne Light to consider biofuel as a reburn fuel. Their consideration focuses upon the Upper Furnace Reburn concept. EPRI, with Foster Wheeler, initiated this program by performing a fuel analysis for that location. Other modeling and support studies also proceeded. This report reviews the progress for the 16 Cofiring Projects covered under the FETC/EPRI Biomass Cofiring program.

INTRODUCTION

Cofiring has been developed to accomplish the following economic and environmental objectives:

1. Mitigate fossil CO₂ emissions from coal-fired boilers
2. Reduce NO_x emissions from cyclone and PC boilers
3. Provide customer service to utility clients, maintaining loads
4. Increase fuel diversity for utilities

In the longer term, cofiring is seen as a way to develop the infrastructure required for supply and delivery of energy crops. Such crops could include short rotation woody crops (SRWC) and herbaceous energy crops (HEC). The SRWC projects include growing hybrid poplar in the lake states, and growing willow in upstate New York. The HEC projects include growing switchgrass in the Southeast and in the Midwest.

The energy crop projects are funded through USDOE Headquarters, and by several utilities such as TVA. Further, they relate to other biofuel and cofiring projects being developed by USDOE including:

1. The alfalfa gasification project designed to supply energy to Northern States Power
2. The Cheriton Valley project designed to cofire switchgrass with coal in a 700 MW tangentially-fired PC boiler in quantities sufficient to generate 35 MW
3. Elements of the NYSEG project designed to fire not only wood waste, but also designed to fire hybrid willow ground to an appropriate size

As cofiring has progressed, the focus has been increasingly on residues. Economically, residues have the immediate prospect of success. They provide the bridge to the proposed long term energy crop future. The 16 projects in the FETC/EPRI program contribute significantly to that bridge. They are summarized below.

1. Combustion Tests at GPU's Seward Plant (30 MWe, PC)

EPRI and GPU (an EPRI member utility operating the Seward power plant near the Johnstown, Pennsylvania headquarters of GPU's Penelec system) will arrange for other cofunding to augment PETC's cofunding and will conduct a test of mid-level cofiring in a wall-fired PC unit using separate feed for the wood (i.e., not fed through the pulverizers along with the coal, as was done in the recent test cosponsored by PETC, EPRI, GPU and the State of Pennsylvania at Penelec's Shawville plant in November 1995).

2. Fuel Preparation Tests at NYSEG's Greenidge Plant (100 MWe, PC)

EPRI is cosponsoring New York State Electric and Gas Company (NYSEG) in a test program that focuses on the preparation of wood fuel for cofiring in a tangentially fired PC unit with separate feed for the prepared wood fuel. Size reduction equipment, such as wood "grinders" or hammermills, and drying equipment will be evaluated, and the suitability of the prepared product tested in full-scale combustion in the 100 MWe boiler at NYSEG's Greenidge plant. Mid-level, i.e., about 10% by heat, cofiring is planned.

3. Pre-commercial Test Runs at TVA (~200 MWe)

EPRI is cosponsoring the next testing program at TVA, this one being the long-term "pre-commercial" test runs to cofire wood at levels up to 10% by heat, starting at the cyclone plant (Allen) in Memphis, and continuing at one of TVA's pulverized coal plants.

4. Switchgrass Cofiring with Madison Gas & Electric (50 MWe)

EPRI is cofunding the University of Wisconsin at Madison in a test program being conducted by the University and the local utility (Madison Gas and Electric) at MG&E's Blount Street Station, where an existing retrofit to burn refuse-derived fuel (formerly) and shredded paper waste (currently) in a wall-fired PC unit is to be used to conduct the first U.S. test of cofiring switchgrass along with coal in a full-size utility boiler.

5. High-level Cofiring with Southern Company (50 MWe)

Southern Company Services has discussed with EPRI a potential cosponsored project to do long-term testing of high-level (i.e., up to 40% by heat) cofiring of wood with coal, perhaps with some natural gas overfire, in a tangentially-fired PC boiler in Savannah, Georgia. This project would be a follow-up to an initial set of short test runs there in 1993, which indicated that separate feed of this much wood was possible. This test will provide the opportunity to explore the upper limits of cofiring wood with coal in an existing PC boiler.

