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

Quarterly Technical Report

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ABSTRACT

During the period October 1, 2000 – December 31, 2000, Allegheny Energy Supply Co., LLC (Allegheny) executed a Cooperative Agreement with the National Energy Technology Laboratory to implement a major cofiring demonstration at the Willow Island Generating Station Boiler #2. Willow Island Boiler #2 is a cyclone boiler. Allegheny also will demonstrate separate injection cofiring at the Albright Generating Station Boiler #3, a tangentially fired boiler. The Allegheny team includes Foster Wheeler as its primary subcontractor. Additional subcontractors are Cofiring Alternatives and N.S. Harding and Associates.

This report summarizes the activities associated with the Designer Opportunity Fuel program, and demonstrations at Willow Island and Albright Generating Stations. The second quarter of the project involved completing the designs for each location. Further, geotechnical investigations proceeded at each site. Preparations were made to perform demolition on two small buildings at the Willow Island site. Fuels strategies were initiated for each site. Test planning commenced for each site. A groundbreaking ceremony was held at the Willow Island site on October 18, with Governor C. Underwood being the featured speaker.

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EXECUTIVE SUMMARY

The Second Quarter of the USDOE-Allegheny Energy Supply Co., LLC (Allegheny) Cooperative Agreement, October 1, 2000 through December 31, 2000, was characterized by project initiation, engineering, and initial construction activities at both the Willow Island and Albright sites. Technical work that proceeded during the first quarter of the cooperative included the following:

- At Willow Island Generating Station, contract negotiations were concluded between Allegheny and its primary subcontractor, Foster Wheeler Development Corporation (Foster Wheeler). This will led to execution of contracts with all specialty subcontractors.

- At Willow Island Generating Station, detailed engineering by Foster Wheeler, supported by plant engineering staff was concluded. Final equipment selections were made for all aspects of the project. Final project layouts have been approved.

- Preparations were made for the demolition of two small buildings at the Willow Island Generating Station site. These preparations included asbestos abatement. Demolition will precede construction.

- Geotechnical investigations have been completed at both the Willow Island Generating Station and Albright Generating Station sites. Final foundation designs also have been developed for both sites.

- A final system layout was developed for the Albright Generating Station site.

- Biomass injector nozzles were delivered and installed at the Albright Generating Station site. Two nozzles were installed at Albright Boiler #3 for firing sawdust in that tangentially fired boiler. The injection materials handling design was approved for the Albright station.

- Fuel procurement strategies are underway for both the Willow Island Generating Station and Albright Generating Station sites. A review of the most likely suppliers has been conducted with the Fuels Department of Allegheny Energy.

- Planning for the test programs at both sites has commenced. In each case the data acquisition capabilities of the control systems have been surveyed. The fuels have been acquired and a contract has been let with Pennsylvania State University for complete characterization of the sawdust, tire-derived fuel (TDF) and the various coals burned at Willow Island and Albright Generating Stations.

Progress anticipated for the third quarter of this cooperative agreement—January 1, 2001 through March 31, 2001—includes significant activities pursuant to completing the construction of the Albright sawdust handling facility, and initiation of the baseline testing at the Albright site. It also includes ordering all equipment for the Willow Island site, demolition of the two small

buildings on the Willow Island site, and progress on the construction of the Willow Island facility. Progress anticipated also includes initiation of sawdust acquisition for the Albright and Willow Island sites, and completion of test planning for both sites.

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 as shown in Figure 1. 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.

Figure 1. The Willow Island Generating Station

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 150 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. This demonstration must be moved in order for it to be completed. Boiler #12, where sawdust has been fired, is now only maintained for capacity purposes and is not regularly fired. Boiler #15, which was intended as a site for cofiring, has an operating selective catalytic reduction (SCR) system essential to the operation of both Seward and Titus Generating Stations. Recent research by Elsamprojekt and Midkraft, supported by research of Sandia National Laboratories, has shown that biomass cofiring has the potential to be detrimental to SCR catalysts. Consequently the demonstration can no longer be operated at that site.

A favorable biomass fuel supply potential and the favorable technology potential has led Allegheny to consider relocating the cofiring demonstration to Albright. The relocation of the separate injection demonstration from Seward Generating Station to Albright Generating Station 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, it is prudent to capitalize upon such an opportunity.

