DESIGNING AN OPPORTUNITY FUEL WITH BIOMASS AND TIRE-DERIVED FUEL FOR COFIRING AT WILLOW ISLAND GENERATING STATION AND COFIRING SAWDUST WITH COAL AT ALBRIGHT GENERATING STATION

Type of Report: Quarterly
Report Period Start Date: July 1, 2003
Report Period End Date: September 30, 2003
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Date of Report Issue: October 2003

USDOE Award Number: DE-FC26-00NT40894

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DISCLAIMER

ABSTRACT

During the period July 1, 2003 – September 30, 2003, Allegheny Energy Supply Co., LLC (Allegheny) proceeded with demonstration operations at the Willow Island Generating Station and improvements to the Albright Generating Station cofiring systems. The demonstration operations at Willow Island were designed to document integration of biomass cofiring into commercial operations, including evaluating new sources of biomass supply. The Albright improvements were designed to increase the resource base for the projects, and to address issues that came up during the first year of operations. During this period, a major presentation summarizing the program was presented at the Pittsburgh Coal Conference. This report summarizes the activities associated with the Designer Opportunity Fuel program, and demonstrations at Willow Island and Albright Generating Stations.

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INTRODUCTION

Cofiring—the firing of two dissimilar fuels at the same time in the same boiler—has been proposed for using biomass in coal-fired utility boilers. In practice, this cofiring introduces a family of technologies rather than a single technology. The family of technologies includes blending the fuels on the coal pile or coal belt, and feeding them simultaneously to any processing (e.g., crushing and/or milling) systems on their way to the boiler; preparing the biofuels separately from the coal and introducing them into the boiler in a manner that does not impact fossil fuel delivery; or converting the solid biofuels to some other fuel form (e.g., producer gas) for firing in a coal-fired or natural gas-fired installation. The Allegheny project is designed to demonstrate both direct combustion approaches to cofiring.

The Willow Island Demonstration

Allegheny Energy Supply, LLC is demonstrating blending wood waste and tire-derived fuel to create a new opportunity fuel for cofiring in cyclone boilers, and integrating this fuel combination with a separated overfire air system for maximum NO_x management. This project also is demonstrating the use of biomass-TDF blends to reduce SO_2 and fossil CO_2 emissions along with trace metal emissions. The demonstration is occurring at Willow Island Generating Station Boiler #2. It is a 188-MW_e cyclone boiler operated in a pressurized mode and equipped with a “hot side” electrostatic precipitator (ESP). This demonstration, located in Willow Island, WV, has numerous unique features to significantly advance cofiring technology. Allegheny Energy, using Foster Wheeler Development Corporation, has completed a feasibility study for the project and has moved into Phase II—construction and operation of the demonstration system.

Cofiring of wood wastes with coal has been demonstrated as an effective means for using biomass in cyclone boilers; demonstrations have occurred at the Allen Fossil Plant of TVA, the Michigan City Generating Station of NIPSCO, and the Bailly Generating Station (BGS) of NIPSCO. In these demonstrations, NO_x, SO_2, and fossil-based CO_2 emissions reductions occurred. In each case, the volatility of the wood waste created the mechanism for NO_x reduction, while the use of a sulfur-free fuel reduced SO_2 emissions. Testing at BGS opened a new area of investigation: designing blends of opportunity fuels to optimize the impacts of cofiring. At BGS, urban wood waste is mixed with petroleum coke at a specified blend to optimize NO_x emissions management while accomplishing the goals of fossil CO_2 emissions reductions. The NO_x emissions reductions at BGS are ~30 percent when firing the designed opportunity fuel blend.

The Willow Island demonstration blends sawdust with TDF to create a new opportunity fuel for cofiring in a cyclone boiler equipped with a separated overfire air system. This demonstration evaluates the creation of a second opportunity fuel blend that has potential to maximize NO_x emissions reductions from the combustion process. At the same time, SO_2 emissions are reduced along with fossil CO_2 emissions and heavy metal emissions. The Willow Island plant "hot-side" ESP requires the use of a sodium additive to enhance the resistivity of the flyash particles. This demonstration examines the potential of biofuel cofiring to obviate the need for such additives in the control of particulates and opacity—capitalizing upon the potassium and sodium content of the biomass ash.