6. Study and Testing with NIPSCO (~500 MWe, Cyclone)

EPRI is completing a study, cofunded by EPRI and Northern Indiana Public Service Company (NIPSCO), to evaluate the fuel supply and the power plant operations for cofiring wood in a full-size cyclone boiler as one of NIPSCO's voluntary measures to reduce emissions of fossil CO₂

under the Climate Challenge program of the federal government. The next phase, assuming the expected favorable findings that cofiring is a low-cost CO₂ mitigation measure, is to be a cofunded test at, perhaps, NIPSCO's Michigan City plant, where manufacturing process waste wood is the expected source of relatively dry wood already at small size and with potential for a 5% by heat cofiring operation in an urban area outside of the normal wood products regions of the South, Upper Midwest or Pacific Northwest.

7. Switchgrass Test with Nebraska Public Power District

One of EPRI's members, the Nebraska Public Power District (NPPD), has expressed interest in a preliminary evaluation of switchgrass cofiring, an evaluation that can be performed without commitment to a full-size unit test. EPRI has suggested to NPPD an evaluation based on laboratory testing at the Sandia National Laboratory's Combustion Research Facility in Livermore, California. With PETC cofunding this would test the ability of the well-controlled, well-monitored test facility at Sandia to provide data and analysis capable of predicting the potential for the fouling of superheater tubes by the cofiring of high-alkali biomass, namely switchgrass, with coal. Combined with (1) the Madison test (Item 4, above), in which NPPD will participate, and (2) the series of tests done by Sandia on both biomass fuels and coals for DOE, NREL, PETC, EPRI and industry during the past three years, and (3) PETC's in-house testing of switchgrass/coal cofiring at CERF, this new project is expected to reveal the potential and the limits of laboratory testing as a facilitator of decisions on biomass cofiring.

8. Waste Plastics Cofiring with Duke (50-200 MWe, PC)

EPRI, Duke Power Company (Duke), and the National Plastics Council have cosponsored a laboratory test and engineering analysis of the cofiring of clean plastic manufacturing wastes with coal in a PC boiler. The next step is a unit test at full-size in a PC boiler, perhaps at 50 MWe or perhaps up in the 200 MWe range, approximate size. While actual biomass cofiring, i.e., waste wood cofiring, may or may not be part of the first unit tests, this project is important for the future of biomass cofiring because it involves a major investor-owned, coal-firing utility, located in a region of a major wood-products industry as well as major, and changing, agricultural and meat/poultry industries, as well as textile industries. It is an excellent test of waste cofiring justified on purely business grounds (fuel savings and customer service) but with potential to move toward environmental grounds, if warranted.

9. Plastic/Fiber/Pulp Wastes with SCE&G (~100 MWe, PC)

EPRI has discussed possible follow-on testing with South Carolina Electric and Gas Company (SCE&G), tests that would be a follow-on to a test run in 1993 where mixed plastic and wood fiber were fired with coal to determine technical feasibility for disposal of an industrial customer's manufacturing residues. Other residues, consisting primarily, or entirely, of pulp wastes rather than plastic may be tested next. Or, a second test, longer and with more variations, using the same plastic/ fiber residue may be the prime focus. The rationale for this as a biomass cofiring test is similar to that for Duke (a neighboring utility in the same wood industry region), but the scope is more directly on biomass, as well as plastic, as fuel, and the options for boiler retrofit may be different.

10. Urban Wood-Waste Study and Test in Pittsburgh

PETC has suggested that EPRI join an evaluation of the urban wood waste resource in the industrial/commercial/residential region of Pittsburgh and environs. Course, low-cost or no-cost wood wastes would be fired with coal in a stoker boiler at the Bellefield Boiler Plant owned by a consortium that includes the University of Pittsburgh. The University would oversee and monitor a long-term test of low-level (about 2% by heat) cofiring of urban wood wastes (including tree trimmings) together with coal. The key elements of the test would be off-site wood processing, assessment of the urban wood supply and cost by means of actual fuel procurement, and, perhaps, assessment of fines separation and separate cofiring of fines in a normal utility boiler (i.e., PC or cyclone).

