Progress Report: Cofiring Projects for Willow Island and Albright Generating Stations

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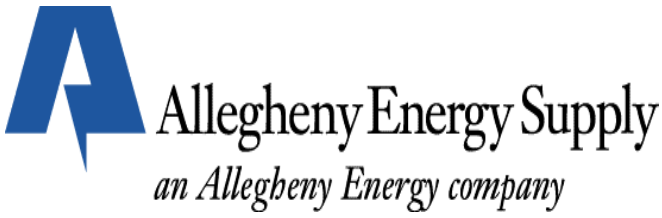

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DESIGNING AN OPPORTUNITY FUEL WITH BIOMASS AND TIRE-DERIVED FUEL FOR COFIRING AT WILLOW ISLAND GENERATING STATION AND COFIRING SAWDUST WITH COAL AT ALBRIGHT GENERATING STATION

Quarterly Technical Report

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ABSTRACT`

During the period October 1, 2001 – December 31, 2001, Allegheny Energy Supply Co., LLC (Allegheny) completed construction of the Willow Island cofiring project. This included completion of the explosion proof electrical wiring, the control system, and the control software. Procedures for system checkout, shakedown, and initial operation were initiated during this period. During this time period the 100-hour test of the Albright Generating Station cofiring facility was completed. The testing demonstrated that cofiring at the Albright Generating Station could reliably contribute to a "4P Strategy"—reduction of SO_2, NO_x, mercury, and greenhouse gas emissions over a significant load range. During this period of time Allegheny Energy conducted facility tours of both Albright and Willow Island for the Biomass Interest Group of the Electric Power Research Institute.

This report summarizes the activities associated with the Designer Opportunity Fuel program, and demonstrations at Willow Island and Albright Generating Stations. It details the completion of construction activities at the Willow Island site along with the 100-hr test at the Albright site.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Sixth Quarter of the USDOE-Allegheny Energy Supply Co., LLC (Allegheny) Cooperative Agreement, October 1, 2001 through December 31, 2001, was characterized by completion of construction activities at the Willow Island site and the 100-hr test at the Albright site. Technical work that proceeded during the sixth quarter of the cooperative agreement included the following:

- At Willow Island Generating Station, all construction was completed. All electrical construction was concluded, controls were installed and control software was installed. The system was operated in a "dry" mode—that is, without any biomass in it. Sawdust was received and the system for receiving, screening, and storing sawdust was completely checked out. Sawdust was fired in the Willow Island boiler on December 19, 2001.

- Following the short term testing reported in Report 40894R05, a 100-hour test was completed at the Albright Generating Station during this quarter. The 100-hour test was conducted to assess the reliability of the system, and the capability of cofiring over a broad load range. The test was successful; 100 hours of operation were completed within 104 clock hours, and the interruption was discressionary to fix a faulty relay. These tests were analyzed documenting the ability of cofiring to reduce SO_2, NO_x, mercury, and greenhouse gas emissions over the load range of 90 MWe – 130 MWe. The 100-hour test concluded all of the planned testing. Operation was continued at the plant through the remainder of the quarter. The 720 test hours were essentially completed during this period. During this quarter, Allegheny informed USDOE of its intent to continue testing at the Albright Generating Station in 2002, conditional upon adequate supplies of acceptably priced biomass fuel.

Progress anticipated for the seventh quarter of this cooperative agreement—January 1, 2002 through March 31, 2002—includes completion of start-up at the Willow Island Generating Station and initial short-term testing at this location. Continued long-term operational testing is expected at the Albright Generating Station.

1.0. 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.

1.1. THE WILLOW ISLAND DEMONSTRATION

Allegheny Energy Supply, LLC will demonstrate 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 will demonstrate the use of biomass-TDF blends to reduce SO_2 and fossil CO_2 emissions along with trace metal emissions. The demonstration will occur 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 plans to move directly 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 will blend sawdust with TDF to create a new opportunity fuel for cofiring in a cyclone boiler equipped with a separated overfire air system. This demonstration will create a second opportunity fuel blend that maximizes NO_x emissions reductions from the combustion process and that can be integrated into the overall NO_x emissions management strategy using overfire air. At the same time, SO_2 emissions will be 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 will examine 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 optimizing the sawdust-TDF-coal blend for maximum impact in the cyclone combustion process. Further, it involves optimizing this blend to capitalize upon the overfire air system for NO_x management. It is estimated that the project will 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, may 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.