The demonstration program involves utilizing the sawdust-TDF-coal blend for maximum impact in the cyclone combustion process. It is estimated that the project can fire at least 10 percent wood waste, along with about 10 percent TDF in the project.

While this demonstration involves integrating past successful programs, it provides a significant enhancement of cofiring and the use of biomass. If successful, it will be the first demonstration where cofiring has been explicitly integrated into an overall NO_x control strategy as a significant contributor. Further, if successful, it provides a means for cyclone boiler owners and operators to consider NO_x management strategies other than end-of-pipe solutions or expensive fossil-based combustion strategies to achieve compliance with current and proposed regulations.

Further, this will be the first cofiring demonstration where the boiler is equipped with a "hot side" electrostatic precipitator—an ESP installed between the economizer and the air heater rather than after the air heater. Such "hot side" ESP's conventionally use sodium additives to improve the resistivity of the flyash and enhance its capture. Biomass, with its concentrations of potassium and sodium, has some potential to reduce or eliminate the need for such additives. This demonstration will address that condition and, as a consequence, advance the use of cofiring in coal-fired boilers.

The Albright Demonstration

The Albright Generating Station demonstration provides a means for comparing the NO_x reduction results obtained at Willow Island Generating Station—in a cyclone boiler—to those that can be obtained in a pulverized coal boiler. The Albright Generating Station Boiler #3 is a 140 MW_e boiler, comparable in capacity to the Willow Island boiler. It burns a similar eastern bituminous coal. Of critical importance, the Albright boiler is equipped with a low-NO_x firing system including a separated overfire air system.

The Electric Power Research Institute (EPRI) has developed a demonstration of sawdust cofiring in a PC boiler at the Seward Generating Station. A favorable biomass fuel supply potential and the favorable technology potential has led Allegheny to decide to relocate the cofiring demonstration to the Albright Generating Station. The relocation of the separate injection demonstration from Seward Generating Station to Albright provides opportunities to extend the knowledge base concerning cofiring—capitalizing upon the configuration of Albright Boiler #3. Specifically cofiring has not been applied to a generating station equipped with low NO_x firing separated overfire air system. In relocating the demonstration from Seward to Albright, Allegheny Energy and USDOE have capitalized upon such an opportunity.

The Combined Results

The combination of the Willow Island demonstration at the cyclone boiler and the comparative data developed at the Albright demonstration in a tangentially-fired pulverized coal boiler will provide definitive data concerning the emissions reduction potential of biomass cofiring in units already equipped with low NO_x firing systems. As such, these data will help define the potential, and limits, of biomass cofiring as an emissions reduction strategy. At the same time these demonstrations will provide a means for evaluating biomass cofiring as a cost-effective strategy for voluntary fossil CO_2 emissions reductions. Finally these projects will demonstrate additional environmental benefits of cofiring.

EXECUTIVE SUMMARY

The Thirteenth Quarter of the USDOE-Allegheny Energy Supply Co., LLC (Allegheny) Cooperative Agreement, July 1, 2003 through September 30, 2003, was characterized by demonstration operations at the Willow Island site and continuous improvement at the Albright cofiring site. Technical work that proceeded during the twelfth quarter of the cooperative agreement included the following:

- At Willow Island Generating Station, improvements were completed and cofiring continued with both biomass and TDF.

- Allegheny, after evaluating the sawdust supply for the Albright Generating Station and determining the need for an oversized material grinder, completed detailed engineering and procurement for the installation of a new grinder. The grinder selected was a 2-stage grinder, to be installed at the discharge of the oversized particles from the screen. The grinder was delivered by Industrial Biomass, Inc., and, after evaluation, was augmented by a dust management system. The dust management system was designed and fabricated.

- A major paper summarizing the Willow Island and Albright demonstrations was presented at the Pittsburgh Coal Conference.

- Progress anticipated for the fourteenth quarter of this cooperative agreement—October 1, 2003 through December 31, 2003—includes completion of the demonstration phase of the Willow Island project, installation of the 2-stage grinder at Albright, and the completion of additional testing at the Albright Generating Station. Progress will include initiation of activities associated with preparation of the final project report..

