PENNSTATE

Feasibility Analysis for Installing a Circulating Fluidized Bed Boiler for Cofiring Multiple Biofuels and Other Wastes with Coal at Penn State University

Final Report

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Joseph J. Battista
Cofiring Alternatives

March 26, 2003

Work Performed Under Grant No. DE-FG26-00NT40809

For
U.S. Department of Energy
National Energy Technology Laboratory
P.O. Box 10940
Pittsburgh, Pennsylvania 15236

By
The Energy Institute
The Pennsylvania State University
C211 Coal Utilization Laboratory
University Park, Pennsylvania 16802

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DISCLAIMER

EXECUTIVE SUMMARY

The Pennsylvania State University, utilizing funds furnished by the U.S. Department of Energy's Biomass Power Program, investigated the installation of a state-of-the-art circulating fluidized bed boiler at Penn State's University Park campus for cofiring multiple biofuels and other wastes with coal, and developing a test program to evaluate cofiring biofuels and coal-based feedstocks. The study was performed using a team that included personnel from Penn State's Energy Institute, Office of Physical Plant, and College of Agricultural Sciences; Foster Wheeler Energy Services, Inc.; Foster Wheeler Energy Corporation; Parsons Energy and Chemicals Group, Inc.; and Cofiring Alternatives.

The activities included assessing potential feedstocks at the University Park campus and surrounding region with an emphasis on biomass materials, collecting and analyzing potential feedstocks, assessing agglomeration, deposition, and corrosion tendencies, identifying the optimum location for the boiler system through an internal site selection process, performing a three CFB boiler design and a 15-year boiler plant transition plan, determining the costs associated with installing the boiler system, developing a preliminary test program, determining the associated costs for the test program, and exploring potential emissions credits when using the biomass CFB boiler.

The feedstock assessment identified the wastes and by-product streams at Penn State along with wood wastes from sawmills and secondary wood processors in the surrounding region. Approximately twenty different biomass, animal waste, and other wastes were identified, collected, and analyzed. These potential feedstocks included the following: animal wastes such as dairy tie-stall and free-stall manure (mixed with leaves and brush to make it stackable), beef manure, horse manure, poultry litter, sheep manure, and swine waste; wood waste and brush; pallets; Reed Canary grass grown on Penn State's wastewater treatment facility's effluent spray field; bottom and fly ash from Penn State's stoker boilers; agricultural plastics including horticulture hard plastics and plastic bags, bale tarps, and silo bunker covers; used oil; tires; wood shavings and chips from the surrounding region; coal/paper pulp pellets from a nearby paper mill; and sewage sludge. Sufficient biomass materials were identified to provide ≈20% of the fuel feed (on a thermal basis) to a CFB boiler without adversely affecting the wood wastes collected from the region (*i.e.*, there will be a low impact on the quantity of wood wastes available for other uses).

A comprehensive evaluation of the effect of the inorganic elements in the fuel feedstocks on agglomeration, deposition, and corrosion was performed. This included bulk analysis, chemical fractionation to identify the solubility of the various inorganic constituents, and thermochemical modeling. The results indicated that a cofire blend of

biofuels with an appropriate nonfouling coal should not pose any problems in the CFB system given that the coal makes up a majority of the thermal input. Corrosion, agglomeration, and deposition were shown not to be a problem.

The main OPP office that participated in this study was Engineering Services. However, the study was performed while working closely with OPP's Director of Campus Planning and Design who was responsible for the internal site selection process used to identify the optimum site for the boiler system. This was done employing a formal procedure that is used for siting any new construction project at Penn State. In addition, the University's master plan (a 20-year forecast/plan) was used to ensure that the site and production capacity of the boiler plant met with the University's long-range plans. Through this process, it was determined that three boilers were needed and the 15-year boiler plant transition plan was developed. It was decided to incorporate three CFB boilers into the transition plan.

The three CFB boiler system, based on the boiler plant transition plan, was designed and costed by Foster Wheeler with assistance from Parsons. The design was based on the installation of a CFB boiler every five years with the first boiler capable of cofiring coal and biomass. Foster Wheeler's Compact atmospheric CFB boiler was used in the plant design. OPP used Foster Wheeler's CFB boiler system costs when determining the overall costs that would be incurred to implement the boiler plant transition plan.

A multiyear test program was also developed as part of the study. This preliminary program included fundamental, pilot-scale, and demonstration-scale testing. The first boiler has been designed to accommodate special materials for erosion and/or corrosion testing including test coupons, slagging and fouling probes, and heat flux meters. The system has been designed to accommodate the addition of an emissions reduction system (*e.g.*, ceramic or metallic filters, advanced SCR systems, and ESPs) prior to the baghouse. There are two stub duct sections designed into the existing unit's outlet ducting (upstream of the baghouse) that will allow for either full or slip-stream testing without affecting the integrity of the CFB boiler to maintain full load capabilities.

A preliminary investigation into emissions credits and other benefits to the University was conducted. Reductions in NO_x, SO_2, and CO_2 will be realized through the installation of the CFBs and phasing out of the stoker units. For example, when the first CFB boiler is brought on line, there will be reductions of 97, 1,700, and 49,820 tons of NO_x, SO_2, and CO_2 each year, respectively.

NO_x emissions will decrease from 310 tons/year to 213 tons/year when the first CFB is brought on line and the equivalent of two stoker boilers are removed from service. Since New Source Review will not be triggered, this reduction of 97 tons translates into

\$776,000 of NO_x credits (using a conservative value of \$8,000/ton of NO_x). Similarly, when the second CFB is brought on line, the equivalent of two stoker boilers will be removed from service and there will be an additional 95 tons of NO_x net decrease. Using the same credit of \$8,000/ton of NO_x removed, which is likely to be very conservative for actions tens years in the future, translates into a credit of \$760,000.

Credits for SO_2 will also be allowable although the value of SO_2 credits is much lower than NO_x credits. SO_2 emissions will be reduced by ≈1,700 tons/year with a potential credit of ≈\$234,970/year (based on a December 2002 allowance price of \$138.22/ton). As regulations for reducing SO_2 emissions continue to be implemented (*e.g.*, consequence of Clear Skies Initiative or future fine particulate matter regulation), it is likely that SO_2 allowances will increase over today's prices.

Emission credits for CO_2 and possibly mercury are unknowns at this time. However, it is very likely that they too will have economic value in the not too distant future. For example, mercury removal has been valued at \$1,000/ton removed (and may even be higher). It has been documented that mercury emissions from CFBs are extremely low with the mercury being tied up in a stable form in the ash (ARIPPA 2002). CO_2 banks have been set up in Europe and one will begin operation in Chicago (*i.e.*, Chicago Climate Exchange) in March 2003 (AEP 2003). Estimates of CO_2 credits vary (from \$1 to \$800/ton) but if a value of \$6/ton (current price in Europe) is used, a credit of \$298,920 can be realized from the CFB cofiring 20% biomass.

In addition, Penn State recently performed stack testing on the coal-fired stokers and measured HCl emissions of 120 tons/year. Beginning April 2004, facilities emitting >10 tons HCl/year will be required to install control technology for reducing HCl emissions (*i.e.*, Maximum Allowable Control Technology). This will not be a concern with a circulating fluidized bed boiler however, as they have been shown to retain >99% of acid gases such as HCl.

The boiler plant transition plan is currently under internal review. A decision on whether or not to proceed with it, or a modified version of it, will be made at a later date.

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1.0 INTRODUCTION/BACKGROUND

The Pennsylvania State University, under contract to the U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), performed a feasibility analysis on installing a state-of-the-art circulating fluidized bed (CFB) boiler at Penn State's University Park campus for cofiring multiple biofuels and other wastes with coal, and developing a test program to evaluate cofiring biofuels and coal-based feedstocks. Penn State currently operates an aging stoker-fired steam plant at its University Park campus and has spent considerable resources over the last ten to fifteen years investigating boiler replacements and performing life extension studies. This effort, in combination with a variety of agricultural and other wastes generated at the agricultural-based university and the surrounding rural community and the University's need to explore options for replacing the existing boiler plant within fifteen years, led Penn State to assemble a team of fluidized bed and cofiring experts to assess the feasibility of installing a CFB boiler for cofiring biomass and other wastes along with coal-based fuels.

The objective of the project was accomplished using a team that included personnel from Penn State's Energy Institute, Office of Physical Plant, and College of Agricultural Sciences; Foster Wheeler Energy Services, Inc.; Foster Wheeler Energy Corporation; Parsons Energy and Chemicals Group, Inc.; and Cofiring Alternatives.

The CFB boiler system that was used in the study is unique in that it:

- is of compact versus traditional design;
- includes modules to evaluate filters (ceramic and metallic), along with fabric filters, for particulate matter control (work at Penn State has shown that ceramic filters have potential advantages regarding fine particulate matter and trace elements, *i.e.*, mercury removal (Miller *et al.*, 1999));
- contains an advanced instrumentation package including temperature and pressure sensors, deposition and slagging probes, heat flux meters, and corrosion/erosion panels;
- contains multifuel capabilities (making it a versatile test site for industry and government studies); and
- is a commercial facility in a rural, agricultural setting that contains an engineering and agricultural-based university.

The state-of-the-art CFB boiler will allow the University to do the following:

- more economically supply heat to the University Park Campus;
- reduce the amount of airborne pollutants (*i.e.*, NO_x, SO_2, particulate matter, and potentially trace elements), thus helping to reduce the overall emissions from the University's central heating plant;
- reduce the amount of agricultural and other waste products produced by the University that must be landfilled or land applied;
- reduce the amount of CO_2 (a greenhouse gas) emissions (by combusting waste biofuels); and

- ultimately serve as a large-scale (commercial demonstration size) test facility for federally- and other outside source-funded research and development projects related to cofiring of biofuels with coal and other coal refuse.

