

FETC/EPRI BIOMASS COFIRING COOPERATIVE AGREEMENT

Quarterly Technical Report

Reporting Period: 09/27/96 to 12/31/96

Author: E. Hughes and D. Tillman

Report Issue Date: December, 1997

DE-FC22-96PC96252

Electric Power Research Institute (EPRI)
3412 Hillview Avenue
P.O. Box 10412
Palo Alto, CA 94304-1344

“This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability of responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.”

ABSTRACT

Biomass utilization to reduce fossil CO₂ emissions is being supported by sixteen (16) EPRI research projects, each contributing to the commercialization of systems to address greenhouse gas emissions. These projects include: 1) cofiring combustion testing at the Seward Generating Station of GPU Genco; 2) fuel preparation testing at the Greenidge Generating Station of NYSEG; 3) precommercial testing of cofiring at the Allen and Colbert Fossil Plants of TVA; 4) testing of switchgrass cofiring at the Blount St. Station of Madison Gas & Electric; 5) high percentage biomass cofiring with Southern Company; 6) urban wood waste cofiring at the supercritical cyclone boiler at Michigan City Generating Station of Northern Indiana Public Service Co. (NIPSCO); 7) evaluation of switchgrass cofiring with Nebraska Public Power District at Sandia National Laboratories in Livermore, CA; 8) waste plastics cofiring with Duke Power in a tangentially-fired pulverized coal (PC) boiler; 9) cofiring a mixture of plastics, fiber, and pulp industry wastes with South Carolina Electric and Gas; 10) urban wood waste cofiring evaluation and testing by the University of Pittsburgh in stoker boilers; 11) assessment of toxic emissions from cofiring of wood and coal; 12) development of fuel and power plant models for analysis and interpretation of cofiring results; 13) analysis of CO₂ utilization in algal systems for wastewater treatment; 14) combustion testing and combustor development focusing on high percentage cofiring; 15) analysis of problems and potential solutions to the sale of flyash from coal-fired boilers practicing cofiring; and 16) analysis of CO₂ capture and disposal systems.

EPRI is supported in these efforts by numerous contractors including: Foster Wheeler Environmental Corporation, Battelle Columbus Laboratories, New York State Electric and Gas Co., Tennessee Valley Authority (TVA), NIPSCO, the University of Pittsburgh, John Benneman, and others. These projects address various aspects of cofiring for CO₂ mitigation including testing of cofiring with various fuels, and in all types of boilers; development of analytical tools to support the cofiring assessment; addressing specific barriers to cofiring such as the sale of flyash; longer term technology development; and evaluating alternative methods for CO₂ mitigation. Taken together, they address the critical concerns associated with this approach to biofuel utilization. As such, they support implementation of the most promising near-term approach to biomass usage for greenhouse gas mitigation.

This report contains a brief description of each project. It then reports the progress made during the first quarter of the contract, focusing upon test results from the Allen Fossil Plant, where precommercial testing at a cyclone boiler was used to evaluate particle size and NO_x emissions from cofiring.

TABLE OF CONTENTS

| | PAGE |
|--|-------------|
| ABSTRACT | i |
| EXECUTIVE SUMMARY | iv |
| INTRODUCTION | 1 |
| TECHNICAL PROGRESS | 14 |
| Project 1. Combustion Testing at the Seward Generating Station..... | 14 |
| Project 2. Fuel Preparation Tests at Greenidge Generating Station | 15 |
| Project 3. Precommercial Testing at TVA Fossil Plants | 15 |
| Project 4. Switchgrass Testing at Blount St. Station of Madison Gas & Electric | 16 |
| Project 5. High Percentage Cofiring with Southern Company | 16 |
| Project 6. Cofiring Testing at Michigan City Generating Station of NIPSCO | 16 |
| Project 7. Testing Cofiring of Switchgrass by Nebraska Public Power District/Sandia | 16 |
| Project 8. Waste Plastics Cofiring at Duke Power..... | 17 |
| Project 9. Plastics/Fiber/Pulp Waste Cofiring with SCE&G | 17 |
| Project 10. Urban Wood Waste Cofiring in Pittsburgh, PA | 17 |
| Project 11. Toxic Emissions from Cofiring Evaluation..... | 17 |
| Project 12. Fuel/Powerplant Model Development | 17 |
| Project 13. CO ₂ Utilization in Algal Systems | 17 |
| Project 14. Combustion Tests and Combustor Development..... | 17 |
| Project 15. Support for Ash Sales from Cofiring Plants | 17 |
| Project 16. CO ₂ Capture and Disposal Options | 18 |
| REFERENCES | 19 |