EXPERIMENTAL

Does not apply

RESULTS AND DISCUSSION

Overall results include significant operational testing at Willow Island, and the initiation of modifications to the Albright Generating Station Cofiring System.

Results at Willow Island

During the third quarter of 2003, the 13th quarter of the project, Willow Island received approximately 1,000 tons of biomass for cofiring, and burned what it received. Year-to-date totals for biomass consumption were over 2,700 tons of sawdust. Additionally, Willow Island received and burned TDF in the third quarter,.

The testing during the 12th Quarter of the project, then, reinforced previously experienced operational outcomes (see Report 40894R10). Willow Island continues to demonstrate the utility of cofiring sawdust in a cyclone boiler.

Results at the Albright Demonstration

During the 13th quarter, Industrial Biomass evaluated installation of the two-stage grinder that it supplied, which was designed to enhance operations at the Albright Generating Station. As a consequence of discussions between Allegheny Energy, Foster Wheeler and Industrial Biomass regarding unique features of installing the grinder; additional dust management equipment in the form of hoods and a small baghouse was ordered. Industrial Biomass designed and fabricated this system during the 13th Quarter of the project.

In addition to the progress discussed above, a paper summarizing biomass cofiring at Allegheny Energy was presented at the Pittsburgh Coal Conference (see Appendix). This paper summarized the results at both Willow Island and Albright Generating Stations.

CONCLUSION: Expected Technical Progress During the 14th Quarter

Allegheny Energy will complete its cofiring testing during the fourteenth project quarter.The fourteenth project quarter, from October 1, 2003 through December 31, 2003 is expected to see the following progress, as shown in Table 1.

Table 3. Anticipated Progress at Willow Island and Albright Demonstration Sites

Progress at Willow Island	Progress at Albright
Implementation of 10 percent sawdust cofiring testing at the site	Completion of the dust management system and complete installation of the grinding system
Completion of the testing	Resumption and completion of cofiring testing
Start of the final report	Start of the final report

REFERENCES

None

APPENDIX: Paper at Pittsburgh Coal Conference.

session 1

Cofiring Biomass at Allegheny Energy: Conclusions of an Extended Demonstration Program

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ABSTRACT

Allegheny Energy Supply Co., LLC (Allegheny Energy), with support from USDOE-NETL and the Electric Power Research Institute (EPRI) and its Biomass Interest Group (BIG), constructed, operated, and tested cofiring facilities at the Albright Generating Station and the Willow Island Generating Station. Foster Wheeler Power Group, Inc. served as primary subcontractor in the design, construction, and testing of these facilities. The Albright facility supported cofiring in a 140 MW_e tangentially-fired boiler, while the Willow Island facility supported cofiring in a 188 MW_e cyclone boiler. This program recently won an EPRI award for technology transfer. The program included several elements including system design, operations, system upgrading, and extended operations and testing. This paper reviews all aspects of the cofiring program including design and equipment selection, operations, and testing. It compares the results of this program to other cofiring demonstrations performed previously, and draws overall conclusions for future cofiring installations.

INTRODUCTION

Allegheny Energy successfully proposed a significant cofiring demonstration in 1999; this demonstration involved cofiring at both the Albright Generating Station boiler #3, and the Willow Island Generating station boiler #2. Each site was chosen to demonstrate a specific aspect of cofiring: Albright was chosen to demonstrate maximized NO_x reduction through separate injection of sawdust into the fireball of a T-fired boiler. Willow Island was chosen to demonstrate the advantages of blending sawdust with tire-derived fuel in a composite opportunity fuel. Both demonstrations were designed to demonstrate the use of cofiring as a means to achieve greenhouse gas reduction and to achieve a multi-pollutant reduction in the areas of NO_x, SO_2, and mercury. This demonstration has been previously discussed [1 – 3]. Results to date are summarized below.

SYSTEM DESIGN

In general, both systems were designed to receive sawdust, screen it to <¼" particles, transport the acceptable product to a storage system, and then reclaim the sawdust in a metered fashion for firing in the boiler. Both systems were designed to achieve 10 percent cofiring with sawdust on a mass basis, each supporting on the order of 8 MW of electricity generating capacity with biomass. Beyond those gross similarities, however, each design was unique and was based upon the boiler type, the site conditions, and the objectives of the project.