11. Toxic Emissions

Both EPRI and PETC have measured trace emissions and effluents from the combustion of coal and from ash resulting from coal combustion. In this new project, EPRI and PETC will combine their respective data sources, test facilities and expertise in an effort to determine the extent of trace emissions or effluents from the cofiring of wood or other biomass wastes with coal. After an evaluation of data on fuels and control processes, including data on fuel chemistry, ash chemistry, emissions, emission control systems, liquid waste streams and solid waste streams, EPRI and PETC will plan and conduct a test to measure and/or predict the emissions, if any, of toxic species that may arise from cofiring bio-mass with coal. This project will explicitly consider a test at the ECTC (Environmental Control Test Center) at the Kintigh power station operated by NYSEG near Buffalo, New York. The best site and fuel combination for a test will be identified and a test will be conducted, if the evaluation indicates that a useful measurement of toxic emissions can be obtained.

12. Fuel/Powerplant Models, Analysis and Interpretation

In order to interpret results from this entire set of projects and to facilitate the transfer of the results to the industry, EPRI will develop a SOAPP (“State-of-the-Art Power Plant”) module for evaluating wood cofiring situations. SOAPP already has modules for combustion turbine power systems, and SOAPP modules for conventional utility PC and cyclone plants, and also FBC and coal gasification systems, are under development. By July 1996, the first SOAPP cofiring module will be completed, for natural gas as the cofired fuel in a reburn or other mode. This new project (No. 12 of the PETC/EPRI cofiring program) will add wood cofiring to SOAPP, and also will add a fuels database capable of putting the properties of each new cofiring fuel into a context for comparison to some 50 other fuels and for prediction of slagging/ fouling/agglomeration potential in comparison to those other fuels. The result will be a model that will make possible the interpretation of test results from all the cofiring experiments in terms of the performance and cost impacts on a state-of-the-art coal-fired powerplant. Currently, but separate from this proposal, EPRI and PETC are cooperating on the EPRI-developed CQIM computer model by doing tests to obtain data on slagging/fouling for blends of coals. This work will be used and expanded under this PETC/EPRI biomass cofiring project. EPRI’s fuels database for biomass and other alternative fuel properties (including slagging indices, etc.) will be incorporated into CQIM, SOAPP and other analytical frameworks as appropriate. EPRI’s biomass resource assessments and tools for developing supply/cost curves will be applied as appropriate to address regional or local biomass resource issues important to PETC.

13. CO₂ Utilization in Algal Systems for Wastewater Treatment

EPRI and PETC have independently done experiments and studies of systems that can take advantage of the high rates of capture of CO₂ by aquatic biological systems such as seaweed (kelp), microalgae (ocean and land-based) and halophyte species (both in water and on dry land). This new project under this PETC/EPRI cofiring project will assess what appears to be one of the few near-term options for an algae-based system to contribute to reductions of CO₂ emissions: the use of CO₂ to speed the growth of algae in water treatment facilities. This approach adds a coproduct value, namely the improved performance of the water (i.e., sewage) treatment plant, that may make the system one of the low cost options for near-term CO₂ mitigation. Two forms of fossil CO₂ reduction are involved: (1) capture of CO₂ into a biomass form, i.e., a process similar to carbon sequestration in forest biomass, but in this case coupled directly to use of a CO₂-enhanced stream like powerplant fluegas; and (2) replacement of a fossil fuel by a biomass fuel, as the algae grown with the

enhanced CO₂ stream replace fossil fuel, i.e., a process similar to the CO₂ recycling inherent in all uses of biomass fuels replacing fossil fuels.

14. Combustion Tests and Combustor Development

EPRI and TVA have sponsored an initial assessment of slagging combustion as a way to use high-alkali biomass as fuel in power generation without having to solve the problems associated with gas cleanup to meet the purity required by the gas turbines in biomass gasification combined cycle power systems. PETC has completed the first in a planned series of bench-scale tests of the cofiring of high-alkali fuels with coal in CERF (Combustion Environment Research Facility) at PETC. This new project in the PETC/EPRI cofiring program will use test systems at PETC to obtain data to predict performance and guide design for use of high-alkali biomass fuels in mid- to high-level fractions (approximately 20% to even 100% of the heat into a coal-fired power system). The new project will start with follow-up design and fuel/ash studies that apply and interpret relevant work already completed. Tests will be planned and performed as appropriate, in accord with assessments and plans prepared by EPRI and PETC staff and contractors, and in accord with an implementation plan approved by PETC.