1.2. 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.

1.3. 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.

2.0. TECHNICAL PROGRESS

Overall progress has included concluding contract negotiations with Foster Wheeler and, consequently, with the specialty subcontractors. With these contracts in place, progress has been significant on both projects.

2.1. TECHNICAL PROGRESS ON COMBUSTION AT WILLOW ISLAND GENERATING STATION

Technical progress on combustion at Willow Island focused upon completing the construction of the project and initiating start-up and shake-down.

2.2. CONSTRUCTION PROGRESS AT WILLOW ISLAND

The cofiring system being installed at Willow Island is based upon blending the sawdust with TDF and coal in the bunkers, and feeding the blended fuel to the cyclones. Sawdust is received in walking floor vans. They deposit the sawdust into a receiving hopper. From there the sawdust is conveyed to a disc screen for processing. The screen will produce a product at <¼" x 0" particle size for maximum NO_x benefit. Screened product is conveyed to a large live bottom bin for storage. It is reclaimed from the bin and deposited on the main conveyor belt feeding coal to the bunkers. Blending the sawdust with the coal and TDF is accomplished by 3 transfer points and by passing the blend through the secondary crushers. Oversized product from the screen is sent to a small grinder that reduces the particles to <¼" and then integrates them with the product of the disc screen.

Construction of the project is complete. All electrical installations are complete. The building has been detailed, including downspouts. The vacuum system for facility clean-up has been installed. All controls, including software, have been installed. Figure 1 presents an overview of the processing facility as constructed.

Figure 1. Overview of the processing building at Willow Island Generating Station

Following completion of construction, project start-up has been initiated. The entire system was run without sawdust for the better part of a day. Two loads of sawdust were received, screened, and stored in the walking floor building as shown in Figures 2 and 3. Some sawdust was transported to the boiler on Dec 19.

Figure 2. Receiving sawdust at the Willow Island Generating Station

Figure 3. Screening sawdust at the Willow Island Generating Station

Problems were encountered with the cross augers discharging sawdust from the walking floor bin and transporting them to the metering belt feeding the main coal belt. Problems included constant tripping of this system. All other systems work as designed.

2.3. TECHNICAL PROGRESS ON THE ALBRIGHT DEMONSTRATION

The Albright program focused upon completing the data-intensive testing: the 100-hour test to demonstrate system reliability and to confirm the results of the previous short-term testing indicated that the cofiring project could work synergistically with the separated overfire air (SOFA) system, and could be used as a component in a "4 P" Strategy—a strategy to reduce emissions of the following categories:

- Sulfur dioxide (SO_2)
- Oxides of Nitrogen (NO_x)
- Mercury
- Greenhouse gases (particularly fossil-based CO_2)

From October 1, 2001 through October 5, 2001, detailed testing was conducted at the Albright Generating Station demonstration during 104 continuous hours. Cofiring levels ranged from 0 to 10 percent on a mass basis, or 4.7 percent on a heat input basis. During this time period some 100 hours of operation were logged, with 4 hours of down-time occurring to replace a faulty relay causing operational problems.

Because the 100-hours of operation were completed within 104 clock hours, the effective availability factor for the system was >96 percent. During this time there were no line pluggage problems and few other operational issues. During this period of time some 450 tons of sawdust were burned. Parameters varied during these tests included the following:

- Load, measured in either gross MW_e or in main steam flow (kg/sec), ranging from 90 MW_e to 130 MW_e (net) or 97 – 138 MW_e (gross)
- Excess O_2, measured in total percentage (rather than dry percentage) at the furnace exit, focusing on the 2.5 – 4.9 percent range
- Cofiring tons/hr and percentage
- SOFA damper position, ranging from a very closed approach to a wide open approach

The 100-hour test clearly documented the ability of cofiring to stabilize the flame at 90 MWe loads, and indicated the potential to cofire at lower loads. This test documented the ability of cofiring to work with the SOFA system reducing NO_x emissions to 0.25 – 0.26 lb/10^6 Btu while maintaining acceptable levels of unburned carbon (LOI) in the flyash. At the same time cofiring continued to reduce SO_2 and mercury emissions while not increasing opacity or CO emissions. The 100-hour test also demonstrated that cofiring had minimal impacts on boiler efficiency.

