

URBAN WOOD/COAL CO-FIRING IN THE NIOSH BOILERPLANT

FINAL REPORT

SEPTEMBER 30, 2000 — JANUARY 30, 2005

James T. Cobb, Jr.

February 10, 2005

Award No. DE-FC26-00NT40896

By: Department of Chemical and Petroleum Engineering
University of Pittsburgh
1249 Benedum Hall
Pittsburgh, PA 15261

For: U. S. Department of Energy
National Energy Technology Laboratory
Pittsburgh, Pennsylvania
Morgantown, West Virginia

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 or 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

Phase I of this project began by obtaining R&D variances for permits at the NIOSH boilerplant (NBP), Emery Tree Service (ETS) and the J. A. Rutter Company (JARC) for their portions of the project. Wood for the test burn was obtained from the JARC inventory (pallets), Thompson Properties and Seven D Corporation (construction wood), and the Arlington Heights Housing Project (demolition wood). The wood was ground at ETS and JARC, delivered to the Three Rivers Terminal and blended with coal.

Three one-day tests using wood/coal blends of 33% wood by volume (both construction wood and demolition wood) were conducted at the NBP. Blends using hammermilled wood were operationally successful. Emissions of SO₂ and NO_x decreased and that of CO increased when compared with combusting coal alone. Mercury emissions were measured and evaluated.

During the first year of Phase II the principal work focused upon searching for a replacement boilerplant and developing a commercial supply of demolition wood. The NBP withdrew from the project and a search began for another stoker boilerplant in Pennsylvania to replace it on the project. Three potential commercial demolition wood providers were contacted. Two were not able to supply wood. At the end of the first year of Phase II, discussions were continuing with the third one, a commercial demolition wood provider from northern New Jersey.

During the two-and-a-third years of the contract extension it was determined that the demolition wood from northern New Jersey was impractical for use in Pittsburgh, in another power plant in central New Jersey, and in a new wood gasifier being planned in Philadelphia. However, the project team did identify sufficient wood from other sources for the gasifier project.

The Principal Investigator of this project assisted a feasibility study of wood gasification in Clarion County, Pennsylvania. As a result of the study, an independent power producer in the county has initiated a small wood gasification project at its site.

Throughout much of this total project the Principal Investigator has counseled two small businesses in developing a waxed cardboard pellet business. A recent test burn of this biofuel appears successful and a purchase contract is anticipated soon.

During the past two months a major tree-trimming firm has shown an active interest in entering the wood-chip fuel market in the Pittsburgh area and has contacted the NBP, among others, as potential customers. The NBP superintendent is currently in discussion with the facilities management of the Bruceton Research Center about resuming their interest in cofiring this renewable fuel to the stoker there.

TABLE OF CONTENTS

Abstract	iii
Introduction	1
Executive Summary	2
Phase I	5
First Year of Phase II	8
Contract Extension	10
Wood/Coal Cofiring in a Pennsylvania Stoker Boilerplant	10
General Wood/Coal Cofiring	12
Waxed Cardboard Pellets	13
Wood Gasification	15
Pennsylvania Biomass Working Group	17
Conclusions	18
Appendix	20
References	20
List of Acronyms and Abbreviations	20
Pennsylvania Biomass Working Group Paper	
21	
PennFuture Paper	34

INTRODUCTION

This final report opens with a succinct review the work done during Phase I and the first year of Phase II of the University of Pittsburgh's project on "Urban Wood/Coal Co-firing in the NIOSH Boilerplant." It then describes work done during the two-and-one-third-year contract extension period of Phase II of this project.

The core of Phase I of this project was a field test that occurred during a brief period in April 2001. The report on Phase I, submitted earlier, began with a detailed description of the field test. It then discussed "Environmental Aspects," "Wood Supply" and "Plant Operations." Finally, it provided (1) a set of material and energy balances for certain of the test periods and (2) a comparison of the data on mercury speciation to mathematical models of this phenomenon.

The principal work of the first year of Phase II focused upon developing a commercial supply of wood, promotion of biomass/coal cofiring (including discussions of alternate locations for commercial cofiring), reporting and making outside contacts. This is described in an annual report being submitted simultaneously with this final report.

The presentation of the final report has been delayed in anticipation of the resumption of negotiations between a wood/coal blend provider and the NBP. That has just occurred, probably as a result of the recently enacted Alternative Energy Portfolio Standard in Pennsylvania. Late in 2004, Asplundh Tree Expert Company began to show an active interest in entering the wood-chip fuel market in the Pittsburgh area. In January 2005 it contacted the NBP, among others, as potential customers. The NBP superintendent is currently in discussion with the facilities management of the Bruceton Research Center about resuming their interest in cofiring this renewable fuel to the stoker there.

Based upon the experience that he obtained in conducting Phase I of this project and a companion project at the Bellefield Boilerplant, the Principal Investigator has become involved in numerous biomass fuel projects throughout Pennsylvania and New York State. It is appropriate that this activity be reported herein, as it is an important outcome of a project, such as this one, that is conducted under the auspices of a major university by its faculty and students.

EXECUTIVE SUMMARY

During the first year (Phase I) of this project, work was pursued on experimentation, environmental issues, wood supply, plant operations and analysis. During the three-and-one-third years of Phase II, work was pursued on wood supply and promotion of biomass/wood cofiring (including seeking of an alternate boilerplant in which to initiate commercial operation).

PHASE I

The following is the abstract of the final report on Phase I.

“An Environmental Questionnaire was first submitted to the USDOE National Energy Technology Laboratory (NETL). A R&D variance for the permit at the NBP was obtained from the Allegheny County Health Department. R&D variances for permits at Emery Tree Service (ETS) and the J. A. Rutter Company (JARC) for their portions of the project were obtained from the Pennsylvania Department of Environmental Protection. Memoranda of understanding were executed by the University of Pittsburgh with ETS, JARC and the National Institute of Occupational Safety and Health (NIOSH).

“Pallets were used from the JARC inventory. Construction wood was acquired from Thompson Properties and Seven D Corporation. Demolition wood was obtained from the Arlington Heights Housing Project. The wood was ground at ETS and JARC, delivered to the Three Rivers Terminal (TRT) and blended with coal.

“Three one-day tests using wood/coal blends of 33% wood by volume (both construction wood and demolition wood) were conducted at the NBP. Blends using hammermilled wood were operationally successful and can form the basis of Phase II. Emissions of SO₂ and NO_x decreased and that of CO increased when compared with combusting coal alone. Mercury emissions were measured. Material and energy balances for the test periods at the NBP were prepared.

“Evaluation of data from the internet and of results from a kinetic model show that moisture plays a major role in mercury speciation in boilers. The concentration of atomic chlorine is significantly affected by temperature, and concentrations of moisture, CO and NO significantly affect the concentration of atomic chlorine. In the selective non-catalytic reduction region of boilers, the injection of ammonia and methane affects the concentration of the chlorine radical, and the key components controlling the concentration of the chlorine radical are carbon monoxide (formed from methane oxidation) and ammonia.

“Shortly before the end of Phase I, two commercial demolition wood providers were contacted to participate in Phase II.”

YEAR ONE OF PHASE II

The following is the abstract of the final report on the first year of Phase II.

“Three potential commercial demolition wood providers were contacted. Two were not be able to supply wood. Discussions were continuing with the third one, a commercial demolition wood provider from New Jersey. A sample was awaited from the New Jersey firm.

“The possibility of adjusting the fuel from urban waste wood to waxed cardboard pellets produced from produce market by-product was explored and rejected.

“The NBP may be replaced by another stoker boilerplant in Pennsylvania on this project. Its replacement will be sought in the future after a wood supply is determined.

“Three presentations were made, one at Brigham Young University, another at the Pennsylvania Department of Environmental Protection and the third at the 27th International Technical Conference on Coal Utilization & Fuel Systems at Clearwater, FL.

“The Principal Investigator attended the first meeting of the Pennsylvania Biomass Working Group.”

CONTRACT EXTENSION

Work continued on Phase II of the project until the end of January 2005.

A visit was made to the resource recovery plant in northern New Jersey from which the wood sample was awaited. It was determined that the demolition wood from this plant was impractical to use in Pittsburgh. Members of the project team then visited a coal-fired utility boilerplant in New Jersey and the site of a potential wood gasifier in Philadelphia. Neither of these facilities could use the demolition wood from the northern New Jersey resource recovery plant either.

Members of the project team assisted the developer of the wood gasifier project in Philadelphia to evaluate the availability of green wood, urban waste wood and regulatory permitting for its project. Sufficient wood was identified and no regulatory barriers were found.

The Principal Investigator of this project assisted the Fraunhofer Center for Energy and Environment in a feasibility study of wood gasification in Clarion County, PA. The study identified one feasible industrial project, but the plant was shut down before the project could be initiated. However, an independent power producer in the county has initiated a small wood gasification project at its site as a result of the study.

The Principal Investigator has counseled two small businesses in New Paltz, New York, as they have developed a new biomass fuel from a by-product of the produce

sections of grocery stores. Waxed cardboard pellets, manufactured by Dom's Empty Package Services Inc. and sold by Cardigan, were used by Lyonsdale LLP in a test burn of cofiring with wood chips at its boilerplant last month (January 2005). Preliminary indications are that the test was successful and the boilerplant has added the possibility of combusting waxed cardboard pellets to its pending Title V repermitting application. When the permit is approved, the boilerplant intends to enter into a long-term purchase contract with Cardigan.

Very recently (December 2004) the Asplundh Tree Expert Company has shown an active interest in entering the wood-chip fuel market in the Pittsburgh area and has contacted the NBP, among others, as potential customers. The NBP superintendent is currently in discussion with the facilities management of the Bruceton Research Center about resuming their interest in cofiring this renewable fuel to the stoker there.

PHASE I

This section is the executive summary of the final report on Phase I.

EXPERIMENTAL WORK

During the first six months of the project, wood was collected from two sources of construction wood and one source of demolition wood. This material was either ground by JARC or milled by ETS, and delivered to TRT.