LIST OF FIGURES

| FIGURE | PAGE |
|--|-------------|
| Figure 1. Elevation Drawing of Wood Delivery System at Seward Generating Station. . | 14 |
| Figure 2. Schematic of Wood Diffuser System used at Seward Generating Station..... | 15 |
| Figure 3. NO _x Reductions Achieved at the Allen Fossil Plant Compared to the Estimated NO _x Reductions Based Upon Thermodynamic Modeling..... | 16 |

EXECUTIVE SUMMARY

Cofiring biofuel with coal is the practice of supplementing the coal feed to a utility or industrial boiler with such biomass forms as wood waste, herbaceous crop wastes, agribusiness residues, and silvicultural or herbaceous crops grown explicitly as fuel. Traditionally, cofiring at <5 percent (mass basis) is considered to be low percentage cofiring; cofiring at 5 to 25 percent (mass basis) is classified as moderate percentage cofiring; cofiring at 25 to 50 percent is considered high percentage cofiring; and cofiring at >50 percent on a mass basis is when biofuels are the dominant fuel. To date, the cofiring programs have focused upon low and moderate percentage cofiring, although Southern Company has conducted one series of tests where biofuel supplied up to 44 percent of the heat input to the boiler. Cofiring has been practiced in a few cases such as the King Generating Station of Northern States Power Co., where customer service requirements made such practice technically and economically feasible. Widespread cofiring has not been commercialized. However, widespread cofiring is on the verge of commercialization. Significant testing to resolve experience issues, coupled with focused efforts at technology development and the removal of barriers provides a basis for promoting the early commercialization of this technical approach to biofuel usage. With widespread commercial deployment of cofiring will come substantial CO₂ mitigation by the utility industry, along with selected process industries.

The EPRI program contains 16 projects addressing various aspects of cofiring. Much of the focus of this project is on commercial-scale testing of cofiring, and the development of cofiring components. Tests conducted to date have been successful, demonstrating that cofiring can be implemented successfully at power plants where adequate supplies of low-cost fuels exist. At the same time much work needs to be done on selected problems such as quantifying the toxic emissions that could result from cofiring, developing combustion technologies for higher percentage cofiring, and determining the salability of the ash from cofiring plants. Further, alternatives to cofiring merit some examination, particularly as they involve the use of biomass.

The progress made during the fourth quarter of 1996 focused upon testing at the Allen Fossil Plant of TVA and the Seward Generating Station of GPU Genco. Other projects where significant activities were underway included the preparation for switchgrass cofiring at Madison Gas & Electric. This report focuses upon describing the projects in the introduction. Progress at the various projects is then addressed.

INTRODUCTION

The paragraphs below provide an introduction to the FETC/EPRI Cofiring Cooperative Agreement Program, and the 16 projects that are included in that effort.

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

A. Background

GPU/Penelec tested wood cofiring at low-level (about 1.5% by heat) in both wall-fired and tangentially-fired pulverized-coal (PC) boilers at Shawville in 1995. Both EPRI and PETC cosponsored the test, together with GPU and the Commonwealth of Pennsylvania (the prime funder). EPRI and PETC observed both the fuel preparation tests and the combustion tests, and reviewed the draft final report. The tests yielded the first U.S. report on fuel preparation for wood cofiring using both saw-dust, tree trimmings (from right-of-way clearing) and poplar trees as fuel. They also were the first combustion results for wood cofiring in boilers equipped with low-NO_x burners. They revealed two different types of pulverizer/feeder limits when wood is mixed with coal before entering the power plant. The fuel preparation tests indicated how to optimize the economics via high throughput and production of a high-value coproduct.

B. Objective

The new test, covered by the proposal for PETC funding through EPRI, will be at GPU/Penelec's Seward station near Johnstown, Pennsylvania. The boiler proposed for the test is a small, well-instrumented wall-fired PC boiler. The objective of the test is to demonstrate economically feasible wood cofiring in a wallfired PC boiler via optimized wood fuel preparation and NO_x control benefits achieved through separate feed of the wood (i.e., not through the pulverizer) at mid-levels (i.e., 10 to 15% of the heat coming from the wood fuel).

C. Technical Approach

Low-cost fuel is the key to favorable economics in cofiring, since fuel savings must pay for the capital costs of modifying the power-plant for wood fuel handing and combustion. (SO_x credits/offsets are a minor benefit, and, as of today, CO₂ credits do not exist. NO_x credits or cost avoidance opportunities are site specific, if any, and NO_x reduction, without low NO_x burners, is one subject of this test.) Therefore, the approach here is to optimize both throughput of wood fuel and co-product

values, such as mulch production or woody crops grown to reclaim strip-mined land. The goal is to combine reduced fuel handling costs with revenue from coproduct values so as to deliver a low-cost fuel, hopefully using the existing coal supply infrastructure to also enhance local economics benefits.