15. Ash Sales

An immediate barrier to the cofiring of biomass with coal in existing coal-fired powerplants is the potential that the flyash from the cofired operation of the plant will not be purchased by the cement industry, which is now the best market for flyash from coal-fired utility boilers. This project will develop and communicate an action plan that will enable a cement industry standards board to make as early as possible a finding that cofired ash is acceptable for purchase from utility powerplants.

16. CO₂ Capture and Disposal

This project will conduct a series of feasibility studies of various proposed options for capture and disposal of carbon dioxide from U.S. coal-fired power plants. Consideration will be given to both land and ocean-based disposal options in an effort to determine which options would be most amenable to fossil carbon sequestration for both existing and future U.S. power generation capacity. This effort will build on the results of studies previously performed by the International Energy Agency (IEA) Greenhouse Gas Research and Development Program with joint DOE and EPRI funding.

Significant progress has been made on many of these projects, as shown in previous quarterly reports. Substantial progress continues to be made on these projects, as is shown below.

TECHNICAL PROGRESS

Project 1. Combustion Testing at the Seward Generating Station

Plans were finalized for a second series of cofiring tests at the Seward Generating Station, with the actual test period being July, 1997. These tests will be conducted with at least two types of wood waste fuel, providing a means for measuring the difference between fresh sawdust from band mills and old sawdust from circular saw mills. Attempts will be made to obtain kiln dried material to add a third type of biofuel to the cofiring test. These tests will consider capacity, efficiency, and emissions from the boiler. They will focus on unburned carbon in the flyash and fires in the ash pit from burning bottom ash.

The test planning focused upon addressing issues associated with unburned carbon in the flyash carried towards the mechanical collectors. The methodologies for addressing these concerns include performing traverses across the duct exiting the air heater to collect flyash and evaluate it for unburned carbon content. The methodologies also include videotaping the flue gas as the duct changes direction and enters the air heater region. Unburned carbon embers, or “fireflies” will be counted and the rate of “firefly” incidence (number per unit time) will be correlated to the type of fuel being burned and the level of cofiring. Videotaping of the bottom ash pit during testing also will be performed to determine the cofiring impact on unburned carbon losses at this location.

In the planning, logistics were worked out such that a trommel screen was again rented, Jersey blocks were placed to segregate fuel types, and the original cofiring equipment was reinstalled. The process did not include using a tent for fuel storage due to the short nature of the test.

Project 2. Fuel Preparation Tests at Greenidge Generating Station

Greenidge Station tested the processing and firing of willow grown as SRWC. Willow harvested during the winter months was processed in the field with a disc chipper. About 20 tons of SRWC willow were harvested and processed. The biofuel was then blown into walking floor vans and brought to the power plant. During this time period, the willow chips were used at the station. Initially the chips were injected into the NYSEG feeding system. The system plugged. The chips were then processed with a tub grinder for further particle size reduction. These smaller materials were then fed to the system, where they plugged the feed lines to the boiler. Willow, like all SRWC materials, has a low bulk density and a fibrous nature.

The problem of using the willow at Greenidge Station was ultimately addressed by blending low percentages of the SRWC with wood residues for feeding to the boiler.

Such blending reduced the bridging and plugging problems associated with firing SRWC by itself.

Project 3. Precommercial Testing at TVA Fossil Plants

Several parametric tests were conducted at the Colbert Fossil Plant in this quarter. Tests occurred in all three months: April, May, and June. Cofiring percentages were held to <4 percent by mass, based upon plant characteristics. The logistics of biofuel supply and delivery were worked out.

Data from the Colbert Fossil Plant tests were computerized for subsequent analysis. A heat and mass balance model for the plant was constructed by Foster Wheeler. Data were not analyzed at this point due to the expectation of subsequent precommercial tests.