Albright System Design

The Albright system, utilizing separate injection of sawdust into the center of the fireball, was based upon moving selected pieces of equipment from the previous Seward Generating Station demonstration that occurred in a front wall-fired boiler. The system utilizes an oversized walking floor van, placed in a stationary position, to receive the sawdust (see Figure 1). This avoids excavation to construct a receiving pit. The design of this system is based upon receiving sawdust in walking floor vans; this design does not permit the use of tri-axle dump trucks due to the lack of clearance between the tail gate and the receiving system walking floor (see Figures 2 and 3).

Figure 1. A walking floor van unloading to the walking floor unloader.

Figure 2. Testing a tri-axle dump truck at the walking floor unloader.

Figure 3. The lack of clearance between the walking floor sawdust receiver and the dump truck tailgate

The system then involves conveying the sawdust from the walking floor unloader to a 30 ton/hr disc screen (see Figures 4 and 5) supplied by Bulk Handling. The disc screen was chosen among several screening types previously used in cofiring programs. Trommel screens such as those used at Seward Generating Station and Bailly Generating Station along with the Allen, Kingston, and Colbert Fossil Plants produce a well-sized product. Trommel screens also produce copious quantities of dust, and can cause problems with indoor settings. Deck screens were used at the Michigan City Generating Station test and at an early Greenidge Station test. The deck screens used at those locations were prone to blinding, causing significant re-screening of reject material to maximize production. This caused capacity problems and increased equipment intensity at the Michigan City test.

Figure 4. Feeding sawdust to the disc screen at Albright Generating Station

Figure 5. Screening sawdust at the Albright Generating Station

Sawdust leaving the disc screen is pneumatically conveyed to a used Harvistore silo with a Laidig unloading system. Initially reject material from the disc screen was sent back to the sawdust suppliers or otherwise disposed of. Plant employees who farm in West Virginia took much of this material. However a 2-stage grinder supplied by Industrial Biomass was installed to reduce the oversized material to resolve this issue.

On demand, the sawdust is reclaimed from the silo and transported across a Thayer weigh belt feeder to pneumatically assisted rotary air locks (see Figure 6). Baffles in the live bottom surge hopper ensure that the sawdust is evenly distributed between the injection points.

Figure 6. Feeding sawdust to the rotary airlocks at Albright Generating Station

A key feature of the Albright design is the expense of using a separate blower system for each boiler penetration. This permits positive control over the distribution of fuel and—more importantly, air—to each penetration in the boiler. It prevents unbalancing of the firing circle and the fireball in the boiler. Further, the system uses a constant air volume per unit time in order to ensure a safe velocity of the biomass into the boiler. The velocity is set to exceed the flame speed of the sawdust. Two injection points were established on opposite corners of the boiler. Each penetration was capable of handling up to 3 tons/hr of sawdust.

Controls for the system are divided into two parts. Local controls manage the flow of sawdust from the receiving trucks to the silo. A view panel and PLC controls the reclaim of sawdust and the firing of this biomass into the boiler. The operator in the control room has complete control over the usage of the biomass.

Willow Island System Design

The Willow Island system design is fundamentally different from the Albright system design. Because Willow Island #2 boiler is a cyclone unit, sawdust is blended with coal on its way to the bunker. This means that, unlike Albright, the plant must receive a full day's worth of biomass fuel within a 2-hour time window, consistent with plant fueling practices.

In the Willow Island design, walking floor vans are again assumed to be the method for sawdust delivery. These vans discharge their load into a receiving hopper, with the bottom of the hopper being a 50-ton/hr conveyor (see Figure 7). The conveyor discharges sawdust to a 50-ton/hr capacity Bulk Handling disc screen, chosen for the same reasons that the disc screen was chosen for the Albright system.

Figure 7. The sawdust receiving system at Willow Island Generating Station

The disc screen produces <¼” sawdust particles, with oversized material going to a Cresswood Grinder. Acceptable product is then transported to a 400 ton capacity Keith Manufacturing walking floor bin shown in Figures 8 and 9. The walking floor bin was chosen over a silo at this location due to plant preferences. Further, it has given the opportunity to evaluate alternative storage methods.