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

A. Background

At NYSEG's request EPRI has joined NYSERDA, ESEERCO and NYSEG in cosponsoring a test of fuel preparation equipment and processes. Waste wood fuel and woody energy crop material (from the New York short-rotation basket willow, or shrub willow, project near Syracuse) will be "pulverized" and dried to determine the best way to make wood fuel suitable for pulverized coal cofiring.

B. Objective

The objective is to determine the lowest cost way to prepare wood fuel for cofiring in a PC boiler at mid-level (i.e., 10% to 15% by heat) when a separate feed system is used for the wood fuel. The boiler in this case is tangentially fired. The adequacy of the wood preparation system will be verified by combustion tests cofiring with coal in the boiler.

C. Approach

The equipment to be tested will be selected based on initial combustion tests of dry and green sawdust, and on preliminary designs with cost/performance tradeoff analyses using information from vendor quotes and site visits to see equipment offered by vendors. Optional size reduction and drying performance will be determined by tests and by design studies. Confirming combustion tests will be performed. The results will be interpreted in terms of their consequences for design, process selection, equipment selection, performance, and cost of an optional system for size reduction, size screening, and drying.

Project 3. Pre-Commercial Test Run at a TVA PC Plant (~200 MWe)

A. Background

TVA's Allen cyclone plant at Memphis is entering a long-term pre-commercial operation cofiring wood with coal (and, in the Allen case, tire-derived fuel also). Three short-term tests of low-level wood cofiring (about 2% by heat) at the wall-fired Colbert plant and the tangentially-fired

Kingston plant have indicated that low-level cofiring can be successful, and a long-term (about 6 month) test run is needed to establish by experience the reliability and cost of a wood supply, and the routine performance and cost of the plant cofiring operations. A substantial body of test and study work awaits verification by commercial-like operations and stands ready to guide the optimization of such operations.

B. Objective

Test the economics and performance for commercial cofiring operations at low-level in a PC boiler via a 6-month run that tunes plant operations to an optimum and establishes by experience a wood fuel supply of acceptable quality and low enough cost.

C. Approach

TVA's fuel contracting group will arrange wood supply and adjust as needed to optimize during the course of the 6-month pre-commercial run. TVA's plant operations and testing personnel will take data as needed to optimize plant performance and operations. EPRI's contractor, Foster Wheeler Environmental (FWE), will monitor plant operations and performance, take supplemental data as needed, and interpret in a report the data (on fuel supply, quality, and properties, and on the consequences for plant performance and operations) as needed to fully explain the experience in the light of the designs, cost estimates and tests that TVA and EPRI have done in the past to prepare the way for cofiring wood at TVA's PC boilers.

Project 4. Switchgrass Cofiring with Madison Gas and Electric (50 MWe, PC)

A. Background

The University of Wisconsin has analyzed fundamental aspects of biomass combustion for EPRI, and, separately, has also arranged for cosponsorship of over 60% of this combustion test by the regional DOE biomass program, the local utility (Madison Gas and Electric Co., or MG&E), the University, and other utilities. PETC has, also separately and independently, done pilot plant test runs of switchgrass cofired with coal at PETC's in-house Combustion Environment Research Facility (CERF). Switchgrass is a high-alkali biomass fuel, but one of great interest because of its potential to be an energy crop of high yield and easy operation on conventional farms. Because of its high alkali, switch-grass is a challenge for successful combustion or gasification, i.e., avoiding the snares of slagging, fouling, deposition and agglomeration. MG&E has the ideal, low-cost test setup at a full-sized (in this case about 50 MWe and wall-

fired) PC boilers, ideal because the plant (Blount Street Station) was retrofit over ten years ago to fire RDF made from municipal solid waste. The plant is ready, even having a dump grate ready if needed, and with a biomass fuel handling system installed for the former RDF fuel and now in routine use to prepare and feed shredded paper waste as the supplemental fuel. The background and expertise of EPRI, PETC, University of Wisconsin, FWE, and various investigators of alkali ash slagging/fouling properties also stand ready to observe and interpret this first switchgrass cofiring test at a U.S. utility power plant.

B. Objective

The objective is to measure performance and operation, both fuel handling and combustion, when switchgrass is cofired with coal in a full-size PC boiler.