In early April 2001 six truckloads of wood/coal blends were produced at TRT and delivered to the NBP – one truckload of a 20% construction wood by volume/80% coal blend and five truckloads of a 33% wood by volume/67% coal blend. Two of the 33% blends contained construction wood and three contained demolition wood. The load from each truck was fed to the NBP bunker and thence to the boiler. The 20% blend and the first of the 33% blends with construction wood utilized tub-ground wood. This material did not flow well through the receiving grill nor through the spreaders. However, the third 33% blend with construction wood and the three 33% blends with demolition wood, all with hammermilled wood, flowed well through the receiving grill and the spreaders.

Emissions monitoring during combustion, using the blends, showed decreases in SO₂ and NO_x, and increases in CO and particulates to the baghouse, when compared with combusting coal alone. Mercury levels increased by over 200% when the blends with construction wood were combusted, but they decreased by 14% when the blends with demolition wood were combusted, when compared with combusting coal alone.

RESULTS AND DISCUSSION

Environmental Aspects

Early in Phase I the Environmental Questionnaire was submitted to NETL.

Prior to the demonstration a letter was submitted to the Allegheny County Health Department, requesting an R&D variance to the boilerplant's operating permit for the project. The project was discussed with the solid waste regulators of the Pennsylvania Department of Environmental Protection (PADEP). Both agencies provided R&D variances to the permits of ETS, JARC and NIOSH for this project.

Following the demonstration, JARC and ETS began to consider establishing urban waste recycling facilities that would provide properly sized wood for producing a commercial wood/coal blend for the stoker boiler market in Pittsburgh.

Wood Supply

Early in Phase I memoranda of understanding were executed with JARC and ETS.

Five tons of construction wood waste were received by JARC in November 2000 from Thompson Properties. JARC ground this material along with 35 tons of pallet waste in December and delivered these “BioGrind Wood Chips” to TRT.

Three truck-loads of construction wood waste were delivered to ETS in December by Seven D Corporation. In February 2001 ETS hammermilled this material and delivered the chips in two rollofs to TRT.

In March four rollofs of roof joists from the Arlington Heights Housing Demolition Project were collected. Half of the wood was ground by JARC and half was hammermilled by ETS. Both lots were delivered to TRT.

Wood/coal blends were prepared at TRT and delivered in April to NBP.

Following the demonstration preliminary discussions were held with two potential commercial sources of demolition wood.

Plant Operations

A memorandum of understanding was executed with the NIOSH in March. In that same month an insurance rider was acquired by JARC for the demonstration.

Following the demonstration, the plant superintendent expressed satisfaction with the blends containing hammermilled wood, supplied by ETS. The project team met twice with staff of NIOSH to discuss details of Phase II and to define the steps needed to progress toward commercial operation using a 33% wood/67% coal (by volume) blend at the NBP.

Analysis

The project team performed energy balances on four test periods at the NBP.

Analysis of the effect of conditions in boilers, especially those co-firing biomass with coal, on mercury speciation has shown:

1. Moisture is a key parameter affecting mercury speciation.
2. Mercury speciation at the NBP are similar to those at the Big Bend Boilerplant.

3. The concentration of atomic chlorine decreases significantly as temperature decreases.
4. The concentrations of moisture, CO and NO significantly affect the concentration of atomic chlorine.

Results of mathematical modeling of mercury speciation in the selective non-catalytic reduction region of boilers are:

1. The injection of ammonia and methane affect the concentration of the chlorine radical.
2. The key components controlling the concentration of the chlorine radical were carbon monoxide (formed from methane oxidation) and ammonia.

FIRST YEAR OF PHASE II

This section is the executive summary of the final report on the first year of Phase II.

COMMERCIAL SUPPLY OF WOOD

The ETS and the JARC both decided not to establish a construction/demolition (C/D) debris recycling business. Preliminary discussions were held with one potential commercial source of C/D wood from New Jersey. A sample of wood was being awaited from this source.

PROMOTION OF BIOMASS/COAL COFIRING

The staff at the Bruceton site of the National Institute of Occupational Health (NIOSH) discontinued its involvement in this project. The project team will seek a resumption of discussions with the NIOSH staff when a commercial fuel blend was available. In the meantime, it entered into discussion with other boilerplants to seek an alternative to the NBP for commercial cofiring in Phase II.

In its search for an alternative to the NBP, the project team held a preliminary discussion with several staff members of Trigen Energy Corporation about their design-build-operate biomass thermal plants. It also held a preliminary discussion with several staff members of Piney Creek Cogeneration Plant about cofiring the commercial C/D wood from New Jersey in their waste coal-fired circulating fluid bed combustor.

The principal investigator visited the Trigen-Syracuse Energy Plant in Syracuse, NY and the boilerplant of Black River Power on Fort Drum near Watertown, NY. At both facilities he discussed the cofiring of waxed cardboard pellets manufactured from produce market by-product by Dom's Empty Package Service Inc. (DEPSI) of New Paltz, New York. In a later discussion with the Contracting Officer's Representative at NETL, it was determined that neither of these commercialization projects would satisfy the conditions of the contract, which calls for urban waste wood to be combusted in a stoker boiler in Pennsylvania.

REPORTING

Members of the project team gave presentations on biomass energy, including a description of this project, to the graduate seminar at the Chemical Engineering Department at Brigham Young University and to staff members the Office of Pollution Prevention and Compliance Assistance of the Pennsylvania Department of Environmental Protection (PADEP) in Harrisburg, PA.

The project's Principal Investigator gave a presentation on "Cofiring Mixtures of Urban Wood and Coal to Stoker Boilers" at the 27th International Technical Conference on Coal Utilization & Fuel Systems at Clearwater, FL.

OUTSIDE CONTACTS

The project's Principal Investigator participated in the Challenges for Chemical Science Workshop, held at the headquarters of the National Academy of Science/National Academy of Engineering in Washington, D.C.

The project's Principal Investigator attended the first meeting of the Pennsylvania Biomass Working Group in Harrisburg.

CONTRACT EXTENSION

During the two-and-one-third years of the contract extension the Principal Investigator worked both specifically on initiating wood/coal cofiring in a Pennsylvania stoker boilerplant and generally on facilitating bioenergy projects.

WOOD/COAL COFIRING IN A PENNSYLVANIA STOKER BOILERPLANT

NIOSH Boilerplant

Although the NBP had been withdrawn from the project, it was anticipated that, if a source of wood could be found, the facilities management at the Bruceton Research Center might be open to renewing their interest in cofiring at the boilerplant. At the conclusion of first year of Phase II, the project team was awaiting a sample of wood from a resource recovery plant, H&C Container Service, in North Bergen, New Jersey. In early March 2003, Dr. Cobb and Mr. Bendet met at the plant with two of its owners. Mr. Bendet had been working with one of the owners for several years to develop a market for the wood from the North Bergen plant as a renewable fuel.

Here is a description of the facility as it was being operated in March 2003. The fully-enclosed sorting area of the complex comprises approximately 30,000 sq.ft. Trucks bringing construction and demolition debris are weighed and photographed, and then dumped at the north end of the sorting area. Clean wood is hand-picked into a pile, metal into another, and the remainder is lightly crushed and pushed to the center of the area. Municipal solid waste is dumped at the south end of the sorting area. It is lightly crushed and moved to the center. A grapple mixes the combined waste in the center and lifts it to a short shaker conveyor. Fines are removed in a trommel-like system and piled at the north end of the sorting area. Next, an air separator blows off plastic, paper and fluff. The remaining waste is then fed onto belts where fabric masses and wood pieces are hand-picked. Glass, brick, stone, concrete and metal pieces fall from the end of the belt. The wood pieces are crushed and floated on water; the sink is sent across the street for crushing. Saleable products are clean wood, aggregate, metal and inorganic fines. The inorganic fines are used for landfill cover and may be used in the near future for AMD control. Non-saleable by-products are disposed to landfill. The complex has extensive rail- and truck-loading facilities to transport product for sale and by-product for landfill.

All personnel are carefully vetted. The New Jersey Department of Environmental Protection closely monitored the development of the project and continues to closely monitor its operation. The plant is fully permitted.

The wood is tub-ground outside the north end of the area. There may be as much as 2,000 T/D of ground wood available. Currently it is sold for mulch during nine months of the year and landfilled in the winter. The company owns landfills in the midwest and is purchasing more.

After reviewing the cost and other barriers to importing properly sized wood from the North Bergen facility for cofiring at the NBP, the project team terminated its interest in this source of renewable fuel for stoker boilers in western Pennsylvania. It did explore the possibility of importing it to Conectiv's B. L. England Station at Beasley's Point, New Jersey, and to the boilerplant of the Philadelphia Naval Business Center, as well as to the Center's projected wood gasification facility (see below).

Very recently (December 2004) the Asplundh Tree Expert Company has shown an active interest in entering the wood-chip fuel market in the Pittsburgh area and has contacted the NBP, among others, as potential customers. The NBP superintendent is currently in discussion with the facilities management of the Bruce Research Center about resuming their interest in cofiring this renewable fuel to the stoker there.

Philadelphia Naval Business Center

Cinergy Solutions has the contract to operate the boilerplant at the Philadelphia Naval Business Center. Three inactive coal stoker boilers are located in the plant. During the winter of 2002-2003 the Principal Investigator twice visited the boilerplant (the second time with Mr. Bendet) to explore the possibility of reactivating the most recently installed stoker and refitting it to cofire wood with coal. It was later determined that that boiler had not been properly protected when it was shut down in the mid-1990's and therefore could not be easily restarted.