Given this opportunity, Allegheny and Foster Wheeler will accomplish the following:

- Disassemble and remove the existing demonstration from the Seward site,
- Supply and install two biomass injectors in Albright Boiler #3
- Install piping sufficient to transport sawdust to the biomass injectors at Albright Boiler #3

- Install the process equipment removed from Seward Generating Station to the Albright Generating Station
- Construct a steel building to house the process equipment associated with the demonstration of separate injection cofiring
- Demonstrate cofiring at Albright, providing emissions data for comparison to the Willow Island demonstration.

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 THE WILLOW ISLAND DEMONSTRATION

Activities at the Willow Island demonstration include both engineering and the beginnings of construction. These are discussed below.

2.1.1. Engineering and Design Activities

Detailed Design has been completed for the Willow Island site. As part of this design, all of the process equipment has been selected and orders have been placed for its supply and delivery. The equipment selected includes:

1. A below-ground sawdust receiving hopper, with outfeed conveyor, capable of receiving and moving 50 ton/hr of sawdust
2. A disc screen producing acceptable sawdust particles with a top size of 9.5 mm x 0 mm (3/8" x 0"), and with a processing capacity of 50 ton/hr
3. A screen outfeed conveyor moving sawdust to a storage bin
4. A 408 ton live-bottom storage bin with stock-out and reclaim systems
5. An outfeed weigh-belt conveyor with 100 ton/hr capacity
6. A comminution system with associated conveyors, capable of grinding oversized wood particles and returning the ground product to the screen system
7. A steel building housing the processing system
8. Associated mechanical equipment, electrical systems, and controls; the controls are integrated into the overall fuel yard control system

The final design is for a system that is simple, and more compact, than the original concept. The disc screen has a higher capacity than the trommel, and is less prone to generating excessive dust. The live bottom storage bin has the potential to be superior in performance to the silo. Further, its lower profile and design facilitates year-round maintenance. The grinding of oversized wood particles reduces the generation of residues that must be returned to the sawdust suppliers. The more compact design provides for a smaller steel building housing the activities.

Figure 2 is a plan view sketch of this final design. Figure 3 is presents selected elevation views of this final design. These provide the essence of the Willow Island project.