C. Approach

The University of Wisconsin (Ken Ragland and Danny Aerts, professors in Mechanical Engineering) will plan, arrange and document the switch-grass operations (harvesting, fuel analysis, transport, handling, shredding, etc.) and the power plant combustion and ash operations. A number of well-qualified technical experts will contribute as advisors, performers, and reviewers: EPRI's biomass cofiring contractor (FWE), U. Wisconsin's ash consultant (Milt Blander of Argonne National Lab), PETC (Jim Ekmann, Mark Freeman, et. al.), two EPRI utility cosponsors (Wisconsin Power and Light Company, and Nebraska Public Power District), other consultants perhaps (especially, Larry Baxter and Don Hardesty at Sandia in Livermore), and the host utility (MG&E, with staff engineer Craig Weiss).

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

A. Background

Southern Company Services and Savannah Electric, one of the Southern Company's operating subsidiaries, has already taken the bold step of cofiring wood in a PC boiler at the very high level of 40% by heat. This was done in 1993 in a set of test runs at about twelve different set points culminating in a test at 40% by heat. Natural gas overfire was used on some test runs. More comprehensive data, especially regarding the limits to such high-level cofiring when higher moisture and lower cost wood is used, is needed to confirm and apply the results. However this background test established an important possibility.

B. Objective

The objective of this project is to test the limits in high-level cofiring of wood fuel with coal, including natural gas as an additional supplemental fuel, in a PC boiler that is representative of much existing generating capacity in the U.S. utility industry.

C. Approach

The first step is to assess the economic prospects for low-cost fuel that can justify a major retrofit at a small unit, a situation expected to represent that of many utility power plants that are today prime candidates for starting a new U.S. biomass power industry via cofiring, or for being closed due to their poor economics in the emerging competitive environment of the U.S. electric utility industry. Southern Company Services will arrange for an investigation of this subject using the expertise and generic results from the work related to the Savannah Electric project. The next steps are the confirmation of a win/win fuel supply arrangement, an independent assessment and interpretation of the tests being conducted at NYSEG per Item No. 2 (above), the planning of a second set of test runs at Savannah using both green and dry wood fuel, the confirmation of funding for these new tests, and then the actual conduct of the new test runs to establish the limits for high-level cofiring of wood in retrofit PC boilers representative of many existing units in the U.S. This project begins with the purchase of Southern Company's report on the 1993 tests and the agreement of Southern Company to interpret the report in a new assessment of prospects for such operations generally in the U.S. utility industry.

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

A. Background

EPRI is completing an assessment of waste wood cofiring at one or more of the cyclone boilers in the NIPSCO system (Northern Indiana). NIPSCO is cofunding, and wants EPRI to include in this particular case study (which is EPRI's fourth one cofunded with a utility) a comparison of biomass cofiring with other CO₂ reduction actions listed by NIPSCO in its response to DOE regarding the federal Climate Challenge program. A biomass cofiring option low in cost (as measured in \$/ton CO₂) is emerging from the assessment. Therefore, the next step is expected to be a full-size test at one of NIPSCO's cyclone boilers.

B. Objective

The objective of this project is to confirm by test at NIPSCO the feasibility and benefit of urban/industrial wood waste cofiring in a cyclone unit. This will establish whether any NOx benefit appears likely when drier wood fuel is cofired in a cyclone.

C. Approach

As EPRI's contractor, FWE will plan the test with NIPSCO. NIPSCO will cofund, as well as provide in-kind support. FWE will monitor the test and fully report the results. EPRI will prepare a report to interpret the combined projects (i.e., the case study and the unit test) in terms of NIPSCO's options in their Climate Challenge response, also including EPRI's interpretation of a study done for NIPSCO by Purdue University regarding woody crops as another source of biomass fuel.

Project 7. Switchgrass Test with Nebraska Public Power District

A. Background

A 1993 study by the Union of Concerned Scientists on biomass as a major renewable power source in the Mid West gave rise to an interest in switchgrass as an energy crop in Nebraska. Cyclone boilers fueled by very low cost coal are a major source of generation today for Nebraska utilities. The Nebraska Public Power District (NPPD) has discussed possible tests with EPRI, and is going to provide in-kind engineering analysis support in the Madison, Wisconsin switchgrass cofiring test, Item No. 4 above. EPRI has suggested that NPPD may want to help create and join a cofunded project at Sandia National Laboratory in Livermore, California. This project at Livermore is the test that EPRI is proposing here for PETC funding.

B. Objective

The objective is to measure slagging/fouling/deposition as switchgrass is cofired with coal in the Combustion Research Facility at Sandia, Livermore, and to interpret the results so as to predict success or failure of possible long-term cofiring of switchgrass with coal at a cyclone boiler on the NPPD system. This will serve as a test of the capability of relatively low-cost laboratory testing to guide a decision on whether or not a utility should commit resources to perform a full-size unit test.