Stoker Boilerplants in Western Pennsylvania

During the period covered by this report, members of the project team made visits to three stoker boilerplants at state-owned facilities in western Pennsylvania: the State Correctional Institution – Pittsburgh, Polk State Hospital and Torrence State Hospital. At all three plants the operators and the state-level facilities managers and their technical advisors expressed a basic interest in wood/coal cofiring. However, several barriers were identified. First, a clear specification for a wood/coal blend that could be fed to the stokers, without modification to them, needed to be defined. Second, this blend needed to be placed in the annual fuel bid package. Third, bids would have to be received that offered this blend to each of the boilerplants, and those bids would have to carry the lowest cost on a BTU basis. To begin this process for any one of these three boilerplants required a provider of a wood/coal blend that met the specifications for that facility. The project team was unable to identify such a provider and consequently no commercial wood/coal cofiring could be developed for any of the three sites.

GENERAL WOOD/COAL COFIRING

B. L. England Station

Conectiv's B. L. England Station is located at Beasley's Point, New Jersey across Great Egg Harbor from Ocean City. The station's Unit #1 is a 120 MWe front-fired cyclone boiler using bituminous coal. In October-December 1998 it cofired waste wood (recycled pallets) with coal to the cyclone of Boiler #1 by layer loading before the primary crusher at about 12% by weight or 10 tons of wood/hour. The purpose of this test firing was to determine its NOx reduction potential. There were no negative boiler effects, impacts on emissions were favorable and there were no major handling problems. However, the NOx reductions were not high enough to achieve compliance, so the test program was ended without being commercialized.

In early March 2003 Dr. Cobb and Mr. Bendet met at the station with Conectiv's Vice President, Generation and the station's Manager of Generation, Station Engineer and Environmental Coordinator to explore the possibility of resuming activity toward wood/coal cofiring there. Mr. Bendet briefed them generally on wood availability from H&C Container Service. Dr. Cobb briefed them on New Jersey's Renewable Portfolio Standards (RPS). In the ensuing conversation, Mr. Bendet obtained much information on the general operation of the 138 MW cyclone boilers at the station, and both Mr. Bendet and the Vice President, Generation obtained much information on the demonstration in the mid-1990s of cofiring waste wood. It was learned that the wood specification was 3/8"x0 with a cap of 10% fines (sawdust). Larger wood chips passed through the cyclone without fully combusting. Too many fines overloaded the combustor and didn't fully combust either.

Delivery of urban waste wood from North Bergen was then examined. Trucks could drive down the Garden State Parkway to Exit 25 at Marmora, then back-track a few miles to the station. There was a possibility that an ash backhaul might be negotiated.

During the conversation it became clear that there was a disconnect between generation plant operators and corporate energy purchasers in regard to renewable energy. Corporate energy purchasers satisfy the RPS through the bid process. To that moment, the B. L. England Station had not sought to produce renewable energy nor been approached by corporate about doing so. The earlier demonstration had been performed to see if biomass could help significantly reduce emissions of NOx; it couldn't, nor was it economic, so it wasn't pursued.

After the meeting, the Vice President, Generation spoke with Conectiv's energy purchasers about this possibility. By then, H&C Container Service had quoted a price for a 3/8"x0 wood product for delivery to the B. L. England Station from North Bergen. The Vice President, Generation determined that development of commercial cofiring would be the responsibility of the station as part of Generation's general business development activity. The station would have to find out from the energy purchasers what the market price of renewable energy is, next determine what price of renewable fuel is economic, and then be shown by the wood producer that it can meet that price. The project team is unaware of any substantive activity by Conectiv in this direction following its visit.

WAXED CARDBOARD PELLETS

Dom's Empty Package Services Inc

DEPSI, founded in the 1950's, collects mixed byproducts of produce sections of supermarkets (Safeway, Publix, Kash-N-Karry etc. in northern New Jersey) and restaurants. These byproducts are wood baskets, specially printed cardboard, non-reusable but recyclable cardboard, and non-reusable waxed cardboard. DEPSI sorts the byproducts, sells the wood baskets and specially printed cardboard back to growers, recycles the regular cardboard, and produces easily transportable 1/4" and 1" pellets from the waxed cardboard for sale. The major uses by purchasers of the waxed cardboard pellets are for wax recovery and for fuel in boilers and stoves. DEPSI's current total capacity for collection and sorting of byproducts from supermarkets and restaurants is over 100 tons per day, of which 10% is waxed cardboard. It can manufacture waxed cardboard pellets at the rate of 0.75 tons per hour in its equipment at New Paltz.

Through 2003 customers of DEPSI waxed cardboard pellets (previous to Cardigan's formation) included Timber Energy Resources, Inc. (boiler fuel) and an India company (wax recovery). Early in the decade DEPSI had hoped to develop a market for waxed cardboard pellets locally as fuel for home pellet stoves. Bags of pellets were sold for a while through the Safeway supermarket chain. However, it was determined that the heating value of the pellets was too high for use in the majority of pellet stoves then in service. In 2003 at a meeting of the Pennsylvania Biomass Working Group (see below) the Principal Investigator was introduced to a new home pellet stove, developed by Harman Stove Company and the Pennsylvania State University with support from the West Penn Power Sustainable Energy Fund, that is designed to combust material (in particular, off-spec shelled corn) having higher heating values than common wood pellets. This information was transmitted to DEPSI. Discussions were held between DEPSI and Harman, but no commercial relationship evolved.

In a special arrangement bundled waxed cardboard was sold for several months in 2002 to Trigen Syracuse Energy Corporation as a boiler fuel. This is important because, prior to combusting this material, Trigen Syracuse obtained a modification to its Title V permit from the New York State Department of Environmental Protection to allow it to cofire waxed cardboard in its boilerplant.

Cardigan

Cardigan, a small woman-owned business, was founded in 2003 to take over, continue and expand that portion of DEPSI's business relating to the pelletization of waxed cardboard that is collected by an expanding DEPSI and other byproduct handlers, and the marketing, sale and shipment of the pellets produced. The Principal Investigator has counseled both DEPSI and Cardigan since being introduced to them by the staff of NETL in the middle of 2002. Cardigan currently leases and operates DEPSI's

pelletization equipment at New Paltz and DEPSI's delivery vehicles when transporting pellets to customers.

Waxed cardboard pellets, manufactured originally by DEPSI and now by Cardigan at New Paltz, have generally been acceptable as a fuel. Acceptance has been observed by the following.

- In 1995 Argonne National Laboratory examined the ultimate and proximate heating values of the waxed cardboard pellets and offered the opinion that flue gas emissions from coal-fired boilers cofiring waxed cardboard pellets should be below regulatory levels for SO₂, NO_x, HCl and CO₂.

- In 1997 a test burn of a blend of 1" waxed cardboard cubes and wood was conducted at Timber Energy's boilerplant at Telogia, FL.

- In December 1997 the New York State Department of Environmental Conservation (NYSDEC) issued Beneficial Use Determination (BUD) 510-3-60 to Waste Conversion Technologies, a subsidiary of DEPSI that was considering construction of a waxed cardboard pelletization facility. Cardigan is pursuing the issuance of a BUD for its use with waxed cardboard that has entered the waste stream.

- In summer 2002 Trigen Syracuse cofired shredded waxed cardboard at its coal-fired boilerplant. During the period of cofiring waxed cardboard, the boilerplant "witnessed reduced emissions in its air testing criteria. Results reflecting reduced values of carbon monoxide and dioxin/furan were consistent with anticipated data for the alternative fuel blends." The corporation has the "opinion that [used] waxed corrugated boxes are a viable source of fuel."

- Finally, in fall 2003 a judicial agreement was reached with NYSDEC that waxed cardboard pellets are outside the scope of solid waste regulations when they produced from a byproduct of the supermarket and restaurant industries. Thus, Cardigan may freely sell waxed cardboard pellets for any use, including boiler fuel. It is the responsibility of boilerplants using them as fuel to seek and obtain permits for their use.

Cardigan's recent and current customers for pellets to use as boiler fuel include two greenhouses and Lyonsdale LLP. In fall 2003, for example, a number of truck-loads of 1/4" pellets were shipped to one of the greenhouses where, using a frontloader, they were blended with wood chips (the regular fuel for the facility) and fed successfully to the boilerplant there.

This fall (2004) Lyonsdale LLP purchased 250 tons of 1/4" pellets. Lyonsdale LLP operates a boilerplant in Lyons Falls, NY (in Lewis County, 35 miles north of Utica on the edge of the Adirondack Park). This 19 MW wood-fired cogeneration facility delivers 17,000 PPH steam to Burrows Paper Corporation. It uses a 290 mmBtu/hr stoker moving grate boiler. Its principal fuel is virgin wood chips and it is permitted to co-fire clean waste wood (byproduct of the lumber, pallet and furniture industry) at up

to 30 weight percent of the total fuel feed rate. It is described on the homepage of its owner, NGP Power Corporation, at <http://www.ngppower.com/Projects.html>.

The waxed cardboard pellets purchased from Cardigan were used by Lyonsdale LLP in a test burn of cofiring with wood chips at its boilerplant last month (January 2005). Preliminary indications are that the test was successful and the boilerplant has added the possibility of combusting waxed cardboard pellets to its pending Title V repermitting application. When the permit is approved, the boilerplant intends to enter into a long-term purchase contract with Cardigan.

WOOD GASIFICATION

Philadelphia Naval Business Center

During his second visit to the boilerplant at the Philadelphia Naval Business Center with Mr. Bendet in early March 2003, the Principal Investigator learned that the current vision of the plant operator, Cinergy Solutions, was to propose installing a new 10 MW wood-fired circulating fluid bed combustor (CFBC) to feed an existing 400 psi condensing steam turbine and produce electricity only. The current steam system has very poor efficiency and would be eventually shut down in favor of distributed heat production, either building-by-building or feeding from small centers to small groups of buildings.