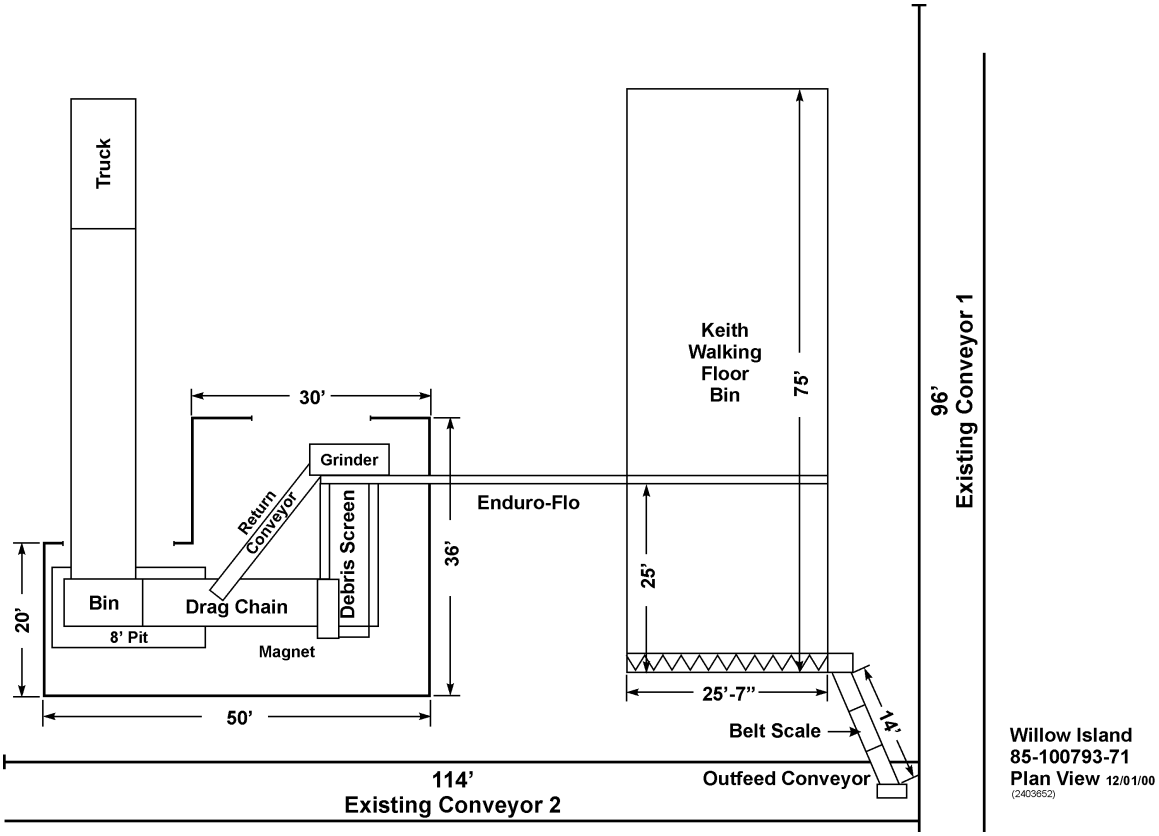

Figure 2. The Plan View of the Willow Island Design.

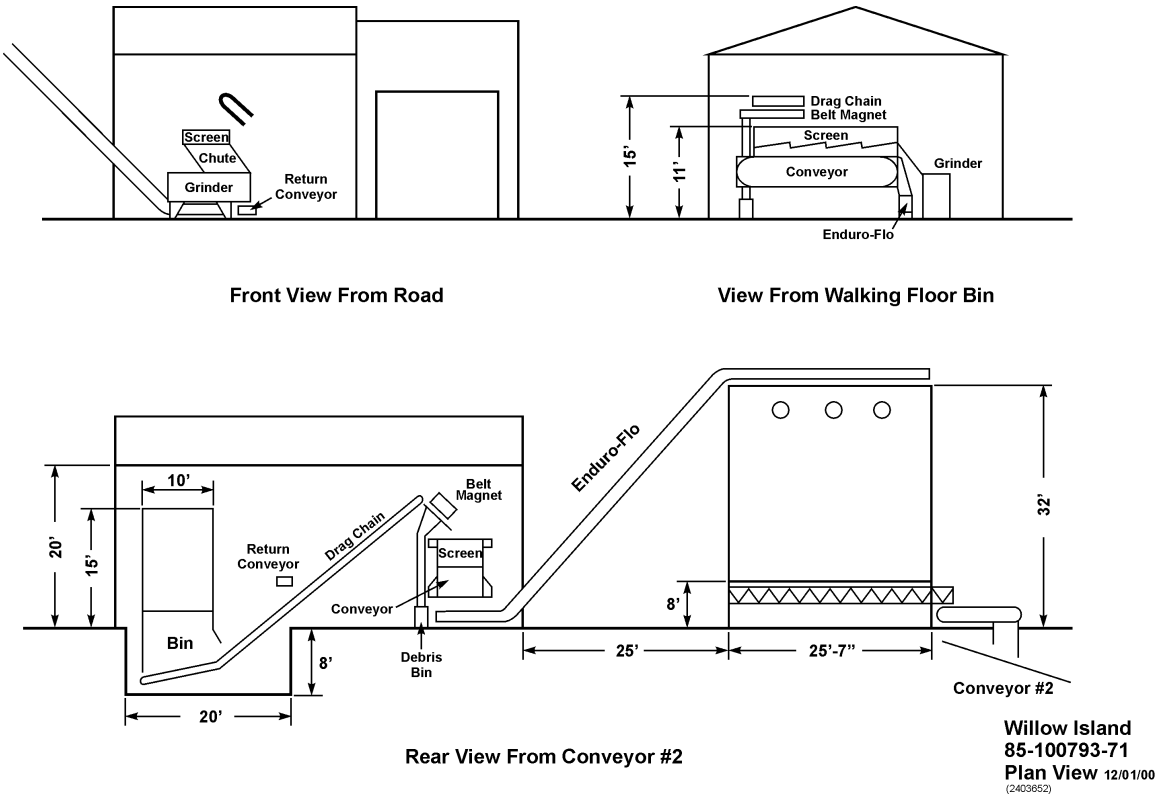

Figure 3. Selected Elevations of the Willow Island Design

2.1.2. Initial Construction Activities

Construction activities have been initiated at the Willow Island Site. Initially two small buildings on the site must be demolished. The asbestos abatement has been completed and the buildings have been readied for demolition. Construction drawings are proceeding, with final designs being submitted by several of the equipment vendors.