Figure 8. The Keith Mfg. Walking floor bin under construction

Figure 9. Sawdust being loaded into the walking floor bin at Willow Island

The walking floor bin is powered by an extensive hydraulic system driving each of the walking floor members. It discharges sawdust into a trough where twin counter rotating augers reclaim up to 75 ton/hr of biomass for blending with coal, and with TDF if the separate TDF system is operating. The sawdust, reclaimed by the augers, is deposited onto a weigh belt conveyor (see Figure 10) that, in turn, deposits the sawdust onto the main coal belt (see Figure 11). Note that the arrangement for depositing the sawdust onto the coal belt is designed to minimize dust; however dust is not eliminated altogether in this design. The cofiring system has the capacity to deposit 75 ton/hr of sawdust on the main coal belt; however it is normally run at a maximum speed of 50 ton/hr, consistent with practices of the coal handling department.

Figure 10. Weigh belt conveyor at Willow Island Generating Station

Figure 11. Sawdust discharge chute connecting to the main coal belt.

OPERATING RESULTS FROM THE DEMONSTRATIONS

The combined demonstrations have fired over 8,000 tons of sawdust, along with several thousand tons of TDF at the Willow Island Generating Station. Both demonstrations have been fired successfully at up to 10 percent biomass (mass basis).

Reliability Results

Both systems proved highly reliable. The Albright Generating Station cofiring demonstration is normally used during day shift operations. However, in October 2001, the unit successfully completed a 100-hour continuous run. That run was completed prior to upgrades to the system with particular emphasis on the addition of the 2-stage grinder [1].

The Willow Island system was started up in the spring of 2002 and, after a short start-up period, has run successfully since that time. Continuous upgrades have been made to this system including dust management around the sawdust unloading and conveying systems [2 – 3].

Both systems have fired sawdust into the coal-fired boilers without causing difficulties in operations. Cofiring has occurred through numerous summer high temperature events without incident. This is consistent with the experiences at both Seward Generating Station and Bailly Generating Station, where cofiring did not cause reliability problems, even during summer high temperature events. It is also consistent with the experiences at the Allen Fossil Plant, where testing routinely occurred in the August time frame, despite the weather in Memphis, TN.

Operations Results

Both systems were designed to minimize manpower requirements. Ideally these systems were to be installed such that the truck driver could unload them without plant support. That has not happened. However system management has been less labor intensive than the Bailly or Seward demonstrations, and less than the Ottumwa demonstration as well.

Both systems were designed to minimize efficiency losses associated with cofiring a green (40+ percent moisture) biomass fuel. This objective has been accomplished. Net station heat rate (NSHR) values at these plants have increased by 0.3 – 0.35 percent when cofiring at 10 percent biomass (mass basis). Further, in both cases the practice of cofiring sawdust or using a blended opportunity fuel did not impact boiler stability or operability. The efficiency impacts represent an improvement over prior demonstrations when the biomass alone is considered. In prior demonstrations, 10 percent cofiring of sawdust typically resulted in about a 1 percent increase in NSHR [1]. One improvement supporting improved cofiring operations has been the installation of a Diamond Power GasTemp™ probe to measure furnace exit gas temperatures at the Willow Island Generating Station. This probe, shown in Figure 12, permits careful monitoring of combustion conditions with and without cofiring operations.