The following summer (2003), Cinergy Solutions engaged a consulting team, comprised of the Dr. Cobb, Mr. Bendet and Joseph Battista, to conduct a preliminary evaluation of the availability of wood wastes within an economic radius of the Philadelphia Naval Business Center and the regulatory climate for their combustion there. The consulting team contacted numerous providers of both green wood and urban waste wood in the region to obtain an estimate of the amount of wood waste that might be available to the Center from specific companies, such as wood processors, tree services, construction companies and resource recovery facilities in Pennsylvania, New Jersey, Delaware and Maryland. The team identified companies that might be interested in establishing a wood brokerage component to their businesses. The team also contacted governmental agencies, such as the Philadelphia Energy Office, the Philadelphia County air regulators, the regional solid waste regulators of the PADEP, and headquarters staff of the PADEP, to obtain a preliminary understanding of the expectations and constraints of a waste wood combustor in Philadelphia County.

The team reported to Cinergy Solutions that a sufficient amount of green wood was readily available well within an economic distance from the plant. A list of contacts for sources of green wood was provided, along with the names of several companies that might broker wood to the plant. Several resource recovery facilities were identified that were interested in being contacted to supply urban waste wood to the plant. Finally, the team provided a list of contacts at the various governmental and regulatory agencies with oversight of the proposed facility. Preliminary discussions uncovered no well-defined, significant barriers to the project.

In the intervening months since the team gave its report to Cinergy Solutions, the project has been redefined. The CFBC has been replaced with a gasifier. This unit could be the first phase of a possible electric generation facility, but the value of fuel gas currently is considerably higher than the value of electricity. Further, a market for fuel gas exists near the center.

The project continues to move ahead, although slowly. Discussions have been held with wood gasifier providers. Recently, a single, large green wood provider was identified for the proposed plant.

Clarion Feasibility Study

During the first eight months of 2003 the Principal Investigator and several undergraduate students from the School of Engineering of the University of Pittsburgh assisted the Fraunhofer Center for Energy and Environment in a feasibility study of wood gasification in Clarion County, Pennsylvania. The study was supported by an Energy Harvest Grant from the PADEP. The final report of the study can be found at

<http://www.dep.state.pa.us/dep/deputate/pollprev/energy/Fraunhofer%20Gasification%20Report%20Final.pdf>

The prime possibility for wood gasification in that county was determined to be a manufacturing site that used a significant amount of natural gas for heating. The wood gasification process there proved to be very feasible economically in competition with the high price of natural gas. Unfortunately, that site was shut down soon after the study was completed.

Piney Creek Cogeneration Plant

Piney Creek Limited Partnership operates a coal-waste-fired CFBC just south of Clarion, Pennsylvania. As noted above, during the first year of Phase II of this project, the project team visited the plant and led a public meeting in Clarion to explore the possibility of cofiring wood to the combustor there. The plant owners were kept informed of the Fraunhofer feasibility study. Recently, they were awarded an Energy Harvest Grant to assist them to install, own and operate a stand-alone wood-fired gasifier and associated boiler to provide heat and hot water for a commercial fish farm that they are developing at the plant site.

PENNSYLVANIA BIOMASS WORKING GROUP

The Pennsylvania Biomass Working Group was founded three years ago as the state affiliate of the Northeast Regional Biomass Program. It was originally intended to serve two purposes: first, to be a forum for the sharing of interests and experiences in the

area of biomass fuels and second, to develop white papers to provide information and guidance to state agencies and the legislature. The Principal Investigator has been an active member of the group since its inception.

The Working Group meets regularly about three times each year. It holds a comprehensive roundtable at the beginning of each meeting, then listens to a set of presentations from entities conducting projects related to biomass fuels. The group embarked on its second mission shortly after its founding. It created four subcommittees, one each on Resources, Biodiesel, Anaerobic Digestion, and Combustion and Gasification, and asked each subcommittee to develop a white paper in its assigned area. In the spring of 2003 with assistance of the subcommittee on Combustion and Gasification, Dr. Cobb prepared a first draft of a white paper on the background and possibilities for biomass combustion and gasification in Pennsylvania; this draft is reproduced in the Appendix. The Working Group received the draft but did not continue its activity toward further development of white papers.

One of the members of the working group is PennFuture, a major environmental advocate in the Commonwealth. With the urging and assistance of the Principal Investigator, PennFuture included a technical roundtable on “What Role Can Biomass Projects Play in Getting to 10%?” at its annual *Getting to 10% Conference* on May 12, 2004 in Harrisburg. Along with Dr. Cobb, the panel included (1) John Brabender, Director, Project Development, Cinergy Solutions, (2) Joseph Sherrick, Office of Energy and Technology Development, PADEP, (3) a Vice President of Tractebel, representing the Northumberland Cogeneration Plant, and (4) a representative of the U.S. Environmental Protection Agency’s Landfill Methane Outreach Program. Dr. Cobb’s paper for the conference proceedings is also reproduced in the Appendix. A major topic of the conference was the Alternative Energy Portfolio Standard, then pending in the Pennsylvania legislature, that was passed and signed into law later that year by Governor Rendell.

The Principal Investigator has expanded his activities in relation to areas of interest to the Working Group. He is counseling other companies and agencies on biodiesel production facilities and anaerobic digesters.

CONCLUSIONS

During the field work of Phase I, four blends of wood and coal were prepared, using both construction wood and demolition wood, delivered to the NBP, and fed to the spreader stoker boiler at the plant. Feeding and firing of a blend of 33% hammermilled wood and 67% coal (by volume) was acceptable operationally. The following observations were made during the tests.

1. The quantity of emissions of SO₂ and NO_x were reduced by the use of wood/coal blends. The quantity of CO and particulates to the baghouse were increased.
2. The quantity of mercury emitted from the boilerplant was reduced when cofiring with demolition wood, but increased when cofiring with construction wood.

Commercialization of wood/coal cofiring at the NBP has proven very difficult to develop. There being no established C/D wood recycling business in the Pittsburgh region nor one being developed at the conclusion of field work in mid-2001, it was not possible to offer a wood/coal blend using wood from this region to the NBP at that time. It proved too expensive to transport processed C/D wood from New Jersey, where there was a large supply, either.

In Fall 2001 the NIOSH staff decided not to continue developing the commercial introduction of a wood/coal blend at the NBP at this time, so other approaches to commercial biomass cofiring were explored. Alternative boilerplants in western Pennsylvania were sought, but unsuccessfully. Shifting the project from C/D wood to waxed cardboard pellets was determined to be disallowed by the stipulation of the contract.

Finally, just recently (Winter 2004-2005) the Asplundh Tree Expert Company has shown an active interest in entering the wood-chip fuel market in the Pittsburgh area and has contacted the NBP, among others, as potential customers. The NBP superintendent is currently in discussion with the facilities management of the Bruceton Research Center about resuming their interest in cofiring this renewable fuel to the stoker there.

During the past three years, while awaiting the appearance of a commercial wood provider in western Pennsylvania, the project team has participated in numerous projects attempting to commercialize biomass energy facilities in Pennsylvania, New Jersey and New York. They include the following.

1. Members of the project team visited a coal-fired utility boilerplant in New Jersey, but found that it was institutionally incapable of cofiring demolition wood from northern New Jersey.
2. Members of the project team assisted the developer of the wood gasifier project in Philadelphia to evaluate the availability of green wood, urban waste wood and

regulatory permitting for its project. Sufficient wood was identified and no regulatory barriers were found.

3. The Principal Investigator assisted the Fraunhofer Center for Energy and Environment in a feasibility study of wood gasification in Clarion County, Pennsylvania. An independent power producer in the county has initiated a small wood gasification project at its site as a result of the study.

4. The Principal Investigator has counseled two small businesses in New Paltz, NY, as they have developed a new biomass fuel from a by-product of the produce sections of grocery stores. A recent test burn of cofiring these pellets with wood chips at a boilerplant in Lyons Falls, NY, was successful and the boilerplant has added the possibility of combusting waxed cardboard pellets to its pending Title V repermitting application. When the permit is approved, the boilerplant intends to enter into a long-term purchase contract with one of the companies.

5. The Principal Investigator has participated in the Pennsylvania Biomass Working Group and helped to advance numerous biomass energy activities within its purview.

REFERENCES

NONE

LIST OF ACRONYMS AND ABBREVIATIONS

BBP	Bellefield Boiler Plant
BUD	Beneficial Use Determination
C/D	Construction/Demolition
CFBC	Circulating Fluid Bed Combustor
DEPSI	Dom's Empty Package Services Inc.
ETS	Emery Tree Service
JARC	J. A. Rutter Company
NBP	NIOSH Boiler Plant
NETL	National Energy Technology Laboratory
NIOSH	National Institute of Occupational Safety and Health
NYSDEC	New York State Department of Environmental Conservation
PADEP	Pennsylvania Department of Environmental Protection
RPS	Renewable Portfolio Standard
TRT	Three Rivers Terminal
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency

BIOMASS COMBUSTION AND GASIFICATION IN PENNSYLVANIA: BACKGROUND AND POSSIBILITIES

Pennsylvania Biomass Working Group (PBWG)

**Pennsylvania Department of Agriculture
and
Northeast Regional Biomass Program**

Draft – April 27, 2003

ABSTRACT

The total current utilization of renewable energy in Pennsylvania is 2,280 MW(t). Of this, 350 MW(t) is produced from biomass (biogas, timber residues, municipal solid waste, and agricultural residues). In addition to increasing the use of these routes to steam and electricity, Pennsylvania should consider implementing new technologies for steam and electricity from biomass, such as the use of energy crops and biodiesel, along with gasification and the cofiring of timber residue and clean urban wood waste with coal.