The study (contained herein) assessed: quantity and quality of potential biofuels and other feedstocks, preliminary design and cost of a potential boiler system, the impact of the biofuels on CFB operation; and preliminary economic benefits (*i.e.*, credits) for lower emissions. The study also included developing a multiple-year program to test biofuels as the boiler system will be unique in that it will be heavily instrumented and will be able to handle multiple fuels.

1.1 Penn State's Steam Plants

Penn State University, Office of Physical Plant (OPP) currently operates a coal-fired central steam plant at the University Park Campus. The installed coal-fired capacity is 350,000 lb/h (pph) steam generated by four vibra-grate stoker boilers at 250 psig/540°F, which are used as baseload units. Additional steam generating capacity is available with gas or oil fire in three other boilers, totaling 230,000 pph. Electricity is also produced, as a by-product, with a maximum installed generating capacity of 6,000 kW. Currently at peak operation, which occurs when classes are in session and winter conditions experienced, 420,000 pph of steam are required. Steam requirements during the summer are 125,000 pph while approximately 200,000 pph of steam is required during the spring/fall.

Although the present firm steam generating capacity is 530,000 pph, the University prefers not to operate the gas- and oil-fired boilers because the price of the natural gas and fuel oil is significantly higher than that of the coal. Ideally, the University would like to fire only coal and have sufficient coal firing capability to allow for one coal-fired boiler to be down without impacting steam production or forcing the operation of a gas/oil-fired boiler.

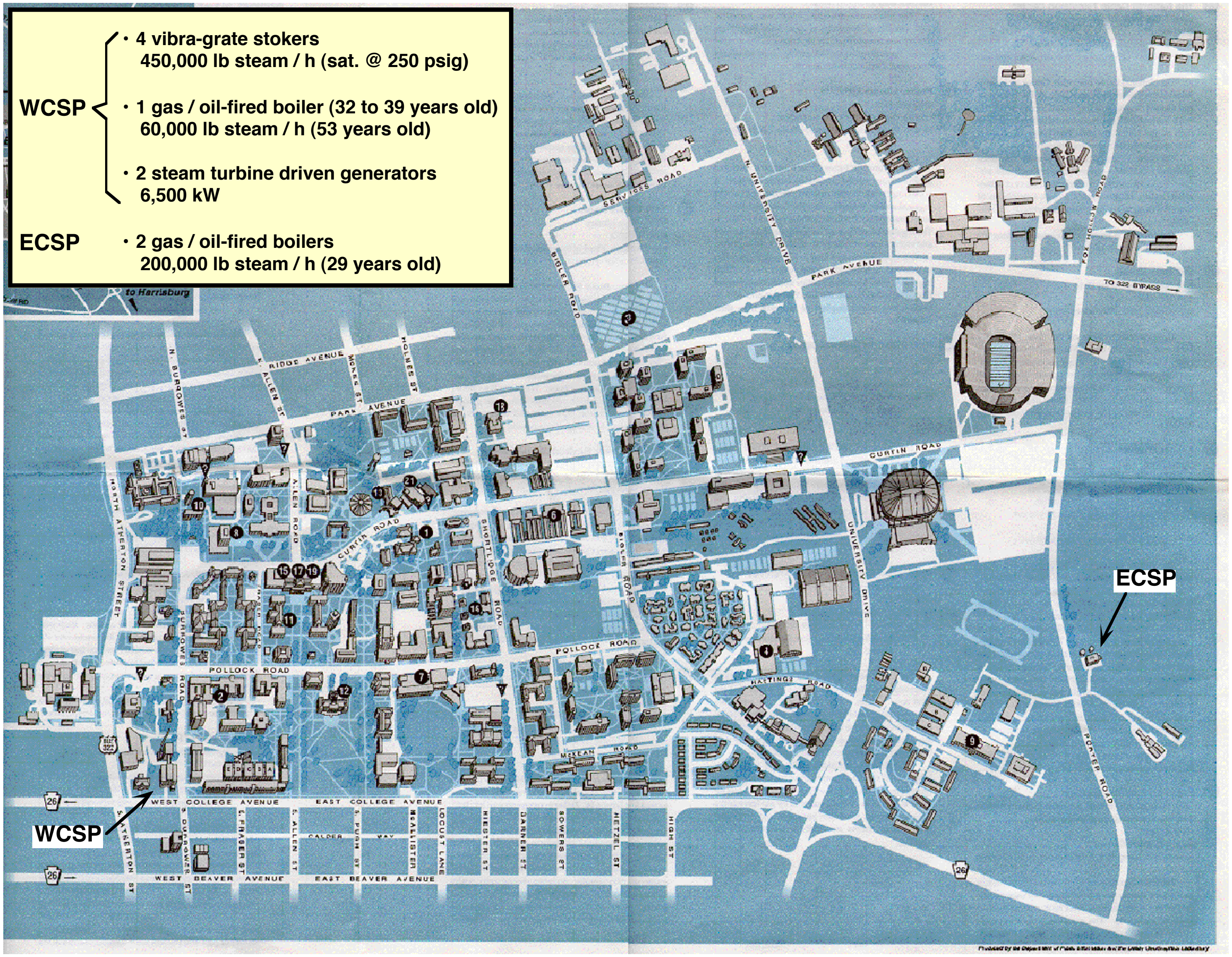
The four stoker-fired boilers at Penn State are all between 35 and 42 years old. When the units were installed (1961 to 1968), the projected life of a typical unit was expected to be approximately 40 years. Since that time, the life of the steam generating units has been reevaluated based on changing technology, economic, and regulatory factors. Life extension studies on many plants have now indicated that economic lives up to 50 to 60 years may be possible depending on the levels of maintenance, type of operation of the units, the cost of competing units, and other parameters related to these factors. In 1997, OPP performed a condition assessment of the existing boilers and the results concluded that the boilers have a useful life of at least 20 years (*i.e.*, to 2017). Consequently, the University has developed a transition plan to install three CFB boilers over 15 years to replace the existing stoker-fired units. The University is exploring the possibility of making one of the CFB boilers biofuel capable to cofire biomass and other waste streams with coal because of the following benefits:

- Waste stream utilization. The CFB boiler would be multifuel capable with coal being the primary fuel and supplemented with waste streams. Waste stream disposal costs would be eliminated. For example, sewage sludge is currently landfilled at a cost of $38.25/ton.
- Lower overall fuel costs. This includes using a lower grade coal including bituminous coal refuse (*i.e.*, gob), growing grasses or crops on University land and cofiring in the boiler, accepting biomass and other wastes from the municipality, and being a test site for industry (*e.g.*, Foster Wheeler) to conduct various fuel tests where the test fuel would be used in place of fuels purchased by the University.
- Higher efficiency boilers.
- Lower boiler emissions.
- Possible alternative to spreading manure on fields and the associated odor problem.
- Potential external funding source for a boiler replacement project. A recent energy assessment for Penn State showed that a coal-fired cogeneration plant was not economically feasible. However, OPP is reconsidering a boiler replacement because there is the possibility that some of the funding may come from other sources, *e.g.*, industrial sponsorship, or state and federal agencies.
- Research component. By being a test site for industry (*e.g.*, Foster Wheeler), not only would there be a decrease in fuel costs but there is the possibility that other operating costs such as labor could be reduced when industry-funded testing occurs.

Penn State's seven boilers are housed at two locations on campus as shown in Figure 1-1. The four coal-fired boilers and one small natural gas and oil-fired boiler are located at the West Campus Steam Plant (WCSP). There is not any room for installing additional boilers at this location. Two 100,000 pph of steam boilers, designed for natural gas and No. 2 fuel oil, are located at the East Campus Steam Plant (ECSP). This facility is used for peaking purposes. This location has been identified for future boiler expansion. OPP is interested in installing three CFB boilers each with 200,000 pph of steam capacity at the ECSP. This will be discussed in more detail in Section 4.0.

1.2 Project Outline

The project consisted of gathering design-related information, collecting and analyzing representative biofuels and coal samples, developing a conceptual CFB boiler system design, developing a preliminary multiyear test program and associated budget, determining the system design/test program economics, and summarizing the



WCSP
- 4 vibra-grate stokers
  450,000 lb steam / h (sat. @ 250 psig)
- 1 gas / oil-fired boiler (32 to 39 years old)
  60,000 lb steam / h (53 years old)
- 2 steam turbine driven generators
  6,500 kW

ECSP
- 2 gas / oil-fired boilers
  200,000 lb steam / h (29 years old)

Figure 1-1. PENN STATE'S WEST CAMPUS AND EAST CAMPUS STEAM PLANTS results of the feasibility study. The work was conducted via the following tasks:

- Task 1. Information and Sample Collection
- Task 2. Biofuels and Biofuel/Coal Characterization
- Task 3. Develop Conceptual Design
- Task 4. Develop Preliminary Test Program/Budget
- Task 5. Determine System/Program Economics
- Task 6. Complete Feasibility Study
- Task 7. Project Management/Reporting

A summary of the activities performed in each task includes:

Task 1. *Information and Sample Collection*: System requirements and infrastructure information were assembled by Penn State and provided to Foster Wheeler. In addition, representative samples of biofuel and coal were collected by Penn State. Cofiring Alternatives performed an assessment of sawmills and secondary wood processors with wood wastes available for marketing.

Task 2. *Characterize Biofuels and Biofuel/Coal Combinations*: Penn State characterized the samples collected in Task 1and performed agglomeration/deposition assessments and Foster Wheeler used the analyses to perform in-house evaluations on issues such as materials handling, deposition, and emissions.

Task 3. *Develop Conceptual Design*: A CFB boiler system was designed to address the multiple project objectives. Foster Wheeler performed the conceptual design with assistance from Parsons Energy and Chemicals Group, Inc. and input from Penn State.

Task 4. *Develop Preliminary Test Program/Budget*: A multiyear test program was designed and costed to use the CFB boiler system for investigating a range of issues when cofiring multiple biofuels and possibly other waste materials. Penn State developed the preliminary test program with consultation from Foster Wheeler.