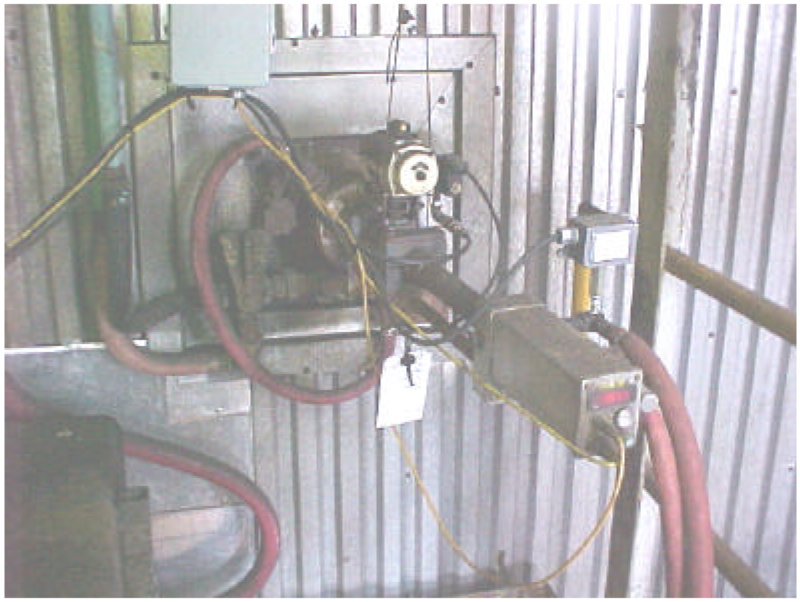

Figure 12. Furnace Exit Gas Temperature Probe at Willow Island Generating Station

The use of an FEGT probe had been desired at previous tests and demonstrations. Measurements were made with portable equipment at the Allen Fossil Plant, and permanent instrumentation was employed at the Michigan City Generating Station tests. The FEGT probe employed at Willow Island Generating Station was the first time that such an instrument was integrated into the overall program from both an information and an operations perspective.

Environmental Results

Collectively the demonstrations have fired >8,000 tons of sawdust and, as a consequence, directly reduced fossil CO_2 greenhouse gas emissions by about 9,000 tons; totally, the demonstrations have reduced greenhouse gas emissions by over 27,000 tons CO_2 equivalent.

In firing sawdust at these demonstrations, Allegheny Energy has substituted a sulfur-free fuel for coal. As a consequence, cofiring has provided up to a ~5 percent reduction in SO_2 emissions when operating at 10 percent (mass basis). Figure 13 depicts the impact of cofiring sawdust on SO_2 emissions at Willow Island Generating Station, as an example of this emissions reduction. Variability about the trend is caused by variations in coal composition, given the coals burned at Albright Generating Station and Willow Island Generating Station [2 - 3].

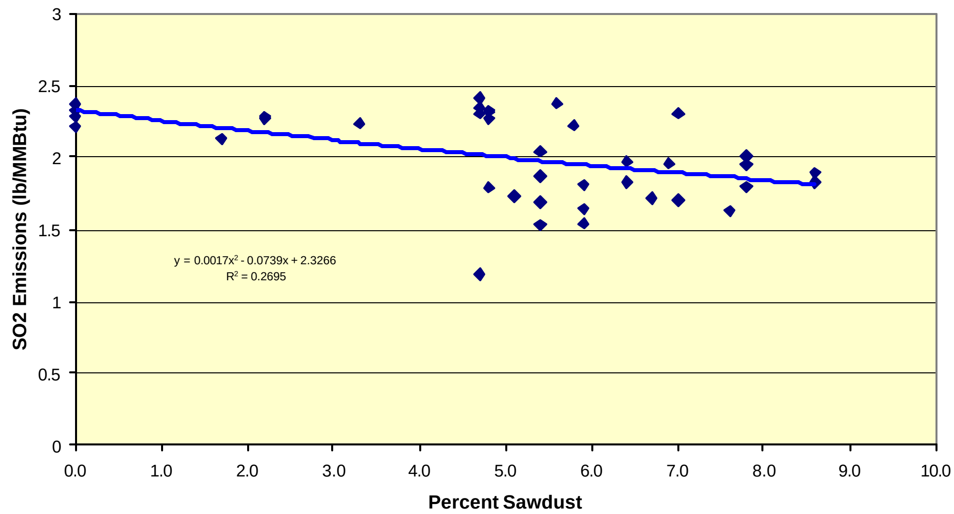

Figure 13. SO_2 emissions reductions at Willow Island Generating Station

Mercury emissions have been reduced because the sawdust burned has been shown to be very low in Hg concentration—typically 0.003 – 0.009 mg/kg. This compares to the coals burned, with Hg concentrations typically at 0.15 – 0.18 mg/kg [1].

NO_x emissions have been reduced at the Albright Generating Station according to the following relationship (see, also, Figure 14):

$$NO_x\ (lb/10^6\ Btu) = 0.361 - 0.0043(W\%) + 0.0217(O_2\%) - 0.00055(SOFA)$$

Where NO_x is measured in $lb/10^6$ Btu, W% is sawdust percentage in the fuel on a mass basis, O_2% is the percentage excess oxygen measured at the furnace exit, and SOFA is the total percentage of the three separated overfire air (SOFA) dampers expressed as percent open [1]. Note that the range of W terms is 0 – 10, the range of O_2% terms is 2.8 – 4, and the range of SOFA terms is 15 – 240. This explains the difference in the magnitude coefficients. Beyond this equation, it has been shown that the sawdust improved the ability to use the SOFA system, by reducing the loss on ignition when the SOFA system was used to the maximum.