CURRENT UTILIZATION OF RENEWABLE ENERGY IN PENNSYLVANIA

Renewable energy is continuously created from solar energy entering our planet's atmosphere. In contrast, fossil fuels (petroleum, coal, and natural gas) formed eons ago and are considered finite or limited resources. The four major types of renewable energy, that are currently available and being utilized in Pennsylvania are biomass, water (held behind dams), photovoltaic cells, and wind. The current capacities for utilization of these four renewable energies in Pennsylvania are:

<u>Renewable Energy</u>	<u>Capacity (kW)</u>
Bioenergy	351,030
Hydropower	1,919,018
Photovoltaic Cells	219.2
Wind Power	10,580
Total	2,280,847.2

CURRENT UTILIZATION OF BIOENERGY IN PENNSYLVANIA

Bioenergy includes biogas, timber residues (milling and logging residues), municipal solid waste (including industrial and medical), and agricultural residues. The current capacities for steam raising utilizing these four bioenergy sources in Pennsylvania are:

<u>Bioenergy Source</u>	<u>Capacity (kW)</u>
-------------------------	----------------------

Biogas	39,650
Timber Residues	71,140
Municipal Solid Waste	239,200
Agricultural Residues	1,040
Total	351,030

The plants having the largest capacities for combustion of these four sources in Pennsylvania are:

<u>Bioenergy Source</u>	<u>Plant</u>	<u>Capacity (kW)</u>
Biogas	Fairless Hills Steam Generation Station	10,000
Timber Residues	Hammermill Paper Company	39,700
Municipal Solid Waste	Delaware County Regional Resource Recovery Project	75,000
Agricultural Residues	Mason Dixon	150
Total		124,850

Note that these four plants combine to provide over one-third of the bioenergy currently being produced in the Commonwealth.

There are several important bioenergy sources that are not included in the current list: biodiesel, gasification, cofiring of solid biomass with coal, and energy crops. Biodiesel is being developed principally for use as a transportation fuel (for example by the Pennsylvania Turnpike Commission), but it could also be used as a substitute for fuel oil in fossil-fuel combustors. Biomass gasification processes are available, but to date none have been installed in Pennsylvania. The lead U.S. project is the one in Burlington, VT. It is described below. A number of demonstrations of cofiring with coal have been conducted in the Commonwealth, but none have led to commercialization. A few demonstration plots of two energy crops, native switchgrass and of hybrid willow, have been established in Pennsylvania, but harvest from neither of these crops has yet been fed to boiler plants in the Commonwealth.

Even though not currently practiced in Pennsylvania, nevertheless, cofiring of biomass (timber waste, municipal solid waste or energy crops) with coal has been shown to be the lowest cost method for generating “green power” in the United States and, at the same time, for reducing the emissions of fossil-based SO₂, NO_x and CO₂. Several commercial projects are in operation in other states. One of these, the Willow Island Project in West Virginia, is described below. In addition to low cost and emission reductions, cofiring can provide a service to customers by creating an end use for low value or negative value products such as sawdust and other fine wood wastes generated by sawmills, furniture mills and related industries. Sawdust, for example, is the feed at Willow Island. Preconsumer off-spec paper products and films are being commercially cofired at the Trigen Syracuse Generating Station, as described below. Cofiring can also be applied to non-woody biofuels such as agribusiness wastes and energy crops, given the proper fuel preparation and feed systems.

About 55 percent of the electrical energy generated in the United States comes from coal-fired boilers. Doing so consumes nearly 1 billion tons of coal per year. Consequently, cofiring can be most successful in the utility market if systems are developed to cofire biofuels with coal in utility boilers. At a level of 10% of energy input, approximately 200 million tons of biomass per year could be fed to utility boilers, displacing 100 million tons of coal per year and leading to a corresponding major displacement of fossil carbon dioxide from the atmosphere.

THE PARAMOUNT ROLE OF SAWDUST IN TIMBER RESIDUES

Because of its ready availability in the wooded, rural areas of Pennsylvania, it may be concluded that timber residue is the current fuel of choice for biomass cofiring and sawmill residue is the primary source of that fuel. This is not to say that other biomass fuels don't have merit, it is just that the economics are difficult even for saw dust and they are much more difficult for other biomass fuels except in some very specific instances.

Sawmill residue is a byproduct from the forest products industry resulting from the processing of trees into lumber and consists of bark, wood chips, wood trimmings and sawdust. It amounts to about one-fourth of the total wood production in the United States. It also makes up over one-fourth of the material being landfilled, and landfills are increasingly turning this material away.

If this material can be economically transported and burned at a power plant, it will reduce groundwater contamination, reduce the strain on landfills and result in a reduction in sulfur dioxide and nitrogen oxide emissions at the plant. It will also cause an overall reduction in the amount of fossil CO₂ entering the atmosphere since wood is a renewable resource.

Therefore, the potential exists for sawmill operators to supply large amounts of sawdust to utilities at a relatively low cost to the power plant. In Pennsylvania the Department of Conservation and Natural Resources estimates that salvageable dead wood, wood slabs and sawdust could provide more than 13 million tons of fuel per year. This is equivalent to over 700 million gallons of #2 fuel oil.

WHAT ARE THE BENEFITS TO COFIRING?

Successful demonstrations of utilities burning waste wood in their coal burning power plants will result in many benefits. Cofiring with sawdust can help utilities meet clean air act requirements. Cofiring may be a low cost approach to fossil CO₂ reduction. Improvements in the handling and burning of renewable fuels will spur additional research in the area of opportunity fuel combustion and cofiring will allow a greater long-term use of Pennsylvania coals, while also promoting a greater use of renewable wood fuel. This will improve the Pennsylvania's position in the U.S. and world marketplace while helping to reduce the emission of CO₂ into the atmosphere. In addition, the forest

product industry's waste streams will be minimized, local jobs in the forest product and transportation industries will be created and urban and right-of-way residues will be reduced, easing the pressure on landfills.

In the future, crops grown specifically for the generation of electric power (closed loop biomass) may promote rural development by encouraging productive use of marginal lands such as mine reclamation sites, riparian zones and conservation reserve program (CRP) land. Forest stands will also be improved which will increase the growth of high value woods while providing an economic and environmentally beneficial source of fuel by culling out damaged or nonproductive varieties of trees.

WHAT IS BEING DONE IN COFIRING AND GASIFICATION?

As noted earlier, several successful cofiring demonstrations have been conducted at power plants in the Commonwealth over the past ten years. They cover many coal boiler types and utilized a number of alternate fuels. In neighboring states a number of successful cofiring demonstrations have also been conducted and several have led to on-going commercial operations.

This paper will feature certain of these demonstrations and commercial cofiring projects (see following table). They are Trigen Syracuse (NY), B. L. England #1 (NJ), Shawville (PA), Seward (PA), and NIOSH (PA).

Station	Company	Boiler Type	Comment
Trigen Syracuse, NY	<u>Trigen Corp.</u>		Shredded preconsumer film and printed paper (labels), pneumatically fed to a pulverized coal boiler
England, BL #1 Beesley's Point, NJ	NRG/Xcel Energy/ No.Sts.Pwr.	Cyclone	Wood chips w/tires and coal by layer loading on belt before crusher
NIOSH (Bruceton Research Center, Pittsburgh)	U.S.DHHS- CDC-NIOSH	Spreader stoker	Fuel switch to a blend of ground construction/demolition wood (30% by volume) and coal

The **Trigen Syracuse Powerplant** contains five pulverized coal boilers, each with a design capacity of 275 MM Btu/hr. Trigen Syracuse is authorized to cofire coal and alternative fuel in three of its five boilers. The powerplant is limited to combusting "no more than 30% by weight alternative fuel on a facility-wide basis. In addition, each boiler is limited to "a maximum alternative fuel firing rate of no more than 9500 lb/hr." The alternative fuel is defined as "processed pre-consumer, non-recyclable, non-reusable, non-contaminated, plastic coated paper, wax-coated paper, paper, and low chlorine content (less than 1% dry weight as received) plastic film."

In 2001 Trigen Syracuse constructed a 17,000 sq/ft processing building to receive, sort, blend and size waste paper products, such as off-spec labels and infant diapers, and unusable film. The film is delivered in large rolls that are sent initially to a chopper. A primary shredder is installed at the corner of the processing building nearest the boilerplant. All of the feed is reduced to a top size of 3 inches. A conveyor belt moves this material up and over to the boilerplant where a secondary shredder reduces the top size to ¼ inch. The air stream that moves the 3-inch material through the secondary shredder conveys the ¼-inch material to the boilers.

During commissioning of the alternative fuel feeding system, a dioxin stack test was conducted in late 2001 to assure that dioxins were not produced from the chlorine-containing films, fed to the boilers.

B. L. England #1 is located at Beasley's Point, New Jersey across Great Egg Harbor from Ocean City. The unit is a 120 MWe front-fired cyclone using bituminous coal. They have cofired waste wood with coal in a cyclone by layer loading before the primary crusher at about 12% by weight or 10 tons of wood/hour. They have test fired recycled pallets for NOx reduction potential. They performed feasibility testing on #1 in October-December 1998. There were no negative boiler effects, impacts on emissions were favorable and there were no major handling problems. The NOx reductions were not high enough to be used for compliance so the project was ended. They are not currently cofiring. A member of the PBWG is discussing a commercial project with the current plant operator (Conectiv), in which ground construction/demolition wood from a resource recovery plant in North Bergen, NJ would be transported to the station and fed to the #1 boiler. An incentive for doing this is the new Renewable Energy Portfolio Standards recently established by the New Jersey Bureau of Public Service, which requires electric utilities to provide at least 3.75% of its electricity sales from renewable sources. Because of their importance as incentives for cofiring, renewable portfolio standards will be discussed in a later section.

The University of Pittsburgh conducted a demonstration of urban waste wood cofiring at the **NIOSH stoker boilerplant** operated by the National Institute for Occupational Safety and Health (NIOSH) at the Bruceton Research Center. A detailed report on the demonstration at the NIOSH, sponsored by the U.S.DOE's National Energy Technology Laboratory (NETL), was provided last year at the 27th International Technical Conference on Coal Utilization & Fuel Systems.

Commercialization of cofiring of urban waste wood at this boilerplant has proven not to be immediately possible. Cofiring is acceptable technically, organizationally and regulatorily, but there is not in Pittsburgh a sufficiently large commercial source of processed urban waste wood.