Project 4. Switchgrass Testing at Blount St. Station of Madison Gas & Electric

The main cofiring tests were conducted during this period of time. Switchgrass was fired at >10 percent by heat input for periods of >4 hours. Combustion conditions were varied. In order to support this program, the switchgrass bales were ground in a “bale breaker” at the University of Wisconsin. The particles from the bale breaker were then loaded into walking floor vans and transported to the Blount St. Station, a 50 MW installation. At Blount St. Station they were introduced into the boiler through feed pipes originally designed to carry RDF. These feed pipes penetrate the boiler between the top two rows of burners.

Data from these tests were analyzed in a preliminary fashion, and they demonstrated the following

- cofiring did not impact boiler capacity
- impacts on boiler efficiency were modest
- impacts on emissions (NO_x, opacity) were favorable

This work, performed by the University of Wisconsin, documented some of the problems and opportunities associated with firing switchgrass. The low bulk density (8 lb/ft³ in the bale; 5 lb/ft³ as prepared for firing) makes transportation and processing expensive. Further, it complicates fuel storage. The favorable impact on emissions provides further documentation of the benefits of biomass cofiring.

Project 5. High Percentage Cofiring with Southern Company

No progress was made on this project.

Project 6. Cofiring Testing at Michigan City Generating Station of NIPSCO

Some 1000 tons of biofuel were received and processed at the Michigan City Generating Station. Approximately 2/3 of this material came from urban wood waste, through a local mulch dealer. The material was ground in an auger shredder to a <1/2" particle size. The material was inspected and essentially free from contamination. Approximately 1/3 of the material was kiln dried sawdust from southern Indiana.

The biofuel was screened with a deck shaker screen, fed by a backhoe. The screen produced a quality product, however a very large portion of the reject pile was acceptable material. Consequently the reject pile had to be rescreened in order to increase the yield of the process to acceptable levels. This created a labor and equipment intensive screening process.

The biofuels were characterized significantly. Of particular consequence was the fact that the urban wood waste was consistent in quality. Average ultimate analyses of the fuels characterized are shown in Table 1.

Table 1. Characteristics of the Fuels to be Burned at the Michigan City Tests				
	Fuel			
Ultimate Analysis (wt %)	Urban Wood Waste	Kiln Dry Wood Waste	Shoshone Coal	Black Thunder Coal
Carbon	27.2	47.7	62.1	53.8
Hydrogen	3.01	5.24	3.98	2.89
Oxygen	22.1	37.7	10.0	11.0
Nitrogen	0.07	0.30	1.44	0.78
Sulfur	0.02	0.02	0.61	0.4
Chlorine	<0.01	<0.01	<0.01	<0.01
Moisture	46.9	8.44	16.4	25.6
Ash	0.76	0.72	5.48	5.57
Higher Heating Value (Btu/lb)	4379	7509	10474	8888

For operational reasons the biofuel was blended with Shoshone coal on a 1:1 volumetric basis; this blend was then stocked out in the coal yard. It was recognized that the blend would be stored in the coal yard over the summer months, and then fired at the earliest in September, 1997. The 1:1 blend on a volume basis yielded a mixture of fuels that was 20 percent wood/80 percent coal on a mass basis. This, in turn, could be blended with the Black Thunder coal on a 1:1 mass basis to result in a blend of 3 fuels containing 10 percent biofuel, 40 percent Shoshone coal, and 50 percent Black Thunder (Powder River Basin) coal. That blend was selected as the final product to be burned in the cofiring tests. Blending was performed by a large front end loader, using a "bucket blending" technique.

The blended fuel had a distinct appearance relative to the coals on site. The fuel piles were a mottled brown, rather than black. The piles did not produce excessive dust; the coal held the biomass in place. There were some concerns regarding spontaneous combustion. Prior testing by TVA of biofuel and biofuel/coal blends indicated that storage of properly constructed piles would not cause spontaneous combustion in the coal yard. Receiving and processing of the fuel ceased on May 28, 1997.

Project 7. Testing Cofiring of Switchgrass by Nebraska Public Power District/Sandia

No progress was made on this project.

Project 8. Waste Plastics Cofiring at Duke Power

No progress was made on this project.

Project 9. Plastics/Fiber/Pulp Waste Cofiring with SCE&G

No progress was made on this project.