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

A. Background

Duke Power Company, with cofunding from EPRI and the National Plastics Council, awarded a contract to ABB-CE in Windsor, Connecticut, to perform a “drop tube” test and an engineering analysis/interpretation regarding the technical feasibility of cofiring clean plastic wastes from manufacturing processes in PC boilers. EPRI has the report. The findings are favorable. The next step is a unit test.

B. Objective

The objective of this project is to confirm and expand the laboratory test results by actual cofiring of shredded film plastic in a full-size PC boiler. This will enable EPRI, Duke, PETC, and the industry to assess the potential that business and customer service considerations will lead to commercial waste cofiring operations that are on a path toward major biomass cofiring in the U.S.

C. Approach

Duke will plan and conduct a unit test, with advice and funding support from EPRI. A second, longer and more inclusive, unit test will also be planned and conducted, if warranted. Wood fuel will be tested, as well as the plastic residues from film plastic manufacturing. If a major test is conducted, as is now expected, FWE will be brought in, as contractor to EPRI, to monitor the test, analyze the data, and report the results in a technical report that interprets these results in the context of EPRI's other cofiring tests.

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

A. Background

South Carolina Electric and Gas Company (SCE&G) has conducted a test burn of manufacturing wastes that are a mixture of plastic with some wood fiber. The test was done in a full-size 75 MWe PC boiler. The results were favorable, but there is a need for more data on the economics and performance of the fuel preparation and handling operations.

B. Objective

The objective is to measure plastic shredding, storage, transport, conveying, feeding and combustion performance in a full-size unit test, and to interpret the results in term of commercial operations done for fuel cost savings and customer service improvement.

C. Approach

SCE&G will evaluate the technical and business options for cofiring waste plastics, waste plastic/fiber, and waste sludge from paper/pulp manufacturing. With support from FWE (or some other contractor chosen by SCE&G), EPRI and SCE&G will plan one or more unit tests as appropriate. The study phase may include an assessment of a dump grate addition in order to make one of SCE&G's PC boilers more fuel-flexible as a performer of customer waste disposal for clean, homogeneous wastes cofired with coal. If sufficient cofunding is available, a unit test will be performed, with a full record and report prepared by FWE (or some other contractor).

Project 10. Urban Wood Waste Study and Test in Pittsburgh

A. Background

PETC has initiated some support for a study of the urban wood waste supply that could fuel a cofiring operating at a stoker boiler owned by the University of Pittsburgh and other owners in a consortium. The study may justify a test.

B. Objective

The objective is to demonstrate the feasibility of a commercial wood waste fuel preparation facility that produces fuel that can be cofired with coal in boilers in an urban setting.

C. Approach

The University of Pittsburgh, or its consultant, will design a process and an organizational structure that can provide suitable wood waste fuel to the stoker boiler, with fines going to a PC or cyclone boiler owned by a utility (unless a higher value use for the fines is found). A test facility to demonstrate the system for receiving and processing the waste wood fuel will be set up and operated. The primary product of the fuel processing facility will be the wood that is to be cofired with coal in the stoker boiler near the University of Pittsburgh. A utility boiler for cofiring the fines will be found and tests conducted there, if possible.

The project will evaluate and test (by experience) the ability for low-cost biomass fuel, which is low in sulfur and in ash and also has NO_x-reducing potential, to succeed in a niche market where emissions reduction, transportation flexibility, improved coal supply options and multiple markets for the wood-based products may create an early market and a demonstration of benefits for biomass fuel use in an urban setting.

Project 11. Toxic Emissions

A. Background

PETC has taken over the operation of EPRI's former High Sulfur Test Center and has converted it into the Environmental Control Test Center (ECTC) with an emphasis on the capability to measure emissions and controls associated with a full spectrum of species, including toxics and trace contaminants, both organic and inorganic. Wood is to be cofired with coal at the ECTC, because the host utility (New York State Electric and Gas Corporation, or NYSEG) plans to cofire waste wood with coal beginning in May or June of 1996 at the Kintigh station, site of the ECTC.

B. Objective

The objective is to assess the extent to which trace elements, trace organic emissions or other toxic emission or effluent species may be associated with the cofiring of biomass fuels with coal.