RENEWABLE PORTFOLIO STANDARDS

Many new regulations have recently been promulgated that promote biomass as a fuel. They include system benefit funds, project incentives, tax credits, and renewable portfolio standards. An excellent review of “State Policy Options for Renewable Energies” was presented in September 2002 to a committee of the Arizona State Legislature by Matthew H. Brown, Energy Program Director, National Conference of State Legislatures. Mr. Brown’s slides are available at <http://www.ncsl.org/programs/esnr/azrenew902/>. The following four subsections highlight four widely enacted options. Other less widely enacted options, not discussed here, include incentives for small projects, accelerated depreciation, low-interest loans or loan guarantees, line extension policies, fuel source disclosure requirements, and government purchases.

System Benefit Funds. Fourteen states collect funds from electric utilities that may be drawn upon to provide renewable, efficient and affordable energy. They include California, Connecticut, Delaware, Illinois, Massachusetts, Montana, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, and Wisconsin. Collections amount to between \$0.40 (Illinois) and \$4.70 (Massachusetts) per capita per year.

Incentives for Large Projects. Six states provide incentives for large renewable projects by allowing those projects to collect an additional \$0.011 to \$0.0675 per kWh over five years from the rate payers. They include California, Illinois, Montana, New York, Pennsylvania and Rhode Island.

Tax Credits. Four types of renewable energy tax credits are available. The federal government for several years has allowed a production tax credit, which is up for renewal in the Energy Bill that should be introduced in the current Congress. A number of states allow an investment tax credit. Eight states allow a sales tax credit, and twenty allow a property tax credit.

Renewable Portfolio Standards. Fifteen states have enacted Renewable Portfolio Standards, including California, New Jersey and Texas. The following table gives the percentages and dates at full implementation for ten of them.

State	Percentage	Date
Arizona	1.1	2007
California	20	2017
Connecticut	13	2009
Maine	30	2000
State	Percentage	Date
Massachusetts	4	2009
Nevada	15	2013
New Jersey	6.5	2012

Pennsylvania	(varies by utility)	
Texas	(2880 MW total)	2009
Wisconsin	2.2	2011

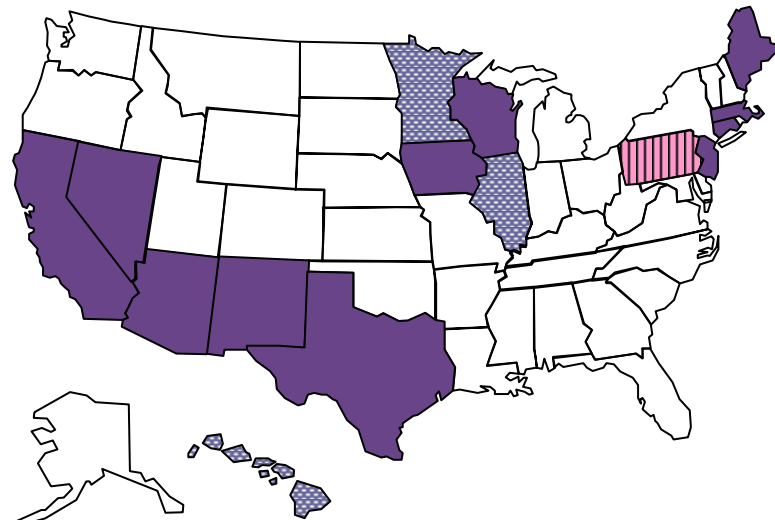
Renewable Portfolio Standards (RPS) arguably provide the principal encouragement for investment in renewable energy. They do not simply assist in moving “green” electricity generation toward profitability; they absolutely require utilities to provide “green” electricity to their customers.

To encourage the adoption of RPS by the several states, U.S. DOE’s National Renewable Energy Laboratory (NREL) has developed elements of a model RPS, which are available at http://eren.doe.gov/state_energy/policy_sl_rps.cfm, “Sample Language for Renewable Portfolio Standards.” In this document, two classes of renewable energy are defined:

Class I: “. . . electric energy produced from solar technologies, photovoltaic technologies, wind energy, fuel cells, geothermal technologies, wave or tidal action, and methane gas from landfills or a biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner.”

Class II: “. . . electric energy produced at a resource recovery facility or hydropower facility, provided that such facility is located where retail competition is permitted and provided further that the Commissioner of Environmental Protection has determined that such facility meets the highest environmental standards and minimizes any impacts to the environment and local communities.”

As noted above, currently fifteen states have enacted Renewable Portfolio Standards legislation, generally as part of electric utility restructuring. A state Renewable Portfolio Standards (RPS) requires that a specified portion of electricity sold in that state is generated from renewable energy resources. The company marketing the electricity can either generate it, purchase it for resale, or in some cases purchase tradable renewable energy credits (green tags) for the electricity.



State-by-state there is significant variation in the provisions of the RPS, such as the renewable energy content required, the timetable for reaching these renewable

content goals, and the renewable energy technologies included. The University of Pittsburgh has particular interest in the RPS and related activities of Pennsylvania and three of its neighboring states, Maryland, New Jersey and New York.

Pennsylvania. The RPS in Pennsylvania is unique among the fifteen states with portfolios. There is no statewide standard or set goal on renewable capacity and generation. During the electric utility restructuring process (1996), instead of a traditional RPS, four utilities — GPU Energy, PECO Energy, PP&L, and Allegheny Power/West Penn Power Company — agreed to establish and fund independent Sustainable Energy Funds (SEF). These for-profit SEFs were created with the goal of promoting (1) the development and use of renewable energy and clean energy technologies, (2) energy conservation and energy efficiency, and (3) renewable energy business initiatives and T&D related environmental improvement projects. Eligible technologies include solar PV and thermal energy; wind power; low-head hydropower; geothermal energy; landfill, bio-based and mine-based methane; waste-to-energy; and sustainable biomass energy. The projects are not required to be electrical generating. Since 1999, over 20 million dollars have been invested in projects through loans, small grants and other financial vehicles.

Additional provisions in the restructuring settlements require that the four utilities provide renewable content to a portion of their default residential customers. Beginning in 2001 PECO, West Penn and PP&L are required to provide 2% renewable content to 20% of their default customers with the renewable content increasing 0.5% per year. Also beginning in 2001, GPU must supply electricity with a 0.2% renewable content to 20% of its default customers with the percent of customers rising to 80% in 2004.

Maryland and New York. To date, neither Maryland nor New York has adopted an RPS. However in New York Governor George Pataki's 2003 State of the State Address he announced that he was directing the Public Service Commission to implement a RPS that would guarantee that within ten years at least 25% of the electricity bought in New York will come from renewable resources.

Both Maryland and New York have adopted Green Power Purchasing for state owned facilities. Maryland Governor Parris Glendening issued an executive order on March 13, 2001 calling for at least 6% of the electricity consumed by state-owned facilities to be generated from "green" energy sources, such as wind, solar, landfill gas, and other biomass resources. The order specifies that no more than 50% of the power procured to meet the requirement come from municipal solid waste facilities. On June 10, 2001, New York's Governor Pataki announced an executive order requiring that state buildings get at least 10 percent of their electric power from renewable energy sources, such as wind, solar, biomass, geothermal or fuel cells by 2005, and 20 percent by 2010. The order applies to the state's buildings and those of quasi-independent agencies like the State University of New York and the Metropolitan Transportation Authority.

New York supports a renewable energy R&D grant program and a loan program to finance renovation or construction of energy projects with a Systems Benefit Charge

from the state's six investor-owned utilities. The R&D grants focus on product and technology development in biomass, photovoltaics, and wind energies.

New Jersey. As part of its electric utility restructuring New Jersey adopted a two tier RPS. Electricity generated from renewable energy resources is divided into the two categories, Class I and Class II, recommended by NREL. The distribution of generation by these two categories depends on the environmental desirability and availability of the generating technologies. As noted above, the Class I category includes electric energy produced from solar thermal and photovoltaic technologies; wind energy; fuel cells; geothermal technologies; wave or tidal action; landfill gas; and harvested-sustainable biomass and recycled wood. The Class II category includes electricity generated at a waste-to-energy facility or a hydropower facility that meets environmental impact standards. Beginning in 2001 each firm selling electricity to retail customers must have in its electric energy portfolio (A) 2.5% electric power content from either Class I or Class II and (B) and an additional 0.5% content solely from Class I sources (3.0% total renewable energy content). From 2003 to 2012 the electric energy portfolios must increase the Class I only content from 0.5% to 4.0%, so by 2012 the total renewable energy content of electricity marketed to retail customers in New Jersey will equal at least 6.5%. New Jersey's "Interim Renewable Energy Portfolio Standards," Subchapter 8, N. J. A. C. 14:4-8, <http://www.bpu.state.nj.us/wwwroot/energy/porfoliostands.pdf>, sets and implementation schedule as follows:

<u>Year</u>	<u>Class I</u>	<u>Plus</u>	<u>Class I or II</u>	<u>Total</u>
2001 (Sept.-Dec.)	0.5%		2.5%	3.0%
2002	0.5%		2.5%	3.0%
2003	0.75%		2.5%	3.25%
2004	0.75%		2.5%	3.25%
2005	0.75%		2.5%	3.25%
2006	1.0%		2.5%	3.5%
2007	1.5%		2.5%	4.0%
2008	2.0%		2.5%	4.5%
2009	2.5%		2.5%	5.0%
2010	3.0%		2.5%	5.5%
2011	3.5%		2.5%	6.0%
2012 and beyond	4.0%		2.5%	6.5%

"By March 1st of each year . . . each electric power supplier and basic generation service [in New Jersey] shall file an annual report . . . demonstrating that the electric power supplier's or basic generation service provider's electric energy portfolio met [these] percentage requirements . . . for the preceding calendar year" Appropriate remediation and penalties are defined in the New Jersey regulation, if the percentage requirements are not met.