Task 5. *Determine System/Program Economics*: Capital and operating costs were determined. In addition, Penn State determined other costs including but not limited to items such as steam line upgrades, electric transformer construction, cost escalation, and utility connections.

Task 6. *Complete Feasibility Study*: The study was completed by incorporating the results from each of the tasks.

Task 7. *Project Management/Reporting*: The project was managed and reported per DOE’s contractual requirements. Reporting included the quarterly program/project management and technical progress reports, and a final report.

2.0 INFORMATION AND SAMPLE COLLECTION

As part of this task, an assessment of the types and quantities of potential feedstocks was performed. A wood products resource assessment was performed by Cofiring Alternatives. In addition, representative samples of biofuel and coal were collected by Penn State. System requirements and infrastructure information were also assembled by Penn State and provided to Foster Wheeler.

2.1 Feedstock Assessment

The feedstock assessment consisted of identifying the waste and by-product streams at the University Park campus and determining the quantities available for the project. In addition, an assessment of sawmills and secondary wood processors with wood wastes available for marketing as well as other potential biomass feedstocks for the CFB was performed. Table 2-1 contains a summary of the assessment.

2.1.1 Wood Products Resource Assessment

The wood products resource assessment was started by identifying the counties that are within 75 miles of Centre County (county where Penn State's University Park campus is located). Next, companies that produce wood products/wastes that are located in these counties were identified (NREL report; Foster Wheeler 1998; The Pennsylvania Wood Residue Directory 1993). Approximately 325 companies were identified (Miller *et al.*, 2000b).

The distance from University Park to the companies was then determined. Although all the original counties selected are within 75 miles of Centre County, many of the companies are farther than 75 miles from University Park. Therefore, all companies greater than 75 miles were removed from the list and the number of companies was reduced to 107. These companies were then called to gather more information.

The results from the telephone calls are listed in the appendices. Appendix A is a list of potential suppliers by distance. The list contains only those parties where contact was made (not all parties returned calls or answered their telephones) and showed interest and/or are currently in business. The list contains 158 companies instead of 107 as originally identified as additional contacts were provided verbally during the telephone contacts.

Appendices B through E contain the results from the final assessment. They include up-to-date listings of potential suppliers (31 companies) for the project that are within 45 miles (except for one company at 47 miles and another at 57 miles). The results are summarized in two tables, listed by alphabet and increasing distance from Penn State (Appendices B and C, respectively).

Table 2-1. Potential CFB Feedstocks

Material	**Quantity (tons/yr)**
Biomass at University Park	
Animal Wastes:	
Dairy manure (tie stall and free stall mixed with leaves)	13,200
Manure from covered manure barn (poultry litter, horse barn, misc.)	1,180
Beef manure	1,033
Sheep manure	265
Swine waste (@ 2.2% solids)	2,505
Wood waste/brush	150
Pallets	92
Reed Canary grass	600
Other Wastes at University Park	
Sewage sludge (@ 2.2% solids)	2,708
Bottom ash	6,990
Fly ash	1,445
Agricultural Plastics - total	2.1
Horticulture hard plastics	0.2
Horticulture plastic bags	1
Bale tarps	0.5
Silo bunker covers	0.4
Used oil	14
Tires	5
Biomass from Surrounding Region (within 45 miles of University Park)	
Wood products (chips/shavings)	>90,000

A summary sheet was prepared for each of the 31 companies from information received during the telephone calls. The summary sheets, provided in Appendices D and E, include the following information:

- Company name;
- Phone number;
- Town nearest company location;
- Contact person;
- Directions from University Park to company location;
- Quantity of sawdust or wood chips available;
- Transportation cost;
- What is done with the sawdust or wood chips; and
- Other notes.

The results from this survey show that there are ≈1,770 tons/week of sawdust and wood chips available. Of this total, ≈475 tons/week (≈27% of total in the region) are being used in the preliminary design.

2.1.2 Other Potential CFB Feedstocks

In addition to the lists of sawmills and secondary wood processors with wood wastes, other biomass residues were assessed for use in the CFB. Appendix F contains a variety of companies and industries identified from the yellow pages, which includes those found in the following categories:

- Bakeries;
- Boxes – corrugated, fiber, and wooden;
- Building materials;
- Cabinet makers;
- Candy – wholesale;
- Feed – wholesale and manufacturers;
- Food, brokers, consultants, products;
- Furniture designers and custom builders;
- Home improvements (possible source of construction/ demolition wood);
- Logging companies;
- Lumber – retail;
- Lumber – wholesale;
- Newspapers (waste newsprint);
- Nursuries – plants, trees, etc. (possible source of wood from prunings, dead stock, *etc.*);
- Potato chips – wholesale;
- Recycling centers;
- Rubbish and garbage removal;
- Septic tanks – cleaning and repairing (possible source of biowastes);
- Sewage disposal systems (possible source of biowastes);
- Stables (possible source of manure and bedding);
- Tire dealers (possible source of waste tires);
- Tire retreading and repairing (possible source of waste tires);
- Tree services;
- Waste reduction, disposal and recycling service – industrial; and
- Windows (possible source of waste wood).

These companies were not contacted for additional information because of liability concerns regarding accepting wastes from the community.

Penn State also had discussions with CQ Inc. about supplying a fuel to the boiler. CQ Inc. was producing pellets (70% coal/ 28% waste paper sludge/ 2% plastics) at Westvaco’s paper mill in Tyrone, Pennsylvania. The pelletizing plant is ≈30 miles from University Park and its capacity could be increased in order to provide Penn State with pellets. However, Westvaco shut down the paper mill in 2001 and the pellets were removed from the list of potential feedstocks. CQ Inc. expressed interest in installing a pelletizing plant at Penn State but Penn State has decided not to pursue that option at this time.

Penn State identified the types and quantities of potential feedstocks at the University Park campus. The results from this assessment are contained in Table 2-1. Representative samples of the materials listed in Table 2-1 were obtained for analysis, with the exception of used oil, pallets, and tires. This is discussed in detail in Section 3.0.

2.2 System Requirements/Infrastructure Information

Penn State provided Foster Wheeler with the necessary information in order to perform the conceptual CFB boiler designs. The information included, but was not limited to:

- the types and quantities of biofuels and other combustible wastes generated at Penn State (see Table 2-1);
- the types and quantities of biofuels and combustible wastes generated in the surrounding region that can be transported to Penn State economically (see Table 2-1);
- the coal and limestone analysis (see Section 3.0);
- infrastructural considerations such as steam and electricity needs, current condition of boilers, steam lines, condensate lines, and feedwater capacity;
- termination points for steam, water, condensate return, and electrical lines; and
- information on permitting, regional codes, and facility siting restrictions.

Information on the types, quantities, and quality of the biofuels are provided in Sections 2.1 and 3.0. The coal and limestone analyses are given in Section 3.0. All other gathered information was used in the conceptual design, which is discussed in detail in Section 4.0. The information that was provided to Foster Wheeler allowed Foster Wheeler and Parsons to perform the scope of work listed in Appendix G and summarized below:

- General arrangement;
- Steam generator;
- Boiler appurtenances and valves;
- Sootblower system;
- Air heaters;
- Major fans;
- Flues, ducts, hoppers, and stacks;
- Particulate removal;
- Burner systems;
- Coal and biofuel feed systems;
- Limestone feed system;
- Solids recycle system;
- Spent bed material system;
- Fly ash handling system;
- Bed ash hydration/reinjection;
- Piping systems;
- Instrumentation and controls;
- Structural;
- Electrical;
- Boiler miscellaneous;
- Plant miscellaneous;

- Shipping and receiving;
- Site requirements during construction;
- Erection;
- Commissioning; and
- Start-up and testing.

Ultimately, a power plant consisting of three boilers was designed (see Section 4.0 for details) but only the first boiler to be installed was designed to cofire biofuels with coal. The cofire boiler, which is designed to produce 200,000 lb saturated steam (@ 250 psig)/h and is discussed in detail in Section 4.0, will have a thermal firing rate of 200 million (MM) Btu/h. The preliminary breakdown of the fuels for the boiler is illustrated in Table 2-2. The firing rate information was developed assuming that all the animal wastes, sewage sludge, and Reed Canary grass produced by the University will be utilized in the boiler. In addition, ≈27% of the total wood wastes from the region (*i.e.*, ≈475 tons/week will be used in the boiler out of ≈1,770 tons/week total produced) is being used in the preliminary design. The ratio of the biomass/wastes-to-total fuel is 0.21 based on thermal input and 0.47 based on quantity of fuel fired.

Table 2- 2. Design Firing Rate Information (based on a total firing rate of 200 million Btu/h)

Feedstock	**Firing Rate (lb/h, as received)**	**Thermal Input (Btu/h)**
Coal	13,190	158,284,634
Sewage Sludge	780	475,700
Swine Waste	715	116,777
Dairy Manure	3,800	10,600,000
Beef Manure	295	944,000
Sheep Manure	76	290,400
Covered Barn Manure	336	507,800
Reed Canary Grass	171	369,189
Plastics	0.6	11,500
Wood Chips/ Shavings	5,700	28,400,000
Total	**25,063.6**	**200,000,000**

3.0 BIOFUELS AND BIOFUEL/COAL CHARACTERIZATION

The potential feedstocks that were collected were analyzed to assist in designing the boiler system, specifically items such as material handling to assess slagging and fouling issues, and assess their impacts on pollution control systems. Predictive techniques were used in lieu of pilot-scale testing which was too expensive for the proposed study. In addition, thermodynamic modeling was performed to assess the agglomeration potential of the fuel blends.

3.1 Fuel Analysis

Analysis of the potential fuels consisted of:

1) Proximate analysis;
2) Ultimate analysis;
3) Higher heating value;
4) Bulk density (where appropriate);
5) Chlorine content (where appropriate);
6) Bulk analysis of the ash; and
7) Rhelogical characteristics (where appropriate).