Construction of the project requires extensive foundation work. Core drilling has been completed with respect to the foundations at Willow Island, as is shown in Figures 4 and 5. The results of this core drilling have been used to develop detailed foundation designs.

Figure 4. Geotechnical Investigations at the Willow Island Site

Figure 5. Geotechnical Investigations at the Willow Island Site

2.1.3. Other Activities

Governor C. Underwood of West Virginia headlined the groundbreaking ceremony at the Willow Island site. This occurred on October 18, 2001.

The Allegheny Energy team has initiated fuel procurement activities. These include a review of the initial fuel surveys, a site visit to a potential fuel broker, and meetings between the Allegheny Fuels Department and the Foster Wheeler fuel specialists.

The test program is in the initial stages of design. Test data acquisition systems have been evaluated. Fuel samples have been procured, and have been sent to Pennsylvania State University for detailed characterization. Fuel characterizations include the following:

- Proximate and ultimate analysis
- Higher heating value
- Thermogravimetric analysis (TGA)
- Carbon 13 NMR studies to determine fuel aromaticity and structural issues
- Kinetics of fuel devolatilization
- Kinetics of char oxidation
- Determination of fuel reactivity constants

These parameters will help determine the optimum fuel blends to be tested in the project.

2.2. TECHNICAL PROGRESS ON THE ALBRIGHT DEMONSTRATION

Technical progress on the Albright Demonstration focused upon engineering and construction activities. A final system design and layout was approved for construction by Albright station personnel. The disc screen for processing the biomass was ordered, for delivery in February 2001.

The sawdust nozzles were fabricated, delivered to the site, and installed as is shown in Figures 6 - 8. These nozzles are connected by ~10 cm (4") pipe to the fuel processing system. The pipe, and associated check valves, have been installed only at the burner level and adjacent levels.

Geotechnical investigations were completed at the Albright site. These have led to the design of foundations for this site. These activities are in preparation for the construction of the facilities at Albright Generating Station.

The Electric Power Research Institute (EPRI) contracted with Foster Wheeler to perform the testing program at the Albright Generating Station. This test program will involve the performance of the sawdust processing facility, the characteristics of the fuel, and the impact of cofiring on airborne emissions. The test program will focus on the impact of cofiring on NO_x emissions in a PC boiler equipped with a separated overfire air system.

Figure 6. Installation of a Sawdust Nozzle at Albright Generating Station

Figure 7. Piping at the Albright Generating Station

Figure 8. Piping Connections at the Albright Generating Station

2.3. EXPECTED TECHNICAL PROGRESS DURING THE THIRD PROJECT QUARTER

The third project quarter, from January 1, 2001 through March31, 2001 is expected to see the following progress, as shown in Table 1.

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

Progress at Willow Island	Progress at Albright
Complete Profiling of the Fuels to be Burned	Complete Profiling of the Fuels to be Burned
Completion of the Test Plan	Completion of the Test Plan
Implementation of Fuel Procurement	Implementation of Fuel Procurement
Demolition of Small Buildings	Complete Deconstruction of Seward Installation
Pouring of All Foundations	Pouring of All Foundations
Receipt of Some Process Equipment	Receipt of Screen and Related Equipment
Initiation of System Construction	Most of Site Construction
Completion of Modeling for Blend Selection	Baseline Testing of Albright Boiler #3

APPENDIX A. ABSTRACT OF PAPER TO BE GIVEN AT CLEARWATER COAL TECHNOLOGY ASSOCIATION CONFERENCE

Developing a Designer Opportunity Fuel System for Willow Island Generating Station

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Allegheny Energy Supply Co., LLC, through a cooperative agreement with the US Department of Energy, is developing a designer opportunity fuel system for the Willow Island Generating Station. This system, designed and constructed by Foster Wheeler, integrates cofiring of sawdust with the cofiring of tire-derived fuel (TDF) in a cyclone boiler. This boiler is equipped with a separated overfire air system and a hot side electrostatic precipitator. The project is designed to maximize the reduction of NO_x emissions through fuel and combustion management. It is also designed to reduce SO_2 emissions and fossil CO_2 emissions. It will generate a significant supply of renewable—green—electricity. This paper summarizes the status of the project, focusing upon the characteristics of the various fuels and also focusing upon the construction of the facility. It addresses the theoretical aspects of the fuels engineering, integrating the biomass—sawdust—fuel with the other fuels at Willow Island to achieve NO_x reductions. It then summarizes these concerns within the overall context of the demonstration.