The 1999 restructuring legislation also provides for a societal benefits charge (SBC) that supports, in part, rebates on the installation of customer-sited renewable

energy electric generation plants. Eligible technologies include fuel cells, photovoltaic, small wind or sustainable biomass technologies with rebates ranging from \$0.15 to \$5.00 per watt. Other SBC funding is available for grid connected Class I technology projects.

WHAT WILL BRING COFIRING AND GASIFICATION INTO THE MARKETPLACE?

As can be seen, there are many similarities in these test burns. Many of these utilities have tried cofiring, found it to be feasible technically and then discontinued operations. What will entice the power generators to get involved? What has kept them from embracing technologies that have the potential to reduce power plant emissions and eliminate waste disposal problems? The answer is only one thing: cost. We can all talk about reduced emissions, helping the customers, increasing jobs, being a good corporate citizen and so forth. These are all admirable goals; but unless the costs of generating electric power from biofuels or other renewables are recoverable from the customer at a reasonable profit, the picture will not change.

The Energy Information Administration projects that the non-hydro renewable generation (biomass, geothermal, municipal solid waste, solar thermal, photovoltaic and wind) will only grow to a 3.5% share of the United States' electric power generation by 2020 with the current subsidies. Biomass is projected to be about half of that. There is a substantial tax incentive (1.8¢/kwh) for biomass energy written into Section 45 of the Federal Tax Code. However it applies only to biomass fuel grown as a crop and harvested for energy (closed loop biomass). Also, the power plant burning the fuel must be a new plant dedicated to biomass (not cofired).

The picture becomes a little brighter when one considers biomass cofiring as an option to kickstart the biomass energy industry. If the Section 45 Tax Credit were expanded to include waste biomass (open loop) in addition to energy crop biomass and also were expanded to include cofiring with coal, oil or gas, the process could quickly become a marketable technology with the added benefits of SO₂, NO_x and CO₂ offsets. It would then be possible to achieve the current goal of 7.5% non-hydro renewable generation by 2010.

Technologies to utilize biofuels are being developed. Many utilities are working to improve these technologies and will be successful in their endeavors, technologically. But if the nation intends to go forward and implement these technologies on a large scale, power generators will need to be induced either by a stick (renewable portfolio standards which will force the installation of renewables regardless of cost) or by a carrot (tax incentives which will put the biofuel costs on an equal competitive basis with natural gas, coal, and nuclear).

If the stick is used, some means will need to be found to help low income families cover the inevitable increase in costs associated with that standard. If a carrot is used, there should be no significant impact on the utility customer. Either of these methods

will begin building the required infrastructure for developing a viable renewable energy market.

Also, the uncertainty surrounding the global warming issue must be resolved in the near term. At the very least, some legislation must be developed by Congress not to penalize utilities that attempt to go forward with CO₂ mitigation plans only to be told later that they can't take credit for anything they did prior to some arbitrary date. And there is a legitimate concern expressed by many utilities that the Environmental Protection Agency (EPA) may declare that biomass cofiring systems will trigger the New Source Performance Standards (NSPS). If this should occur or if this possibility is not put to rest, it will be very difficult for utilities to embrace biomass-to-energy technologies. Cofiring biomass with coal generally results in lower stack emissions (SO₂, NO_x, CO₂ and particulate), it would appear contrary to the objectives of the EPA not to issue an exception from NSPS when cofiring with biomass. A specific exception may be necessary to remove this barrier to initiating a technology that has such a potential improve the environment.

Biomass energy will only increase at a rate equal to the tolerance of the public to cover the added costs of generation. Whether the user pays directly with higher prices or indirectly with industry tax incentives is a decision ultimately for the people and their elected representatives to determine. The utilities are not in a position to shoulder that burden. But utilities and power generators are in a position to provide the nation with a way to deploy these renewable technologies in the near term and to make early reductions in greenhouse gas emissions.

If biomass-to-energy is to grow, realistic subsidies must be set in place to encourage it. The current tax incentives are not sufficiently attractive to entice utilities into biomass energy and they are too limited in scope. In many instances, science and economics take a back seat to politics and popular opinion. However, power companies can benefit from popular opinion, if that opinion recognizes some realities of cost. In any case, if renewable power is to become successful in any meaningful way, the economic realities must be taken into account. Initially, cofiring of biomass wastes must be emphasized in order to develop the infrastructure necessary to allow stand alone units to come along at some later time. Building that infrastructure is vital to the future success of biomass-to-energy.

WHAT MUST BE DONE TO GET THERE?

A restructured electric power industry with open competition will only be able to use the lowest cost generation technologies to survive. Biomass energy will require Federally legislated competitive advantages to succeed. This is not corporate welfare. Most utilities are content using the lowest cost fuel for power. Incentives simply adjust the market place so that biomass can become one of those fuels. Tax incentives coupled

with the willingness for the public to pay higher prices for "green" power will result in increased installations of biomass cofiring and will interest the utilities who have already test fired biomass to reenter the market.

In addition to waste wood, many other opportunity fuels will be utilized such as animal manures, food wastes, agricultural crop wastes, treated sewage sludge, paper and other combustible wastes that can be safely injected into a utility boiler. As more experience is gained at more sites, gradual acceptance of the use of alternate fuels will occur and power plants will increase cofiring. This acceptance of alternate fuel use will spur the development of improvements and increases in waste collection and transport to utility sites. The buildup of a waste infrastructure will create additional markets for waste fuels and will pave the way for closed loop biomass in some locations starting with wood lot management material (weed trees). As costs of other methods of generating electric power increase, the competitive advantages of stand alone biomass generating stations may then be able to compete in the market place.

CONCLUSION

The main issue in kickstarting biomass for energy is not just technology improvements, it is cost. The current tax incentives are not sufficient to affect growing crops for energy. If the Section 45 tax incentives could be applied to open loop biomass or wood residues as has been recently recommended to Congress, however, there would be a dramatic increase in awareness and interest in the use of biomass for power generation.

Critical research in the area of biomass for energy is being done with the cooperation of industry and the DOE. Additional funds in this area are sorely needed. However, in order for biomass to energy to become commercial, there needs to be financial incentives to equalize the playing field. If that doesn't happen, biomass for energy will continue to be an distant goal, waiting for the price of coal, oil and gas to double or triple while transportation costs remain flat. That situation sets the technology back dramatically.

Without a competitive edge to spur commercial use of biomass for energy, there will be no units in service and therefore there will be no push to develop improvements to the technologies which would enable bioenergy to stand on its own. This story needs to be told, by industry and the Department of Energy. This story needs to be heard, by Congress and the public at large.

Unless there is a groundswell of sentiment for action, bioenergy technologies will continue to be tested and proven; but then just put on the shelf until energy prices rise to an appropriate level. The DOE and the power industry must continue research that will lower the price of bioenergy until it reaches the level where bioenergy becomes competitive with other fuels. And policy makers must take action to create competitive advantages for bioenergy so that bioenergy can take its place among the electric generation fuel mix, along with coal, oil, nuclear, and natural gas.

BIOMASS TECHNOLOGIES TO GET TO 10%

James T. Cobb, Jr., P.E., Associate Professor Emeritus
Department of Chemical and Petroleum Engineering, University of Pittsburgh
1130 Benedum Hall, Pittsburgh, PA 15261, (412)624-7443, cobb@engr.pitt.edu

PennFuture's *Getting to 10% Conference*, May 12, 2004, Harrisburg, PA

Three factors are necessary to open the way for sufficient renewable electricity from biomass to flow onto the grid to get Pennsylvania to 10%: (1) enabling legislation and regulation must be enacted to remove barriers and introduce incentives, (2) resources must be developed, such as clean waste wood and energy crops, and (3) technologies must be available to convert these resources to electricity for commercial installations. This paper will focus on the third of these factors in its relation to biomass. The paper will describe the current status of various technologies to convert biomass to electricity, pausing from time-to-time to relate them to the resources needed for their operation. Included will be brief descriptions of twelve related Energy Harvest projects, taken from the website of the Pennsylvania Department of Environmental Protection (PADEP):

<http://www.dep.state.pa.us/newsletter/default.asp?NewsletterArticleID=8256>.

The paper will then offer thoughts about how the businesses of Pennsylvania can obtain details of bioenergy technologies, monitor their status, and seek support for their further development and for commercial projects employing available systems.

Anaerobic Digestion of Animal Waste. This technology has been fully developed for many years, but until recently there have been few commercial installations on the farms of the Commonwealth. One of these is on the southern border of Pennsylvania. "Mason Dixon Farm straddles the Adams County, Pa., and Frederick County, Md., line. At Mason Dixon, methane gas from dairy manure is used to generate electricity. Mason Dixon Farms maintains a herd of 2,300 Holstein cows and 1,700 replacement heifers. From the collecting pits, liquid manure is pumped into the digester that has hot water pipes that use heat from engines generating electricity to maintain a temperature of 105°F to grow the methane-producing bacteria. The biogas is vacuumed off the top of the digester and put under 2 psig to feed the engines." (From the homepage of Cooper's, the John Deere dealer of northeast Maryland and northern Delaware.)

Two things should be noted about this technology. First, distributed (rather than centralized) electricity is generated by this technology. Public utilities face a distinct challenge to connect these many small sources to the grid. Second, a major environmental problem is solved by the utilization (destruction) of animal waste.

Ground will soon be broken for six anaerobic digester projects, funded by the Energy Harvest program.

Clinton County Conservation District. This is an Energy Harvest anaerobic digester project of the District in conjunction with Schrack Farms, a 200-year-old family dairy farm. The project will incorporate a 160 kW generator, producing 4.8 million kWh of electricity. Waste heat from the process will be used to support the digester and used to augment the dairy's hot water boiler.

Indiana County Conservation District. This is an Energy Harvest project of the District in conjunction with Brookside Dairy. The project will develop an anaerobic digester that is expected to produce approximately 770,000 kWh per year.

Lancaster County Conservation District. In this Energy Harvest project the District in conjunction with the Wanner's Pride-N-Joy Farm, a 400-head dairy farm, will develop an anaerobic digestion system that will be capable of producing about 967,000 kWh annually.