The analysis and photographs of the various biofuel feedstocks that were collected are provided in Appendix H. In addition, candidate coal and limestone analyses were provided by Bradford Coal Company and Meckley Limestone Products, respectively, for use in the design. Appendix I contains these analyses.

Chemical fractionation analysis was performed on ten of the feedstock streams to assess the potential for bed agglomeration. The following samples were analyzed to determine the mode of occurrence of major and minor elements:

1) Pine shavings;
2) Dairy tie-stall manure;
3) Dairy free-stall manure;
4) Miscellaneous manure (mixture of various small-quantity manure streams that are collected at a central storage barn);
5) Sewage sludge;
6) Sheep manure;
7) Poultry litter;
8) Reed Canary grass;
9) Bottom ash; and
10) Fly ash.

3.1.1 Chemical Fractionation Procedure

The chemical fractionation procedure is based on an element's varying solubility as a result of its occurrence in a fuel. A procedure used to fractionate low-rank coals at the University of North Dakota Energy and Environmental Research Center (Benson and Holm, 1985) and later modified by Baxter (Baxter 1994) was further modified to better address handling issues particular to biomass fuels. A detailed description of the chemical fractionation procedure is given in Appendix J. A schematic representation of the method is shown in Figure 3-1.

Each step results in a liquid and solid residue sample, which are both analyzed for the following major and minor elements, *i.e.,* Al, Ba, Ca, Fe, K, Mn, Mg, Na, P, Si, Sr, S and Ti, using inductively coupled argon plasma spectroscopy (ICP). Analysis of both the liquid and solid residue was conducted so that a material balance could be performed.

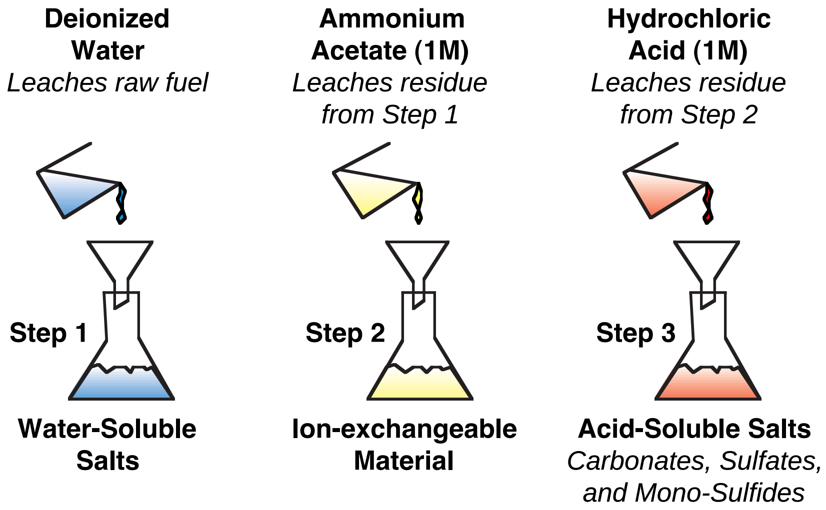


Figure 3-1. **SCHEMATIC REPRESENTATION OF THE CHEMICAL FRACTIONATION METHOD**

In the first step of leaching, water was used to remove elements that are in a water-soluble form. This consists primarily of water-soluble salts, *e.g.,* alkali sulfates, carbonates, and chlorides. The remainder of the residue from Step 1 was subjected to a second leaching step using ammonium acetate to remove elements that are bound loosely to organic matter, *e.g.,* ion-exchangeable elements such as potassium, calcium, sulfur, and sodium. Again, the leachate and a portion of the residue from this step were analyzed for major and minor elements.

The final leaching step used hydrochloric acid to remove element-bearing minerals that exist as acid-soluble salts such as carbonates, sulfates, mono-sulfide minerals, and simple oxides. Again, the leachate and a portion of the residue from this step were analyzed by ICP. The insoluble portion of the fuel is generally made up of silicates and other acid insoluble mineral phases.

Certain biomass fuels are inherently difficult to work with given the chemical fractionation procedure. It is often difficult to obtain a representative sample given the heterogeneous nature of the fuels. As an example, the manure samples consist of a mixture of manure, straw and sand taken from the floor of the two dairy barns, and chicken litter is a combination of the chicken manure and the wood shavings that are used as a bed material in the chicken barns. This heterogeneity was noted as a major problem in a round robin study conducted by von Puttkamer *et al.* (2000). It is also extremely difficult to grind such heterogeneous samples given the different grindability of straw, sand, and dried manure. It is also difficult to work with samples that contain material that have inherently different wetabilities and densities, *e.g.,* sand versus straw. Often only the liquid portion of the sample is analyzed due to time and cost considerations. This is not always appropriate as it was observed that material balances for individual elements between the sum of the solid and liquid samples and the original parent was not as good as generally obtained in coal samples. Zevenhoven-Onderwater *et al.* (2000) have also reported such difficulties in obtaining good material balances between analysis of solid and liquid samples. In short, biomass fuels required special consideration when applying the chemical fractionation procedure. Therefore modifications to the preparation, *e.g.,* cutting and grinding the sample, and filtering steps, *e.g.,* addition of a centrifuge step, were made to accommodate the physical characteristics of the biofuels. A detailed description and schematic of the chemical fractionation procedure is given in Appendix J.

3.1.2 Chemical Fractionation Results

Ten potential feedstock materials were chemically fractionated. The ash analysis for each feedstock is given in Table 3-1. The ash analysis of a potential cofire coal used for thermodynamic modeling of the inorganic chemistry (reported in section 3.2) is also given. The weight percent removed as a function of its occurrence, *i.e.*, water soluble, ion-exchangeable, acid soluble, or insoluble, is given in Table 3-2. Chemical fractionation analysis for Red Oak shavings (listed in Appendix H) is not given. The weight percent of ash of each fraction for Red Oak shavings was so low that poor closure was obtained with the ICP data. As a result, the material balance was extremely poor. For purpose of discussion, the water soluble and ion-exchangeable portions are combined as they are both indicative of species that are highly reactive during combustion, *i.e.,* organically-bound or water soluble mineral phases such as carbonates. These elements often react during combustion with the more inert elements, *e.g.*, aluminum and silicon, to form inorganic phases that have lower melting points. The combined water soluble and ion-exchangeable portions are referred to as water soluble/ion-exchangeable. Acid soluble elements are

Table 3-1. Ash Analysis of Potential Feedstocks

	Cofire Coal	WWTP Sludge	Sheep Manure	Poultry Litter	Dairy Tie-Stall Manure	Dairy Free-Stall Manure	Misc. Manure	Fly Ash	Bottom Ash	Pine Shavings	Reed Canary Grass	Red Oak Shavings
Oxide (wt. %)												
Al_2O_3	25.34	6.21	3.08	9.14	2.26	0.96	1.34	32.8	30.8	13.4	1.66	3.04
BaO	–	0.05	0.05	0.05	0.02	0.02	0.01	0.24	0.18	0.15	0.05	0.24
CaO	2.28	37.7	12.8	12.7	23.3	6.38	3.44	2.36	1.48	8.75	9.57	45.70
Fe_2O_3	18.34	4.39	1.95	4.04	1.37	1.29	0.93	10.8	10.4	5.94	1.47	4.69
K_2O	2.22	1.20	23.4	9.94	10.7	6.75	1.77	1.82	1.62	4.94	18.1	6.10
MgO	0.82	3.67	5.74	4.01	8.91	2.65	1.06	1.55	0.55	3.35	5.29	4.92
MnO	–	0.07	0.17	0.36	0.14	0.17	0.03	0.01	0.02	0.49	0.11	3.49
Na_2O	0.25	0.40	4.64	3.60	7.04	1.32	0.88	0.44	.032	1.38	2.34	1.39
P_2O_5	0.4	2.30	9.21	14.0	14.7	2.90	2.54	2.14	0.34	1.44	13.8	2.80
SiO_2	48.2	35.6	29.3	39.4	26.0	74.98	84.8	46.8	53.0	57.2	43.0	18.70
SO_3	0.67	2.43	5.52	2.58	0.14	0.04	0.01	0.14	0.09	0.05	0.02	0.10
SrO	–	0.12	0.03	0.03	0.11	0.10	0.14	0.28	0.20	0.80	0.11	0.26
TiO_2	–	0.59	0.20	0.51	5.08	2.06	1.20	1.22	1.57	1.16	4.99	0.00
Ash (wt. % db)	14.70	53.0	20.9	17.	62.5	62.3	73.5	72.6	72.	0.10	4.1	1.60

Table 3-2. Elemental Weight Percent Removed as a Function of Treatment during Chemical Fractionation

Weight % Water and Ion-exchangeable

Sample	K	Na	Ca	Mg	Al	Si	S	Fe	P	Mn	Sr	Ti
WWTP Sludge	24.1	55.6	31.2	33.3	0	0	51.8	20.7	21.9	33.3	33.3	17.4
Sheep Manure	96.3	97.6	60.8	78.3	26.8	28.9	81.1	45.5	78.1	33.3	100	20
Chicken Litter	85.4	88.5	41.2	68.0	15.5	7.9	95.3	23.7	63.6	41.7	0	13.6
Dairy Tie-Stall Manure	96.3	97.9	67.8	89.8	0	0	90	0	84.7	100	0	78.6
Dairy Free-Stall Manure	95.5	93.8	79.5	92.0	12.5	0	100	21.4	85.0	100	0	84.2
Misc. Manure	95.5	89.5	74.3	86.8	23.8	7.2	0	13.2	62.1	ND	14.3	95.3
Fly Ash	49.4	58.8	46.5	76.8	25.6	26.6	36.4	36.4	23.2	ND	25.7	75
Bottom Ash	32.4	50.0	46.3	32.4	33.8	30.5	37.5	36.8	33.3	ND	28.4	66.7
Pine Shavings	62.5	50.0	91.7	75.0	15.4	17.3	78.1	12.5	100	100	0	100
Reed Canary Grass	96.6	100	92.5	94.7	20	52.5	86.8	33.3	100	NR	NR	100