C. Approach

EPRI will estimate the probable emissions of trace contaminants in various cofiring situations, including the cofiring planned at Kintigh. Based on this estimate, EPRI and PETC will review possible measurements at the ECTC and compare the detection thresholds for measurements at the ECTC with other options that may arise for a test of toxic emissions from a cofired power plant at some other time or place. Based on this review and on an agreement between EPRI and PETC on the best time and place, if any, for a test of toxic emissions during a cofiring operation, this project will be completed in one of three ways: (1) a report on the estimate and review, giving reasons for not proceeding to perform a full test of toxic emissions and effluents at this time; (2) implementation and reporting of a test of toxic emissions associated with cofiring at the ECTC; or (3) planning, later implementation, and eventual reporting of a similar test at some other time and place.

Project 12. Fuel/Powerplant Models, Analysis and Interpretation

A. Background

EPRI has a biomass fuels/experience database (ready for presentation in May 1996) and two computer models of powerplants (SOAPP and CQIM) that are available as starting points for interpreting cofiring test results in terms of the performance, cost and design implications for existing and new

coal-fired powerplants. EPRI has also done several analyses of biomass resources and fuel supply, which can be extended or applied to specific cases or regions of interest to PETC, such as the Pittsburgh case (No. 10, above).

B. Objective

To display results from all of these PETC/EPRI cofiring projects in terms of fuel properties, slagging and fouling implications, system designs (including repowering), costs, and business economics.

C. Approach

Expand the fuel and powerplant data in EPRI's existing databases. Incorporate EPRI's fuels database into SOAPP and CQIM, as appropriate. Add biomass cofiring capabilities to EPRI's SOAPP and CQIM models. Run cases on SOAPP and CQIM to display the implications of test results in terms of slagging potential and system economics. Incorporate resource assessments and fuel supply/cost analysis, as appropriate.

Project 13. CO₂ Utilization in Algal Systems for Wastewater Treatment

A. Background

The capture and utilization of CO₂ by microalgae is an active area of long-term R&D in both the U.S. and abroad, most notably Japan. EPRI, PETC, and DOE have carried out extensive investigations of these concepts in the past. The nearest-term application of this technology is in wastewater treatment systems using microalgae ponds: CO₂ addition would improve the performance of such systems and generate increased biomass-derived fuels that can replace fossil energy sources. However, a better definition of the potential of this technology, its economics, CO₂ reduction benefits, and applicability in the U.S. is required.

B. Objective

The objective is to determine both the cost and potential amount of CO₂ mitigated per unit wastewater flow with such systems, and the overall potential of this technology in reducing CO₂ emissions in the U.S. Both generic and two site-specific analyses will be carried out to answer these questions. The overall objectives are (1) to determine if this is of future interest for development by EPRI and PETC, and (2) to specify R&D issues and needs.

C. Approach

Prior work at the University of California Berkeley has developed systems for wastewater treatment with microalgae ponds. The Berkeley team has reduced this technology to practice at several currently operating wastewater treatment plants in California and elsewhere. This team also pioneered the concept of microalgae production for fuels and CO₂ utilization, as described in a recent PETC report. That study identified wastewater treatment plants as the nearest-term option for CO₂ utilization with microalgae. A feasibility analysis will be carried out for utilization of CO₂ both directly from power plant flue gas and concentrated CO₂ delivered to such systems. The work will include an initial generic analysis followed by site-specific analysis of two existing microalgae waste treatment plants in California (selected from among five operating plants, at Hollister, Modesto, Stockton, Sunnyvale, and St. Helena). Issues addressed will include (1) improvements in waste treatment and biomass productivity achieved with CO₂ supplementation, (2) engineering designs of such systems, (3) production and use of fuels (methane, lipids), (4) overall greenhouse gas mitigation, (5) system economics, and (6) the potential for applications and greenhouse gas reductions in the U.S. and abroad.

Project 14. Combustion Tests and Combustor Development

A. Background

TVA has joined EPRI in cofunding as assessment of slagging combustion for biomass fuels, including high-percentage (80% biomass, 20% coal) cofiring with coal. A conceptual design and cost estimate for a retrofit at Watts Bar Fossil was included. EPRI has co-sponsored laboratory tests of reburn for NO_x control using wood and comparing wood to natural gas and coal as the reburn fuel. PETC has tested switchgrass cofiring with coal in the CERF test unit at PETC, and has designed other combustion tests in cooperation with DOE and two other national laboratories: Sandia-Livermore and NREL. This project, No. 14 of the PETC/EPRI biomass cofiring program, will include further combustion tests at PETC, with initial focus on the planning and implementation of tests in a bench-scale slagging combustor, if such tests are deemed to be productive in resolving issues raised during the PETC/EPRI cofiring program and if such tests are not already supported by the DOE biomass cofiring program involving PETC, Sandia and NREL.