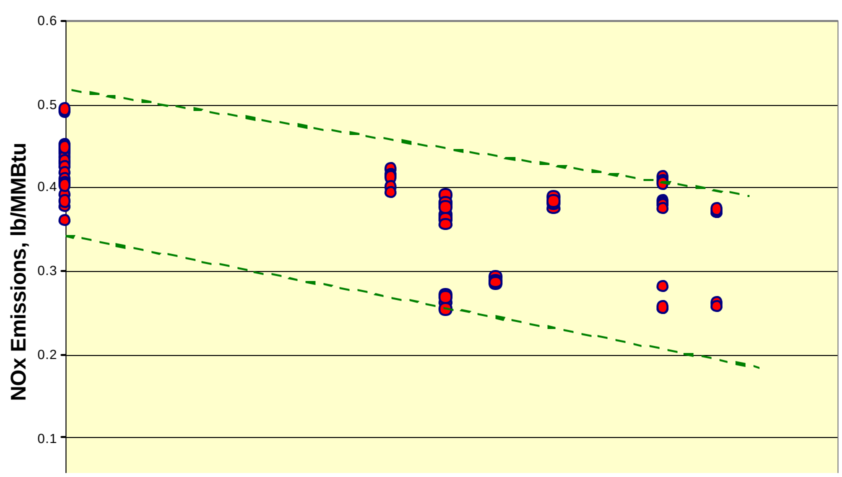

Figure 14. NO_x emissions at Albright Generating Station as a function of cofiring

The reduction of NO_x emissions at Albright Generating Station has exceeded results from such other T-fired boiler cofiring tests as Plant Gadsden of Southern Company, and Greenidge Station of AES (previously owned by NYSEG) [1].

NO_x emissions at Willow Island Generating Station have not decreased with cofiring. There has been no apparent impact on these emissions. The potential to achieve NO_x emissions in a cyclone boiler as a consequence of cofiring has not yet been achieved at this station despite favorable results at Allen Fossil Plant, Michigan City Generating Station, and Bailly Generating Station.

CONCLUSIONS

The cofiring demonstrations at Albright Generating Station and Willow Island Generating Station have been generally quite successful. Systems installed have generally performed well, and have provided a basis for designing full commercial cofiring installations. Operationally the systems have been reliable, and have not caused reliability or operability problems with the units involved. As a consequence, testing has been conducted despite hot weather events. From a capacity perspective, the cofiring systems have had no negative impact. From an efficiency perspective, the cofiring systems have had a very minor impact—showing improvement over previous demonstrations.

Environmentally the cofiring demonstrations have shown the capability for reducing greenhouse gas emissions, SO_2, NO_x, and mercury emissions. The ability to integrate cofiring with SOFA has been shown to be a significant gain. The lack of NO_x reduction at Willow Island has been observed, and the causes are under consideration. Overall, the cofiring demonstrations have been a significant success, building upon the prior test and demonstration programs and developing new techniques for biomass handling and combustion.

REFERENCES

1. Tillman, D.A. 2001. Final Report: EPRI-USDOE Cooperative Agreement: Cofiring Biomass with Coal. Contract No. DE-FC22-96PC96252. USDOE. Pittsburgh, PA

2. Tillman, D.A., K. Payette, T. Banfield, and S. Plasynski. 2002. Cofiring Demonstrations at Allegheny Energy Supply Co., LLC. Proc. 19th Annual International Pittsburgh Coal Conference. Pittsburgh, PA. Sep 23 – 26.

3. Tillman, D., K. Payette, T. Banfield, and G. Holt. 2002. Firing Sawdust and Tire-Derived Fuel with Coal at Willow Island Generating Station. Proc. 27th International Technical Conference on Coal Utilization and Fuel Systems. Coal Technology Association. Clearwater, FL. March 4-7. pp. 165-176.