Weight % Acid Soluble

Sample	K	Na	Ca	Mg	Al	Si	S	Fe	P	Mn	Sr	Ti
WWTP Sludge	74.2	0	68.1	53.5	0	0	46.4	44.1	49.3	33.3	50	0
Sheep Manure	0.9	1.2	38.3	19.3	0	0	17	18.1	20.9	66.7	0	0
Chicken Litter	0	0	58.3	17	0	0	2.4	41.6	32.1	58.3	100	0
Dairy Tie-Stall Manure	1.3	0	32.2	8.2	36.4	11.8	10	80	15.3	ND	0	21.4
Dairy Free-Stall Manure	2.3	0	20.5	8	0	0	0	64.3	15	ND	0	15.8
Misc. Manure	0	5.2	25	13.2	42.9	18.6	100	78.9	36.4	ND	28.6	2.4
Fly Ash	12.9	14.7	22.1	7.4	19.5	14.7	27.2	21.5	63.1	ND	21.9	0
Bottom Ash	10.2	4.2	13	14.7	10.8	10.7	25	17.8	20	ND	17.1	0
Pine Shavings	0	0	8.3	0	0	0	0	25	0	ND	0	0
Reed Canary Grass	2.3	0	5	5.3	0	0	0	50	0	ND	0	0

NR: none reported, ND: not detected/below resolution limit

Table 3-2. Elemental Weight Percent Removed as a Function of Treatment during Chemical Fractionation (continued)

Weight % Insoluble

Sample	K	Na	Ca	Mg	Al	Si	S	Fe	P	Mn	Sr	Ti
WWTP Sludge	1.7	44.4	0.8	13.2	100	100	1.8	35.2	28.8	33.4	16.7	82.6
Sheep Manure	2.8	1.2	0.9	2.4	73.2	71.1	1.9	36.4	1	ND	0	80
Chicken Litter	14.6	11.5	0.5	15	84.5	92.1	2.3	34.7	4.3	ND	0	86.4
Dairy Tie-Stall Manure	2.4	2.1	0	2	63.6	90.9	0	20	0	ND	100	NR
Dairy Free-Stall Manure	2.2	6.2	0	0	87.5	100	0	14.3	0	ND	100	NR
Misc. Manure	4.5	5.3	0.7	0	33.3	74.1	0	7.9	1.5	100	57.1	2.3
Fly Ash	37.7	26.5	31.4	15.8	54.9	58.6	36.4	42.1	13.7	100	52.4	25
Bottom Ash	57.4	45.8	40.7	52.9	55.4	58.9	40.8	45.4	46.7	100	54.5	33
Pine Shavings	37.5	50.0	0	25	84.6	82.7	21.9	62.5	0	ND	100	NR
Reed Canary Grass	1.1	0	2.5	0	80	47.8	13.2	16.7	0	NR	NR	NR

NR: none reported

usually derived from acid soluble mineral phases, *e.g.,* pyrite and some clays. Insoluble phases are generally minerals such as quartz and aluminosilicates. Many of the insoluble and some of the acid soluble portions are indicative of the presence of dirt and other contaminates that make up the fuel sample and must be considered as part of the total fuel analysis. The degree of variability in the manner in which elements occur in biofuels is similar to that observed in low-rank coals (Falcone Miller and Schobert 1993; 1994a; 1994b). It should be mentioned that sample reproducibility is also difficult due to variability of the fuels.

3.1.2.1 Alkali Metals and Alkaline Earth Metals

In general, the alkali metals and alkaline earth metals, *i.e*., potassium, sodium, magnesium, and calcium, occur predominately in water soluble/ion-exchangeable forms, *i.e.,* associated with the organic portion of the material, in the animal- and plant-derived feedstocks (50-100%). Lesser amounts of these metals occur in acid soluble form. The water soluble/ion-exchangeable forms of these metals are generally present at lower levels (21-59%) in the fly ash, bottom ash, and sludge. In the animal- and plant-derived feedstocks, the alkaline earth elements are associated with the organic portion of the feedstocks and are highly reactive during combustion.

3.1.2.2 Potassium (Figure 3-2) and Sodium (Figure 3-3)

Greater than 95% of the potassium occurs in water soluble/ion-exchangeable forms in the manures and the Reed Canary grass. The chicken litter contained a moderate amount of water soluble/ion-exchangeable potassium (24%) with the balance being in the insoluble form. The increased level of insoluble potassium in the chicken litter is attributed to the significant amount of wood chips in the litter. Sodium is also present predominately (≥76%) in a water soluble/ion-exchangeable form in all of the animal manures, pine shavings, and Reed Canary grass. The alkaline earth elements in the ashes occur in water-soluble/ion-exchangeable and insoluble forms. This bimodal association is a result of the presence of unburned carbon (char) in the ash. The char contains ion-exchangeable forms of alkaline earth elements whereas the insoluble alkaline earth elements are associated with once molten silicate phases that formed during combustion. This is consistent with previous work conducted on coal ash chemistry (Falcone *et al*., 1984; Falcone and Schobert, 1985).

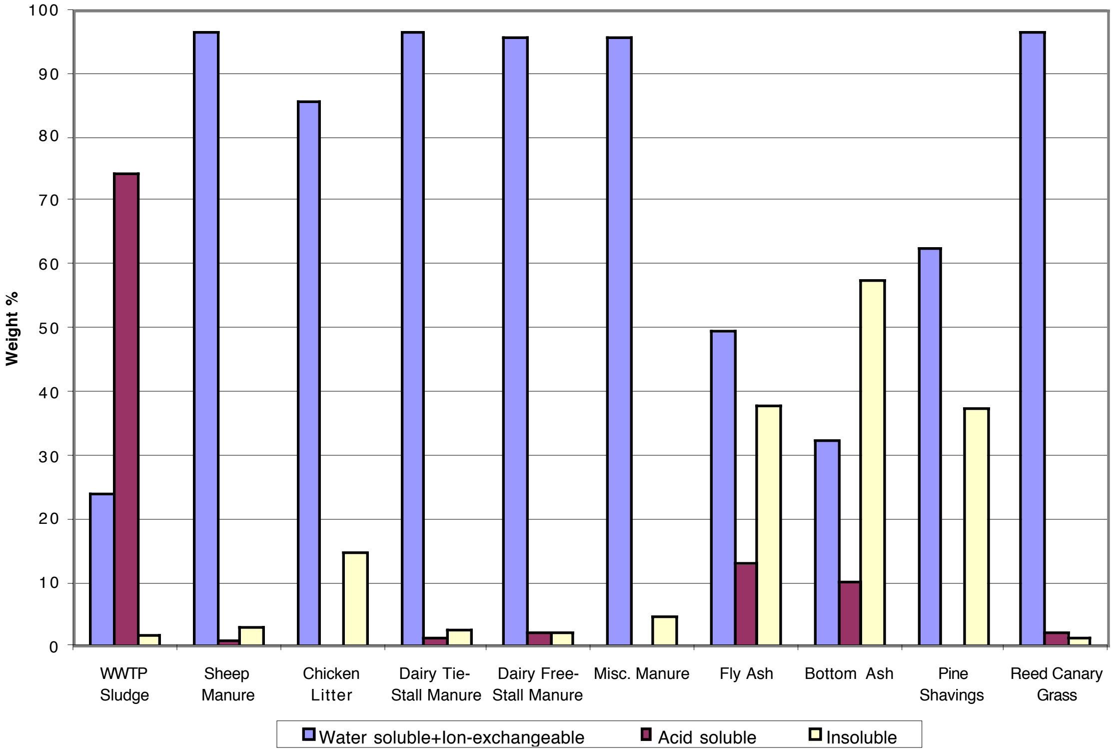


Figure 3-2. OCCURRENCE OF POTASSIUM IN FEEDSTOCKS

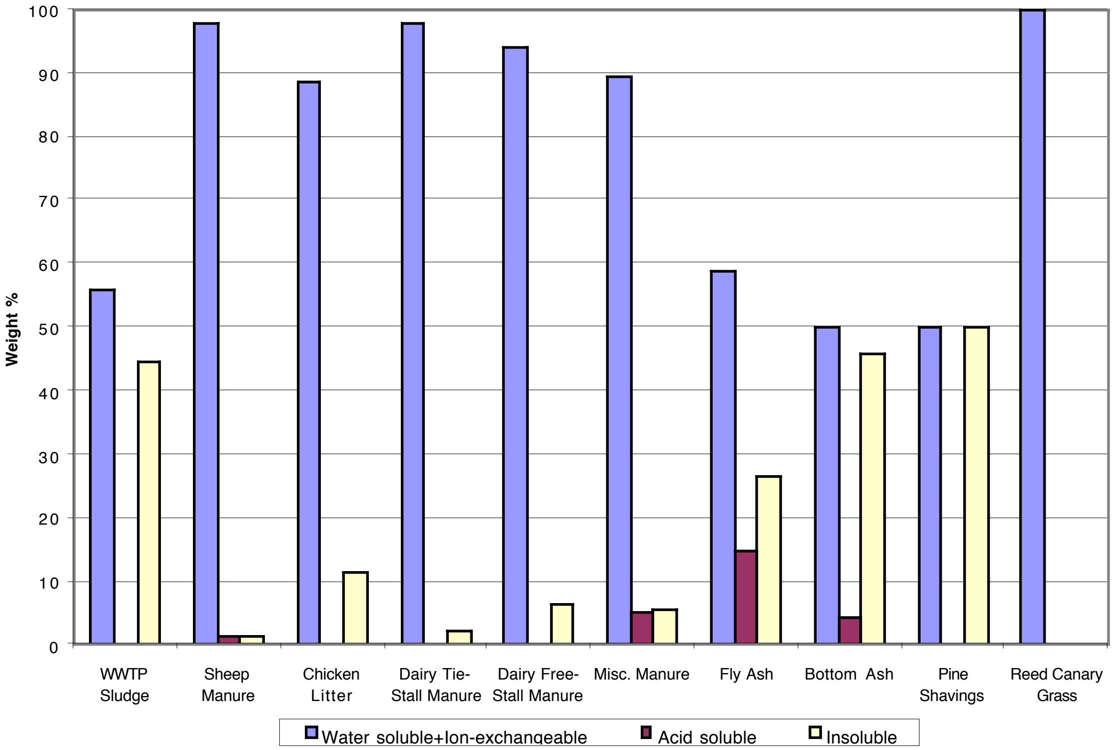


Figure 3-3. OCCURRENCE OF SODIUM IN FEEDSTOCKS

3.1.2.3 Magnesium (Figure 3-4) and Calcium (Figure 3-5)

The majority of the magnesium (68-95%) is present in a water soluble/ion-exhangeable form for all of the feedstocks except for the sludge and bottom ash. The acid soluble form of magnesium makes up 0-54% of the total magnesium. Only in the ash samples, the chicken litter, pine shavings, and sludge is there significant magnesium in an insoluble form (13-53%).