B. Objective

The objective of this project is to measure in the laboratory the capability of slagging combustion to solve the problems of slagging, fouling and/or

agglomeration associated with the combustion or co-combustion with coal of high-alkali biomass fuels. A secondary objective of this project is to perform at PETC other laboratory tests that can cost-effectively resolve issues raised elsewhere in the PETC/EPRI biomass cofiring program.

C. Approach

Prepare a Test Plan for slagging combustor tests at PETC, based on the EPRI/TVA assessment, PETC's existing equipment and expertise, EPRI and EPRI contractor/subcontractor expertise (Foster Wheeler and Reaction Engineering International), and TVA's expertise and potential site or sites for a retrofit unit. The Test Plan is to explicitly state the rationale for the test at PETC in the context of past results (per the EPRI/ TVA assessment) and in the context of other steps that are seen as necessary either before or after the test at PETC. After revision, if needed, and approval by both PETC and EPRI, the Test Plan will be implemented, subject to availability of sufficient funding. If other testing at PETC in support of this PETC/EPRI biomass cofiring program is needed, and funding is available, that testing will be performed under this program if approved by both PETC and EPRI.

Project 15. Ash Sales

A. Background

EPRI is cofunding with Southern Company Services (SCS) a project performed by SCS and Auburn University that is characterizing and testing wood-cofired ash and low-NO_x-burner ash collected as flyash at Southern Company coal-fired power plants. The ash is being tested to determine its pozzalanic properties and performance in making high-strength cement. This EPRI/SCS project is expected to provide data for the revision of ASTM standards as needed, and if warranted by the test results, to assure sales of flyash from coal-fired power plants whose sales of ash could otherwise be prevented by concerns that the ash is too high in carbon content due to low-NO_x burners and/or wood being cofired with the coal. Existing standards for sales of flyash to the cement industry are for coal ash only, and sales of cofired ash are constrained to whatever are deemed by the buyer to be negligible levels of wood in the fuel. Any risk of the ability to sell flyash, and therefore to avoid the costs of flyash disposal, is usually unacceptable to a utility power plant super-visor, and is a reason to rule out further consideration of biomass cofiring at many utility powerplants.

B. Objective

The objective of this project is to develop and implement an action plan that can lead to acceptance of biomass-cofired flyash for purchase by the cement industry.

C. Approach

Identify a fast path, faster than the ASTM standards procedure, for gaining acceptance of biomass-cofired flyash in the cement industry. Develop an action plan for progress along that fast path. Communicate the action plan, and the supporting results from research and testing programs, to those in the cement industry who can make possible the sale into the cement industry of flyash from biomass-cofired coal.

Project 16. CO₂ Capture and Disposal

A. Background

The capture and disposal of CO₂ is an active area of long-term R&D in both the U.S. and abroad, most notably Japan. EPRI, PETC, and DOE have carried out extensive investigations of these concepts in the past. Of particular concern is aquifer storage and disposal of fossil CO₂ removed from stack gases.

B. Objective

The objective is to determine both the cost and potential amount of CO₂ mitigated, and the overall potential of this technology in reducing CO₂ emissions in the U.S. The overall objectives are (1) to determine if this is of future interest for development by EPRI and PETC, and (2) to specify R&D issues and needs.

C. Approach

The approach of this assessment is to consider cofiring in the context of the sequestration options. Sequestration options considered in this project include aquifer sequestration. Other options potentially considered include sequestration in old oil and gas wells.