The 100-hour test involved operations at specific loads and operations when the boiler was controlled "in regulation" or in automatic generation control (AGC) from the dispatch center. Cofiring was successful under both conditions. When in AGC, the boiler was allowed to generate within 20 MW_e windows (e.g., 110 – 130 MW_e, net) under the control of dispatch. This created no problems for the cofiring operation. During the 100-hour test, loads were changed from higher levels (e.g., 130 MW_e) to lower levels (e.g., 90 MW_e) in accordance with the normal commercial practices at Albright Unit #3 while cofiring sawdust. Again the cofiring operations did not create difficulties for the plant.

Conclusions and Expectations

The test program at the Albright Generating Station, to date, has demonstrated that substantial NO_x reduction can be achieved cofiring sawdust with coal in pulverized coal boilers when using separate injection technologies. This decrease in NO_x emissions can come without experiencing increases in opacity or CO emissions. It can come while simultaneously experiencing the expected reductions in SO_2 and mercury emissions. At the same time cofiring had minimal impact on boiler efficiency and on the unburned carbon in the bottom ash and the flyash.

Future testing at Albright Generating Station, and testing at Willow Island Generating Station, will provide more extensive documentation concerning the impact of cofiring biomass with coal on airborne emissions. All evidence available points to the expectation that the trends in NO_x reduction will continue to be measured at both locations.

2.4. EXPECTED TECHNICAL PROGRESS DURING THE SEVENTH PROJECT QUARTER

The seventh project quarter, from January 1, 2002 through March 31, 2002 is expected to see the following progress, as shown in Table 2.

Table 1. Anticipated Progress at Willow Island and Albright Demonstration Sites

Progress at Willow Island	Progress at Albright
Completion of Start-up and Shakedown	Continued testing of the system, consistent with communications between Allegheny and USDOE
Short-term 5% cofiring testing	Delivery of a paper for the 27th International Coal Utilization Conference—the Clearwater Conference
Short-term 10% cofiring testing	
Short term testing of trifiring sawdust and TDF with coal	
Delivery of a paper for the 27th International Coal Utilization Conference—the Clearwater Conference	

3.0. PUBLICATIONS

Papers to be given at the 5th Biomass Conference of the Americas were not delivered as the conference was cancelled. Two papers were submitted and approved for delivery at the 27th International Technical Conference on Coal Utilization & Fuel Systems—the Clearwater Conference. Abstracts of these papers are presented below.

Emissions Management at Albright Generating Station through Biomass Cofiring

Kathleen Payette[1] David Tillman[2] Tim Banfield[3] Tom Nutter[4]

Allegheny Energy Supply Co., LLC. installed a separate injection cofiring system at its Albright Generating Station #3 boiler. Albright #3 is a tangentially-fired boiler with a generating capacity of 140 MW_e (net). It is equipped with a separated overfire air (SOFA) system. This project was funded by USDOE – NETL and USDOE – EERE, with testing funding support from EPRI. The project integrated 10 percent cofiring (mass basis) into the overall operations of the plant, including the operation of the SOFA system. It was designed explicitly to evaluate cofiring for NO_x reduction. Further it was designed to evaluate cofiring as part of a 4P strategy—addressing NO_x, SO_2, mercury, and greenhouse gas emissions. Testing conducted during the summer of 2001 documented the significant reductions in all four pollutants as a consequence of cofiring. Further, these tests documented the ability to use cofiring synergistically with the SOFA system. These results were obtained without significant increases in opacity or CO emissions. This paper summarizes the design and operation of the cofiring system at Albright Generating Station, focusing upon the emissions results obtained from testing.

Firing Sawdust and Tire-Derived Fuel with Coal at Willow Island Generating Station

David Tillman[1] Kathleen Payette[2] Tim Banfield[3] Glenn Holt[4]

Willow Island Generating Station unit #2, a 188 MW_e (net) cyclone boiler equipped with a hot side ESP is host for a designer opportunity fuel system firing a blend of sawdust and tire-derived fuel (TDF) with coal. Construction and testing of the system is supported by USDOE – NETL and USDOE – EERE. The system was designed and constructed to maximize the 4P emissions benefits of cofiring—on NO_x, SO_2, mercury, and greenhouse gas emissions. The design and operations were based upon extensive analysis and combustion modeling. The system, as constructed, is simple and rugged. It has the capability of blending up to 15 percent sawdust and up to 10 percent TDF with the coal; typically it will fire 10 percent sawdust. The project was constructed from March –December 2001, and testing has commenced. This paper reports on the project design, and construction, focusing on process configuration, equipment selection, and expected results.

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