Virtually all of the calcium in the fuels is either present in a water soluble/ion-exchangeable or acid soluble form (Figure 3-5) in all the feedstocks except for the ash samples. Less than 2.5% of the calcium remained in the insoluble portion of the animal- and plant-derived feedstocks. However, 31 and 41% of the calcium was present in the insoluble portion of the fly and bottom ash samples, respectively. This is attributed to its incorporation during combustion in silicate melt phases present in the ash. Unlike potassium and sodium, there was a significant portion of acid soluble calcium in the feedstocks ranging from 5 to 68%. The plant fuels tended to have significantly less acid soluble calcium (8 and 13%) than the manure samples (20-59%).

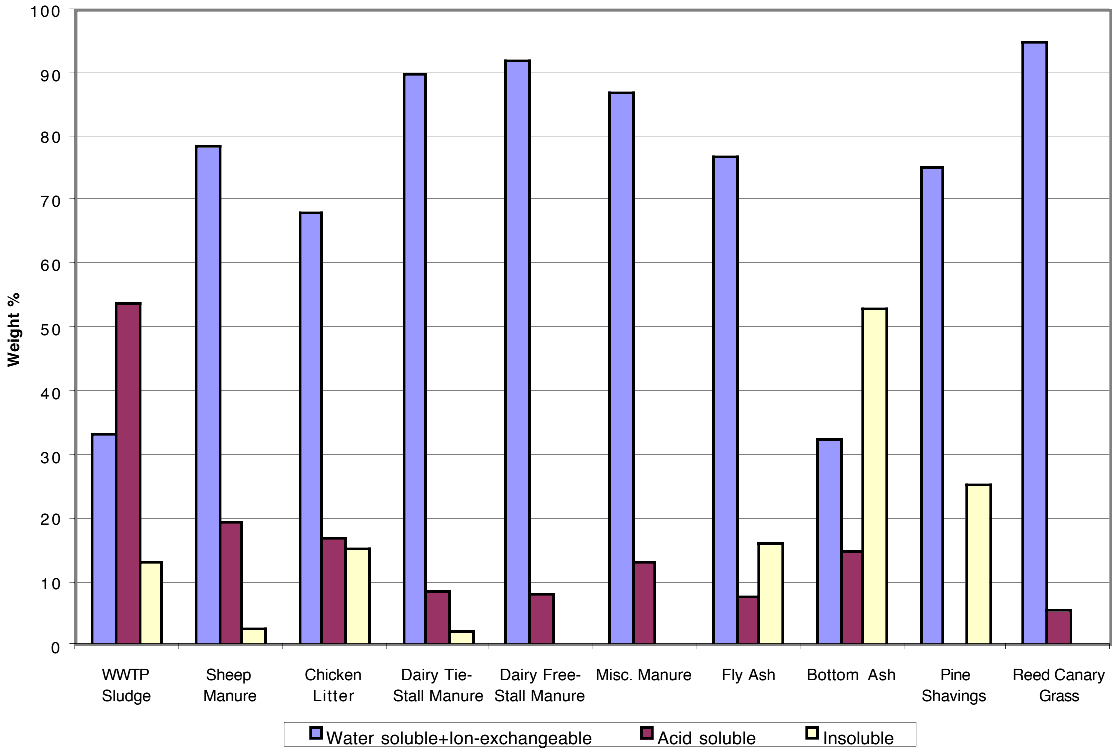


Figure 3-4. OCCURRENCE OF MAGNESIUM IN FEEDSTOCKS

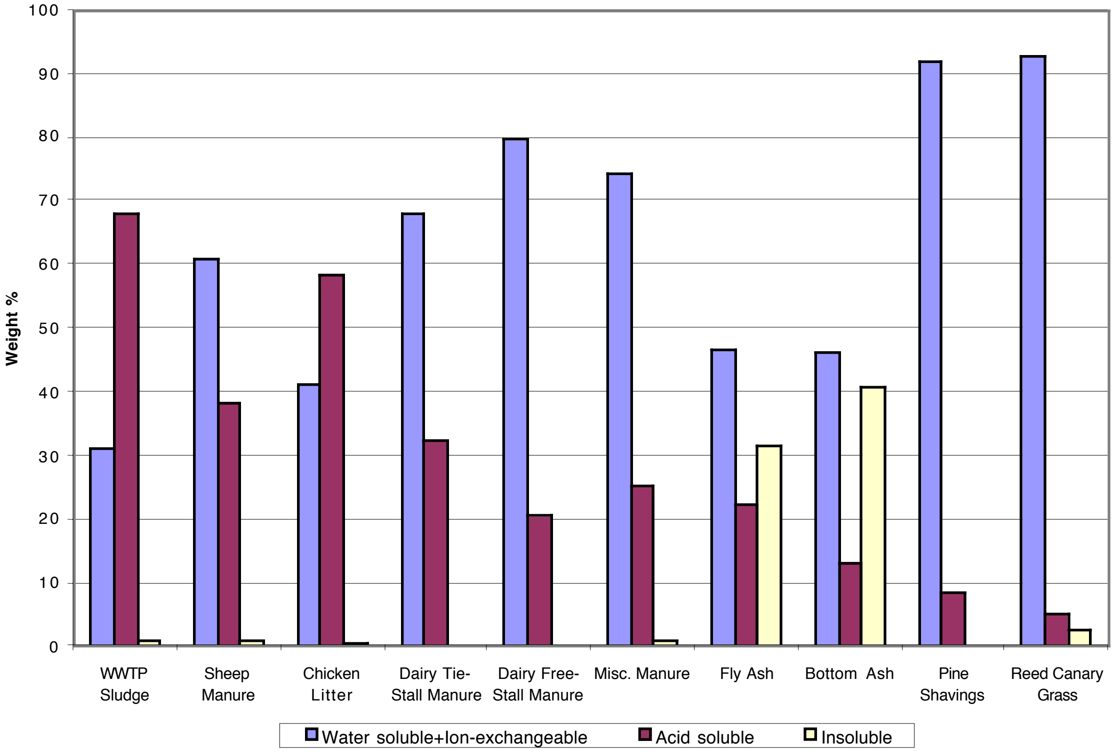


Figure 3-5. OCCURRENCE OF CALCIUM IN FEEDSTOCKS

3.1.2.4 Nonmetals Group – Phosphorus (Figure 3-6)

Phosphorous was present predominantly in a water soluble/ion-exchangeable form (≥ 63%) followed by the acid soluble forms in all the feedstocks except for the ashes and sludge. The occurrence of phosphorous in the animal- and plant-derived feedstocks is very similar to that of the alkali metals and alkaline earth metals. No acid soluble phosphorous was detected in the pine shavings or Reed Canary grass. Only in the ash and sludge samples was there any significant phosphorous in the insoluble form (14-47%).

3.1.2.5 Sulfur (Figure 3-7)

Sulfur occurred predominately in the water soluble/ion-exchangeable portion (36-96%). An anomaly was the seen in the miscellaneous manure sample having 100% of the sulfur present in an acid soluble form. This is suspect given that the miscellaneous manure sample was derived from a combination of the other manure samples. Each of the manure samples had 81-100% of the sulfur reported in a reactive form. The percent of sulfur that was acid soluble ranged from 0 to 100%. Again the sulfur levels in the ash in the insoluble form are much higher due to its incorporation in silicate phases.