Lancaster County Conservation District. This Energy Harvest project by the District is being conducted with the 800-head Graywood Farms dairy. The project will install an anaerobic digestion system capable of producing 1,072 MWh/yr.

Somerset Conservation District. The District is initiating an Energy Harvest project in conjunction with Dovan Farms, a 400-head dairy, to construct an anaerobic digester. The digester would generate 700,000 kWh per year, using a 100 kW generator. Waste heat would be used to support the digester operation and for the farm's hot water boiler. The digested solids and liquids will be land applied on the 900-acre farm, including 400 acres of heavy clay soils on strip-mined land.

Multiple Counties, Pocono Northeast Resource Conservation and Development Council. The council will manage this project on behalf of three farms. The combined total of manure from these facilities is more than 7.4 million gallons annually. The council will install an anaerobic digester at each farm, which in addition to producing methane will also remove a total of about 128,000 pounds of phosphorous (P_2O_5) per year. The combined annual electrical output from this project is 919 MWh.

Hundreds of similar anaerobic digesters are in operation in wastewater treatment plants across the Commonwealth. They produce methane and some of them have electric generating engines. The Energy Harvest program includes a project in this area.

Multiple Counties, Acadia Water Technologies of Philadelphia. The agency is proposing initially to install a total of 1.1 MW of electric generating capacity by working with 10 to 15 wastewater treatment plants to run their methane gas through 55 kW Sterling Engines. Acadia plans to use these early projects as demonstrations ultimately to develop over 5 MW of capacity from treatment plants statewide.

Landfill Gas. A landfill, into which municipal solid waste containing much organic material has been placed, can also be considered as an enclosed anaerobic digester. All modern U.S. landfills are fitted with piping systems to collect the gas

mixture of methane and carbon dioxide that is produced by the decomposition of the organic material. The gas mixture can be combusted directly in an engine to produce distributed electricity or purified to pipeline-quality methane for transmission by natural gas pipeline. The following webpage of the U.S. Environmental Protection Agency lists 21 projects in Pennsylvania in which landfill gas is converted to a useful energy form:

<http://www.epa.gov/outreach/lmop/projects/projects.htm>

Two of these projects, for example, are operated by PECO, which has access rights from Waste Management Inc. to obtain gas from two landfills in Bucks County. PECO pipes the gas to USX's power plant in Fairless, Pennsylvania. The power plant there produces between 12 and 60 megawatts of electricity, and 150,000 pounds of steam hourly. One landfill gas project is being funded under the Energy Harvest Program.

Butler County, Seneca Landfill Inc. This Energy Harvest project at Seneca Landfill will utilize a portion of the landfill gas that is currently being flared to cogenerate electricity and hot water for the leachate treatment system.

Combustion of Agricultural, Forestry and Urban Waste. Many plants in Pennsylvania at all scales of operation combust these waste materials. Most produce heat only, but some produce electricity. A comprehensive survey of them needs to be made.

Over the past decade the U.S. Department of Energy (DOE) and the Electric Power Research Institute demonstrated the cofiring of waste wood and coal to numerous utility boilers, but to date there has been no commercial application of this technology in Pennsylvania (and few across the U.S. for that matter). An indication of the lack of interest in this method of producing electricity from biomass combustion in any form is the absence of any projects of this type from the Energy Harvest program.

Here are two examples of the combustion of waste wood for electricity production in the Commonwealth. The first is Viking Energy of Northumberland, operated by Tractebel Power, Inc., an 18 MW boiler plant built in 1989. According to Tractebel's website, the facility sells electricity to Pennsylvania Power and Light, and steam to Furman Foods. It is a central electricity generator, fueled with wood purchased from local suppliers and delivered to the plant by truck. It should be noted that the delivery of wood constitutes a major cost to the plant. Distributed generation avoids this cost.

The second example is the boiler plant of P. H. Glatfelter's Spring Grove (PA) Plant, an integrated pulp and paper mill. Its boilers use hog fuel and bark. One of its units is a 400,000 pph circulating fluidized bed boiler, designed by Sandwell. Electricity from that unit is produced by an extracting/condensing turbine-generator.

Conversion of Energy Crops. Switchgrass and hybrid willow are being developed as energy crops in the Commonwealth. Because of their ability to control erosion on sloped land formerly used for row crops and to create a barrier along stream

banks to nutrient runoff, these crops (especially switchgrass) are specified as cover on land in the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) of the federal government. Allowing the cover to be harvested in a manner that does not interfere with their use in the CRP and CREP provides an additional income to the farm community. One project in the Energy Harvest program focuses on developing switchgrass as an energy crop.

Westmoreland County, Monona LLC. This is an Energy Harvest project at Monona Farms of Ligonier to use switchgrass, harvested on the farm, as feedstock to co-produce electricity and heat. The energy will be produced using an innovative, small modular biomass gasifier (5 kW); the output will be used by the farm and residence.

Gasification of Biomass. This process involves the partial combustion of organic fuels to a mixture of carbon monoxide and hydrogen, a relatively clean combustion gas. The gas can then be fed to boilers to provide heat or to energy-efficient gas turbines to generate electricity. The Philadelphia Naval Business Center is developing a project whereby a biomass gasifier, manufactured by the Future Energy Resources Corp. (FERCO) of Norcross, GA, will produce fuel gas that will be sold to satisfy nearby thermal loads. When demand is sufficient, a combustion turbine can be installed to generate electricity. A wood gasifier was installed several years ago at the Joseph C. McNeil Generating Station in Burlington, VT. It converts up to 200 tons of wood per day into a gas that is used to co-fuel a wood-fired boiler to generate electricity. This project is thoroughly described in an article in *Mechanical Engineering* magazine:

<http://www.memagazine.org/backissues/dec01/features/preaching/preaching.html>

There are no Energy Harvest projects looking at wood gasification at this scale. It should be noted, however, that the Monona Farms project will use a small biomass gasifier.

Ethanol and Hydrogen Production from Starch, Cellulose and Other Biomass. Starch and cellulose can be hydrolyzed to sugar, then fermented to ethanol by the oldest chemical process known to man. By another route, biomass can be gasified to synthesis gas, and then anaerobic bacteria may be used to convert the synthesis gas into ethanol, as described on the U.S.DOE website:

<http://www.ott.doe.gov/biofuels/gasification.html>

Currently, ethanol is used as a transportation fuel, but in the future it (and the hydrogen from synthesis gas) may be used for electricity generation. Three Energy Harvest projects focus on this area.

Centre County, Pennsylvania Transportation Institute. This Energy Harvest project will demonstrate the operational reliability of a fleet of vehicles that will be fueled by hydrogen and hydrogen/natural gas provided by a hydrogen fueling station at Penn State University. This is an early step in the development of a hydrogen economy.

Chester County Industrial Development Authority. This Energy Harvest project will address the accumulation of more than 400 dry tons of spent mushroom compost per day in Chester County. Through Advanced Fluidized Composting, 95 percent to 100 percent of the spent mushroom compost will be converted into methane and ethanol.

Lehigh County, Solvent Green Inc. This Energy Harvest project will develop a facility that will use a novel technology incorporating pyrolysis and cryogenic air separation to convert several types of organic wastes into merchantable hydrogen, carbon dioxide and argon.

Monitoring Biomass Conversion Technologies. There are many extensive websites that can provide Pennsylvania businesses with information about processes to convert biomass to electricity. The U.S.DOE's Office of Energy Efficiency and Renewable Energy (EERE) maintains a webpage on "Bioenergy":

<http://www.eere.energy.gov/RE/bioenergy.html>

The U.S.DOE's National Renewable Energy Laboratory (NREL) maintains a webpage on "Learning about Renewable Energy and Energy Efficiency":

<http://www.nrel.gov/learning.html>

NREL also provides one on "Biomass Research":

<http://www.nrel.gov/biomass/>

Here in Pennsylvania, PADEP's Office of Energy and Technology Development maintains a website that provides much information on renewable energy, with the exception of bioenergy. It is anticipated that, with the impetus of the Energy Harvest projects in bioenergy and the need for biomass fuels to "get to 10%", this website will be augmented with information on bioenergy. The PADEP website is:

http://www.dep.state.pa.us/dep/deputate/pollprev/pollution_prevention.html

Finally, an important mission of the U.S.DOE's Northeast Regional Biomass Program (NRBP) is providing information on bioenergy in its region. Its website is:

<http://www.nrbp.org/>

Pennsylvania's representative to NRBP's steering committee, and coordinator of the Pennsylvania Biomass Working Group, is David Bingaman, Division Chief, Conservation & Agricultural Technology, Bureau of Plant Industry, Department of Agriculture, 2301 North Cameron Street, Harrisburg, PA 17110-9408, (717)772-5208

Supporting the Development of Biomass Conversion Technologies. The PADEP has determined that the development of wood gasification projects is an

important goal for the Commonwealth. To facilitate this it has published a “Decision Making Guide – Wood Gasification for Energy Generation,” prepared by the Fraunhofer USA Center for Energy and Environment in 2003. It is available on the PADEP website:

<http://www.dep.state.pa.us/dep/deputate/pollprev/Wood%20Gasification%20Decision%20Making%20Guide.pdf>

Fraunhofer prepared a case example of the use of the guide. It is entitled, “Gasification of Wood for Energy Generation in Clarion County” and is also available on the PADEP website:

<http://www.dep.state.pa.us/dep/deputate/pollprev/energy/Fraunhofer%20Gasification%20Report%20Final.pdf>

Finally, the Sustainable Energy Funds – GPU Sustainable Energy Fund, SEF of Central Pennsylvania (PPL Service Area), Sustainable Development Fund (PECO Service Area) and West Penn Power SEF, Inc. – were established by the four utilities during deregulation. Pennsylvania businesses can apply to the SEFs for funds to undertake bioenergy projects. Information about these funds is on the website:

<http://www.paenergy.state.pa.us/sef.htm>