Project 10. Urban Wood Waste Cofiring in Pittsburgh, PA

Dr. J. Cobb and the University of Pittsburgh team continued the cofiring program at Iron City Brewing. Cofiring runs were increased to 40 percent by volume wood waste in the stoker boilers. Problems in bunker storage occurred with the wood and coal separating during the bunker filling process. These problems were overcome. The cofiring program at Iron City Brewing was successful.

Foster Wheeler conducted a fuels investigation in the Pittsburgh area for Duquesne Light. This fuels availability and cost analysis was performed to determine the initial feasibility of using wood waste as a fuel for a reburning system to reduce NO_x emissions at the Elrama station. Elrama uses down-fired or roof fired boilers. It already has a separated overfire air (SOFA) system for NO_x reduction. It requires additional technology for this application. Duquesne Light is interested in using the upper furnace reburn system to address this problem, and is interested in biofuel as the reburn fuel.

This resource assessment was undertaken to determine the nature of the wood waste resource in proximity to the Elrama Station, such that Duquesne Light Company might evaluate the feasibility of pursuing the use of wood waste as a reburning fuel in Elrama Unit #2. Specifically, this assessment addresses the following issues:

- Are sufficient quantities of wood fuel available in the area to support a fuel supply requirement of approximately 42,000 tons/year
- What is the nature of the competition for this resource, and could the competition for the resource stimulate an unacceptable price for the fuel
- What is the range of fuel costs that might be expected for this resource
- What physical and chemical characteristics would be expected for this fuel

This resource assessment focused primarily on sawdust from local sawmills, because it is essentially a pre-sized fuel with a regular particle size distribution, which eliminates the need for size reduction equipment and associated costs. The basis for the assessment included a review of previous resource assessments in the area, a telephone survey of potential suppliers, and site visits to 22 of the larger producers. Fuel samples were obtained and analyzed for their physical and chemical properties. The conclusions are summarized below:

- The total generation of sawdust by sawmills in proximity to the Elrama Station is on the order of 400,000 – 500,000 tons/year. As such, the Elrama Station would consume less than 10 percent of the total resource in the area. A total generation of 110,000 tons/year was readily identified, with the names, locations, and phone numbers of the sawmills surveyed provided in Table 3-2. It therefore appears that there is plenty of sawdust available in the area to support Elrama's needs.
- There are three primary sources of competition for sawdust in the area: (1) local farmers who use it as bedding material for their animals during the winter months, (2) manufacturing facilities which use it as a raw material in their production processes, and (3) sawmills, which use wood waste as a fuel in their boilers, heaters, and/or drying kilns. Farmers tend to capture most of the resource from smaller sawmills. Larger mills, which generate more sawdust, tend to find other uses for their sawdust. The most significant potential competitor in the area is the Fay-Penn Fiber MDF plant under development in Uniontown, Pennsylvania. If this development project goes to completion, then the plant will consume about 500,000 tons/year of wood waste of various types in a resource area centered 30 miles south of Elrama.
- The fuel cost is comprised of two components: purchase price and transportation costs. The purchase price ranges from free (zero cost) to as much as \$6 per green ton. A typical purchase price might be on the order of \$3/ton, or $\$0.33/10^6$ Btu for a heating value of 4600 Btu/lb. Transportation costs have both a fixed cost per load and a variable cost per mile. For a typical distance of 40 miles, the transportation costs would be on the order of $\$0.54/10^6$ Btu. Under this scenario, where the sawdust costs \$3/ton at the mill and needs to be transported 40 miles to the power plant, the total fuel cost would be \$0.87 per million Btu.
- Samples of sawdust from two mills, one using primarily circular saws and the other using primarily band saws, were sent to a fuels laboratory for analysis.

Samples of wood sawdust were collected from each major supplier visited. Although there was some variation in wood species and process equipment, for the purposes of this application, the samples could be subdivided into two major categories: circular saw dust and band saw dust. The thickness of the saw blades are typically 0.25 to 0.125 inches and produce sawdust with a very uniform particle size distribution. Particle size distributions for circular saw dust and band saw dust were determined by sieve analysis, and are presented in Figure 1 in terms of cumulative weight percent passing a particular mesh size. Note that due to the nature of the vibrating screens, the sieve analysis tends to measure the minimum dimension of the wood particles.