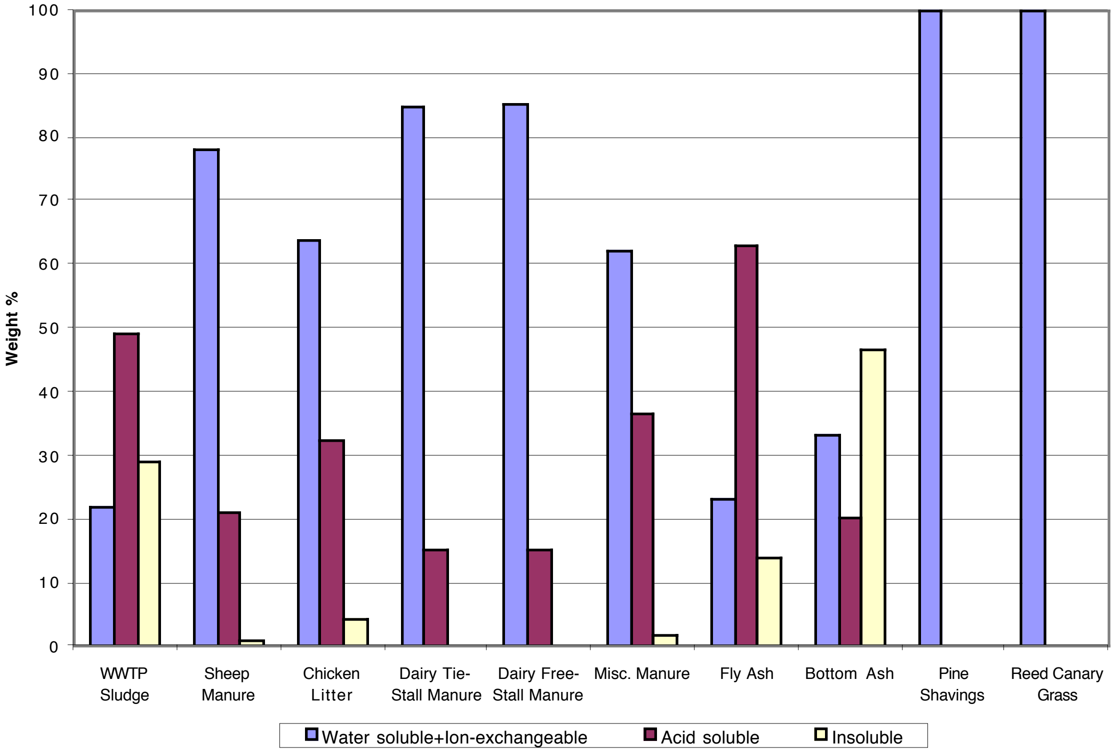


Figure 3-6. OCCURRENCE OF PHOSPHORUS IN FEEDSTOCKS

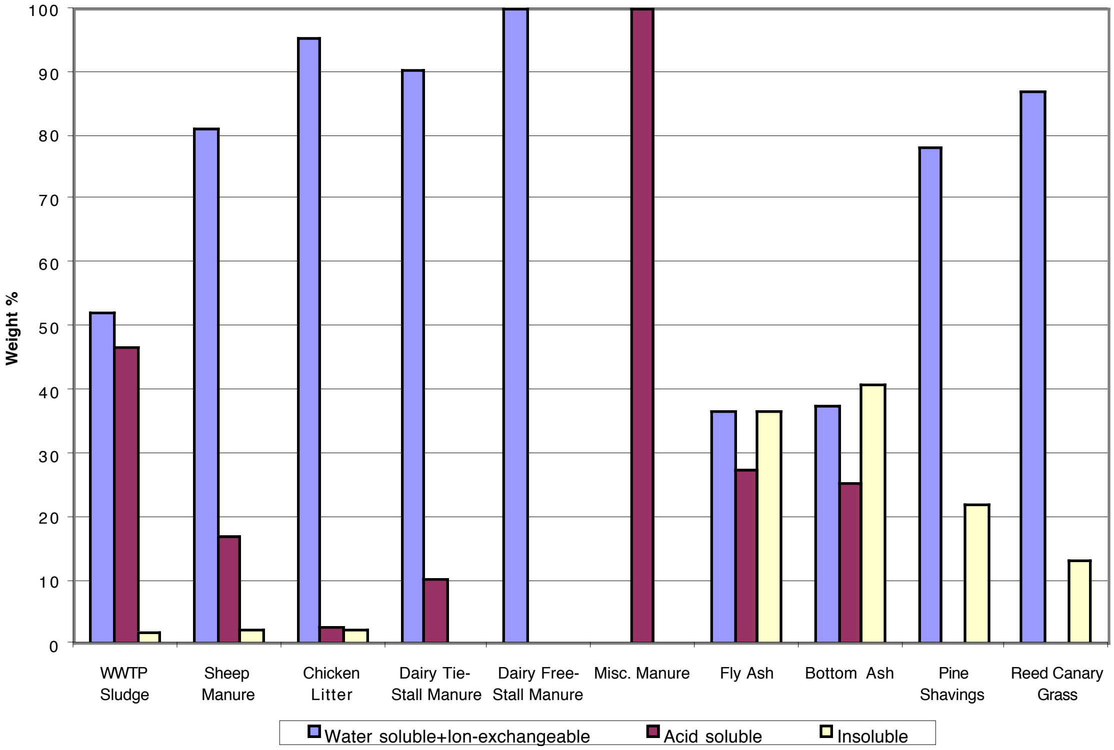


Figure 3-7. OCCURRENCE OF SULFUR IN FEEDSTOCKS

3.1.2.6 Iron (Figure 3-8)

Iron occurs in multimodal forms. In almost all of the samples, no single form accounts for greater than 50%. In the dairy tie- and free-stall manures and miscellaneous manure, 64-80% of the iron is acid soluble. In the pine shavings, the iron is 63% insoluble. During combustion, the presence of iron often acts as a flux (particularity under localized reducing conditions) which results in the formation of molten phases at reduced temperatures. The multimodal occurrence of iron suggests that it may participate in both the formation of condensed phases on particles as well as the formation of molten particles due to its proximity to char and other minerals to form coalesced particles.

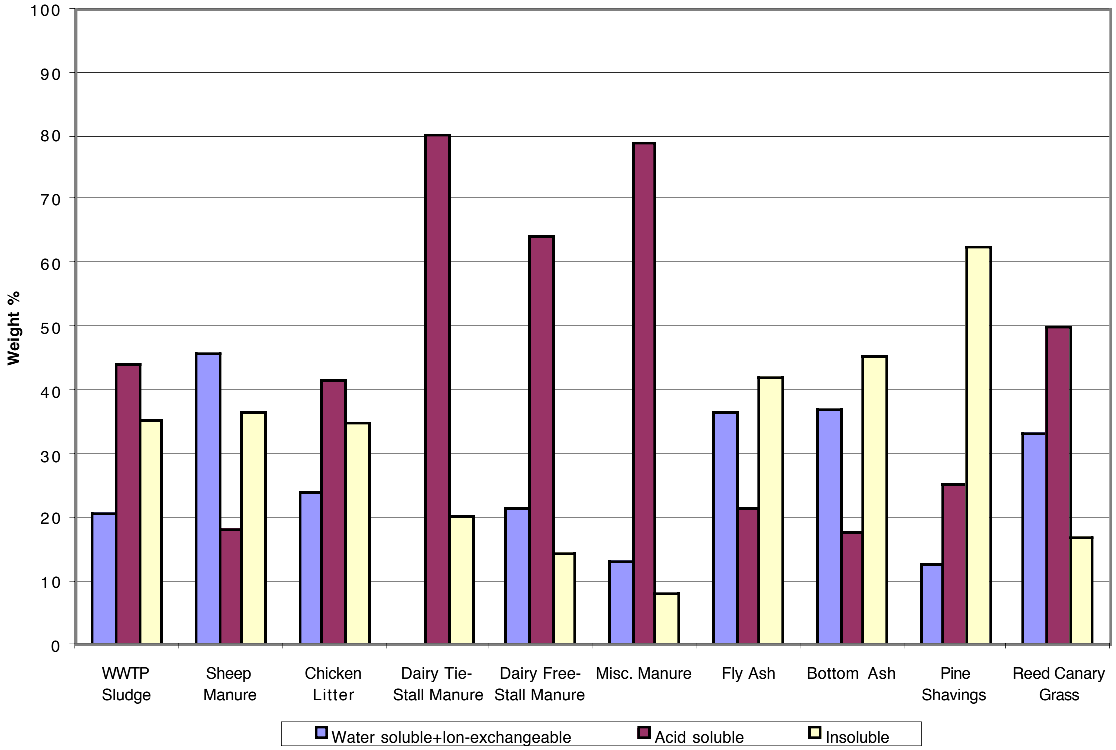


Figure 3-8. OCCURRENCE OF IRON IN FEEDSTOCKS

3.1.2.7 Manganese (Figure 3-9)

In many samples, the levels of manganese were listed as being below detection limits. Therefore the trends shown in Figure 3-9 are based on incomplete data. In general, manganese occurs in either a water soluble/ion-exchangeable form or insoluble form.

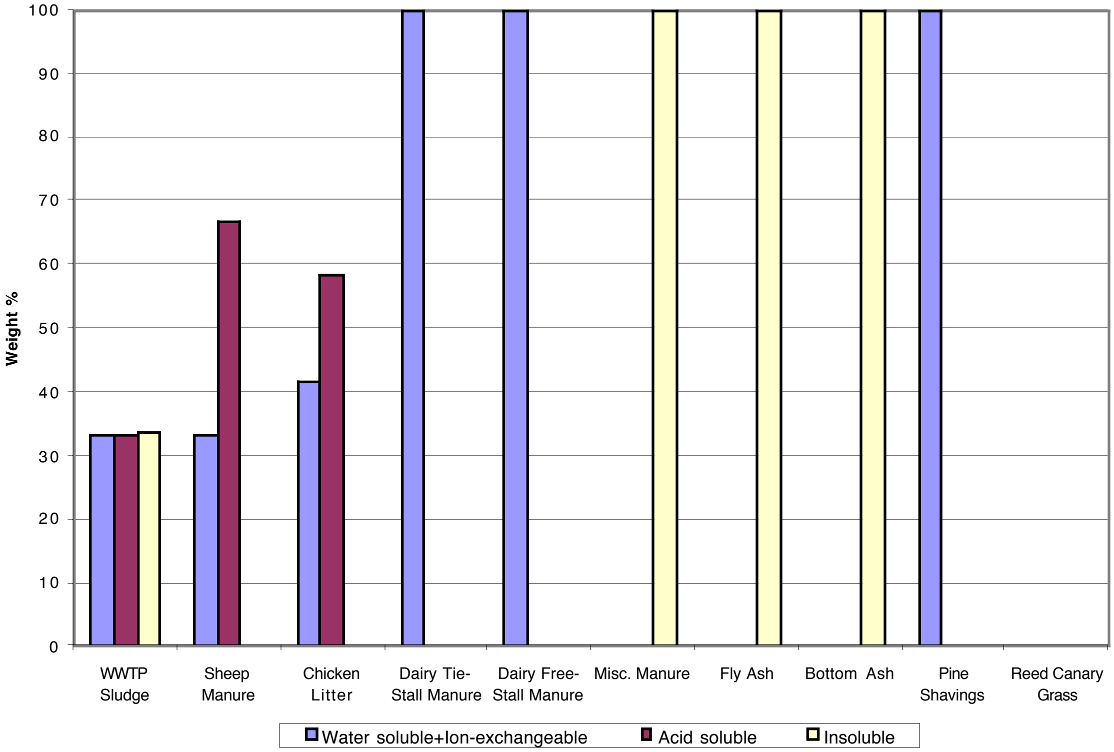


Figure 3-9. OCCURRENCE OF MANGANESE IN FEEDSTOCKS

3.1.2.8 Aluminum (Figure 3-10) and Silicon (Figure 3-11)

Aluminum and silicon are concentrated in the insoluble portion of the fuels. This is expected given that many of the manure samples also included dirt, *i.e.,* quartz, clay minerals, from the stall as well as hay/straw and sand. There was some water soluble/ion-exchangeable and acid soluble aluminum present in some of the samples. At this time it is unknown what the source of this aluminum could be. Water soluble/ion-exchangeable silicon was measured in the pine shavings and Reed Canary grass. Silicon is not typically found in ion-exchangeable form so no explanation is presented at this time. Material balance of silicon was not very good. This is attributed to the varied contamination of sand/dirt in many of the samples.