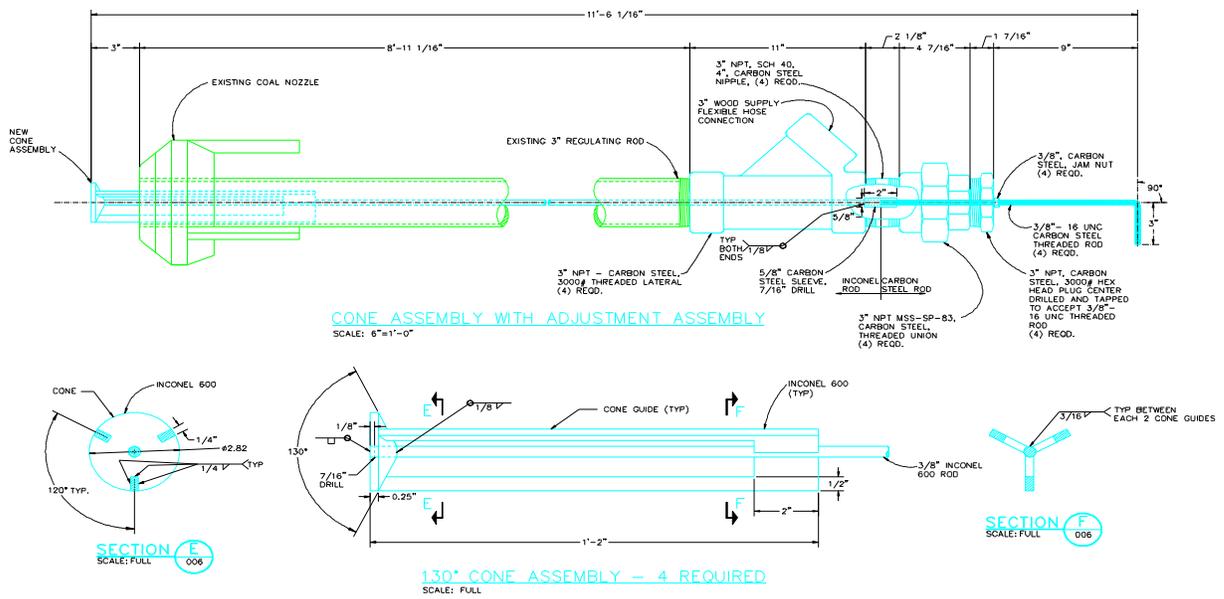


Figure 2. Schematic of Wood Diffuser System used at Seward Generating Station.

Project 2. Fuel Preparation Tests at Greenidge Generating Station

Cofiring tests were conducted October 17-24. These tests were conducted using the original system.

Project 3. Precommercial Testing at TVA Fossil Plants

Cofiring tests were conducted at Boiler #1 of the Allen Fossil Plant, a 272 MW_e cyclone unit. These tests were designed to evaluate the maximum contribution of biomass to NO_x management. During these tests, primary air/total air ratios were varied. Excess O₂ was varied, and the wood waste percentage in the total fuel feed was held at about 15 percent (mass basis), consistent with prior test results indicating that NO_x reductions were maximized at this cofiring level (see Figure 3).

These tests were conducted during the period Nov 1 – 10. Fuel and ash samples were sent to the laboratory for analysis. Test data were transmitted to Reaction Engineering International for computer modeling. All data were entered into computer spreadsheets. Final analysis of the data has not occurred at this time.

Plans were made to continue precommercial cofiring testing at the Colbert Fossil Plant in Colbert, AL. This Fossil Plant has four 190 MW_e wall-fired PC boilers. Construction of a pole barn, by TVA, was completed during this quarter. A trommel screen was installed by TVA at this location.

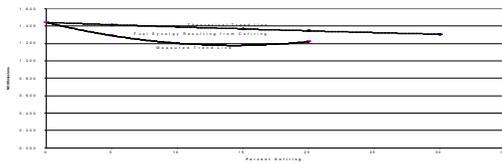


Figure 3. NO_x Reductions Achieved at the Allen Fossil Plant Compared to the Estimated NO_x Reductions Based Upon Thermodynamic Modeling

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

Preliminary tests of switchgrass cofiring were conducted during this quarter at the Blount St. Station. These tests were conducted in October. Cofiring levels of 20 percent (mass basis) were achieved during preliminary tests. Problems with materials handling and particle size reduction were identified and plans were made to significantly modify the materials handling approach.

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

Meetings were held planning this cofiring test at Michigan City. Initial discussions were conducted with the fuels department concerning types of fuel suppliers.

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 successfully completed negotiations with Iron City Brewing to use their stoker boilers for cofiring testing. Sources of urban wood fuel were identified and evaluated. These stoker boilers have substantially less instrumentation than typical utility boilers, and even old utility boilers. Consequently assessments of results are less quantitative. At the same time, these boilers represent typical older process industry boilers suitable for use in cofiring.

Project 11. Toxic Emissions from Cofiring Evaluation

No progress was made on this project.

Project 12. Fuel/Powerplant Model Development

The EPRI Alternate Fuels Database (EPRI TR-107602) was published during this time period. This database presents the characteristics of over 100 biomass sources and representative coals. It also contains methodologies for evaluating the impacts of various fuels on boiler efficiencies. This database was not part of the FETC/EPRI Cofiring Cooperative Agreement; however it provides the basis for future modeling efforts.

As an extension of this database, Foster Wheeler initiated modeling pulverized coal boilers for use in cofiring evaluations. Such models address both efficiency and temperature profiles.

Project 13. CO₂ Utilization in Algal Systems

EPRI initiated contractual discussions with the Institute for Environmental Management (IEM) in Palo Alto, CA, and with John R. Benemann of Walnut Creek, CA. IEM and John Benemann will provide analysis of these systems.

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

No progress was made on this project.

REFERENCES

Foster Wheeler Environmental Corporation. 1996. EPRI Alternate fuels Database. EPRI TR-107602.