Figure 1. Particle Size Distributions for Wood Waste in the Pittsburgh Area.

Wood samples from two sources were sent to a fuels laboratory for proximate analysis, ultimate analysis, higher heating value, and ash elemental analysis. The first source (Zane's Wood Products) was equipped with circular saws and the second source (Precision Pallets) produced sawdust primarily from band saws. Average values for sawdust from these two sources are presented in Table 2. These values are typical for clean, green sawdust.

Table 2. Characteristics of Wood Waste in the Pittsburgh Area		
Parameter	Circular Saw Dust	Band Saw Dust
Proximate Analysis (Weight Percent, As Received)		
Volatile Matter	39.57%	43.92%
Fixed Carbon	7.32%	8.24%
Ash/Inerts	0.76%	1.11%
Moisture	52.36%	46.73%
Ultimate Analysis (Weight Percent, As Received)		
Carbon	24.23%	27.02%
Hydrogen	2.79%	3.09%
Oxygen	19.80%	21.98%
Nitrogen	0.05%	0.05%
Sulfur	0.01%	0.03%
Chlorine	---	---
Ash/Inerts	0.76%	1.11%
Moisture	52.36%	46.73%
Higher Heating Value (Btu/lb)		
HHV, As Received	3,930	4,396
Ash Elemental Analysis (Weight Percent)		
SiO ₂	50.73%	45.73%
Al ₂ O ₃	11.07%	11.81%
TiO ₂	0.06%	0.22%
Fe ₂ O ₃	4.98%	6.95%
CaO	16.70%	18.90%
MgO	3.22%	1.62%
Na ₂ O	0.25%	0.19%
K ₂ O	7.22%	6.21%
P ₂ O ₅	1.47%	1.19%
SO ₃ ⁻	1.60%	4.55%
Undetermined	2.70%	2.63%
Bulk Density (lb/ft ³ , As Received)	20	18

The Duquesne Light survey was based upon the fact that the Elrama Boiler #2 would require some 42,000 tons/year of wood waste for reburn purposes. The survey found some 110,000 tons/year of wood waste in the Pittsburgh area. Competition for the biofuel resource was identified as local farmers, a proposed medium density fiberboard (MDF) plant to be built in Uniontown, and internal use of the material by sawmills to provide steam for dry kilns.

The survey identified an average price of sawdust at \$4.70/ton, or \$0.52/10⁶ Btu at the sawmill. Transportation costs are added to this value. For an average haul distance of 40 miles, transportation costs add \$0.54/10⁶ Btu to the fuel price. For loads coming from

shorter distances, the transportation cost is lower and the delivered price of fuel is lower. These data provided Duquesne Light the opportunity to economically evaluate reburning with wood waste as the NO_x control fuel.

Project 11. Toxic Emissions from Cofiring Evaluation

No progress was made on this project.

Project 12. Fuel/Powerplant Model Development

Construction of the cyclone model was initiated during this quarter. Extensive fuels analyses of wood waste, switchgrass, PRB coal, and other coals provided a basis for evaluation. These characterizations focused on thermogravimetric analysis at heat-up rates ranging from 20°C/min to 250°C/min. Particular attention was given to the merger of the drying and pyrolysis steps during the TGA process for wood fuel and switchgrass; this is in contrast to the separation of the drying and pyrolysis processes when applied to coal. Isothermal TGA's for wood waste, conducted at a temperature of 900°C, illustrate the fundamental difference in volatile behavior between green sawdust and coal, as shown in Figures 2 through 4.

Figure 2. Isothermal TGA Plot for Western Bituminous Coal Heated at 900°C.

Figure 3. Isothermal TGA for Black Thunder (PRB) Coal.

Figure 4. Isothermal TGA for Sawdust.

These data provided a point of cyclone model initiation, along with extensive data from the testing of the Allen Fossil Plant.

Project 13. CO₂ Utilization in Algal Systems

No progress was made on this project.

Project 14. Combustion Tests and Combustor Development

No progress was made on this project.

Project 15. Support for Ash Sales from Cofiring Plants

No progress was made on this project.

Project 16. CO₂ Capture and Disposal Options

EPRI received a cost proposal from Battelle Columbus Laboratories concerning this project, and proceeded with the contracting process.