3.1.2.9 Strontium (Figure 3-12) and Titanium (Figure 3-13)

Titanium was present primarily in a water soluble/ion-exchangeable form (75-100%) in all the samples except for the sludge, sheep manure, and chicken litter where it occurred in an insoluble form (80-86%).

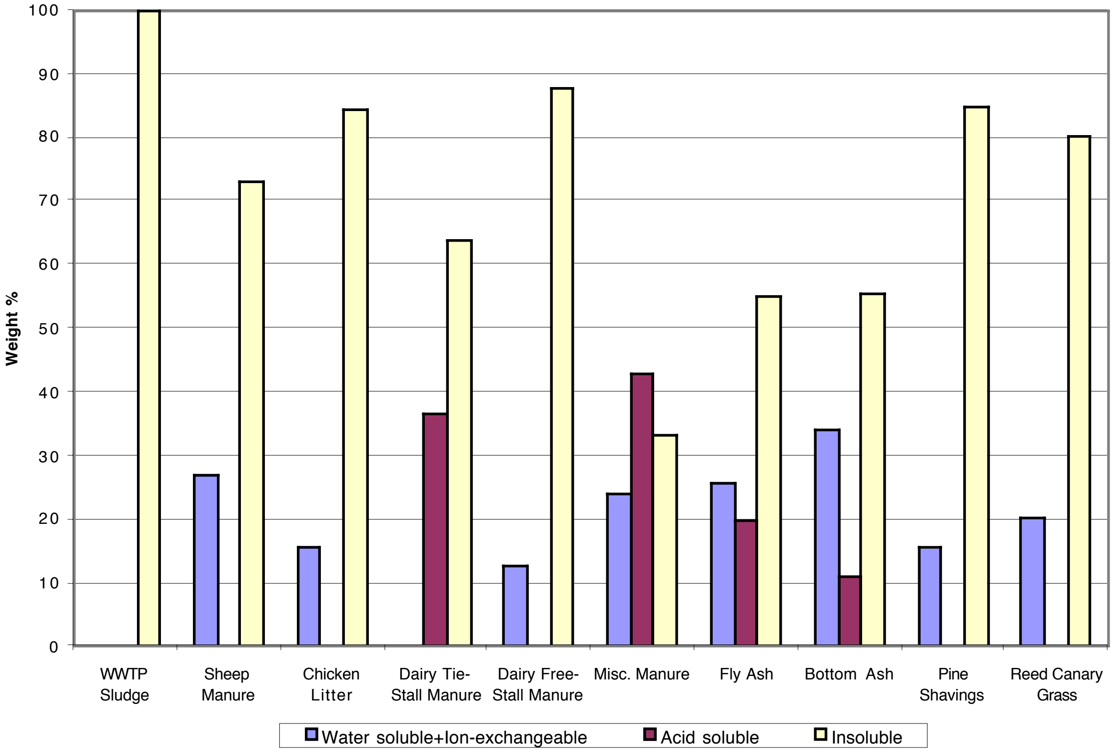


Figure 3-10. OCCURRENCE OF ALUMINUM IN FEEDSTOCKS

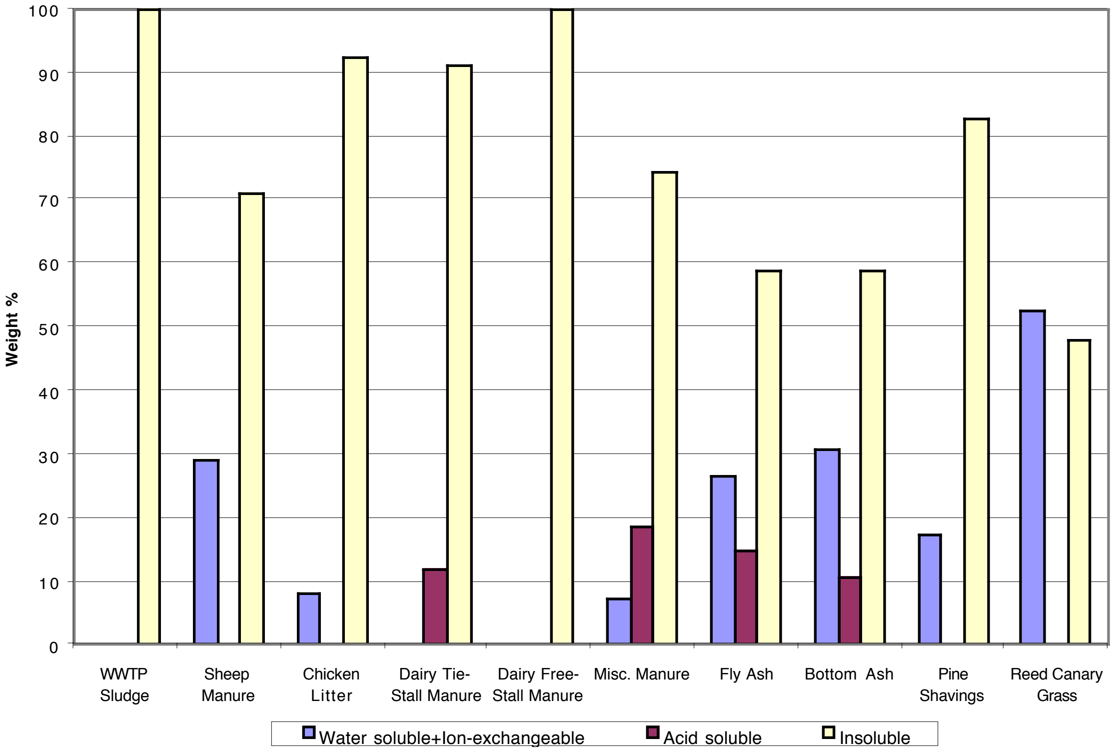


Figure 3-11. OCCURRENCE OF SILICA IN FEEDSTOCKS

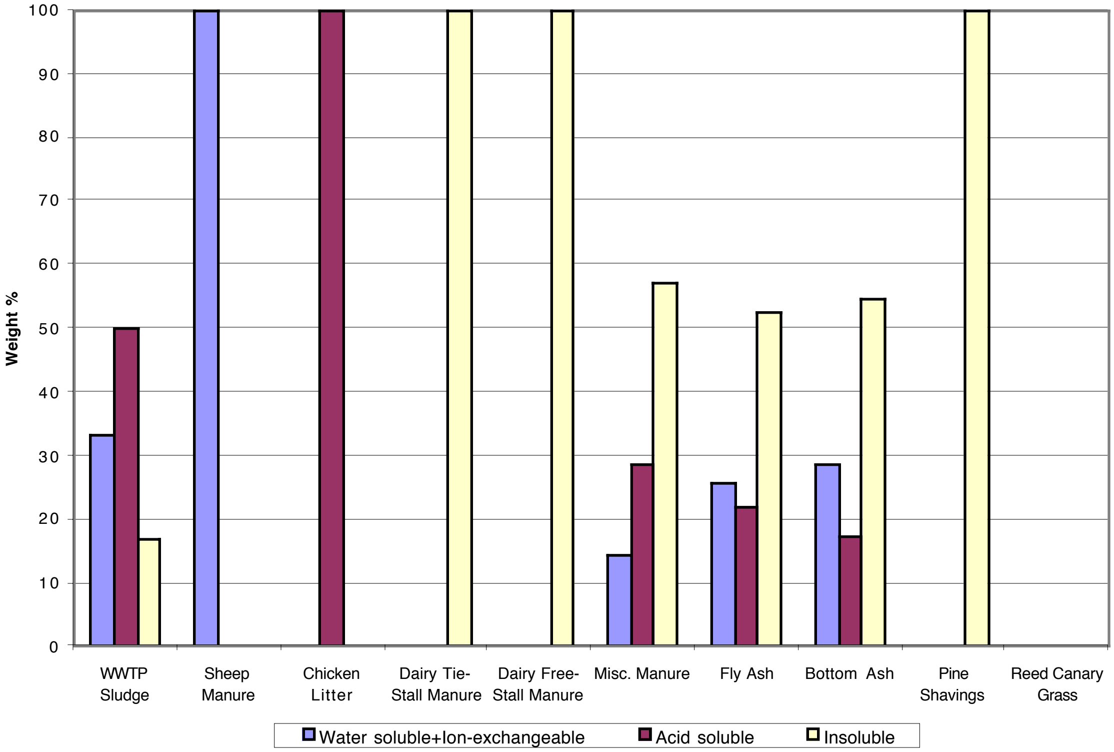


Figure 3-12. OCCURRENCE OF STRONTIUM IN FEEDSTOCKS

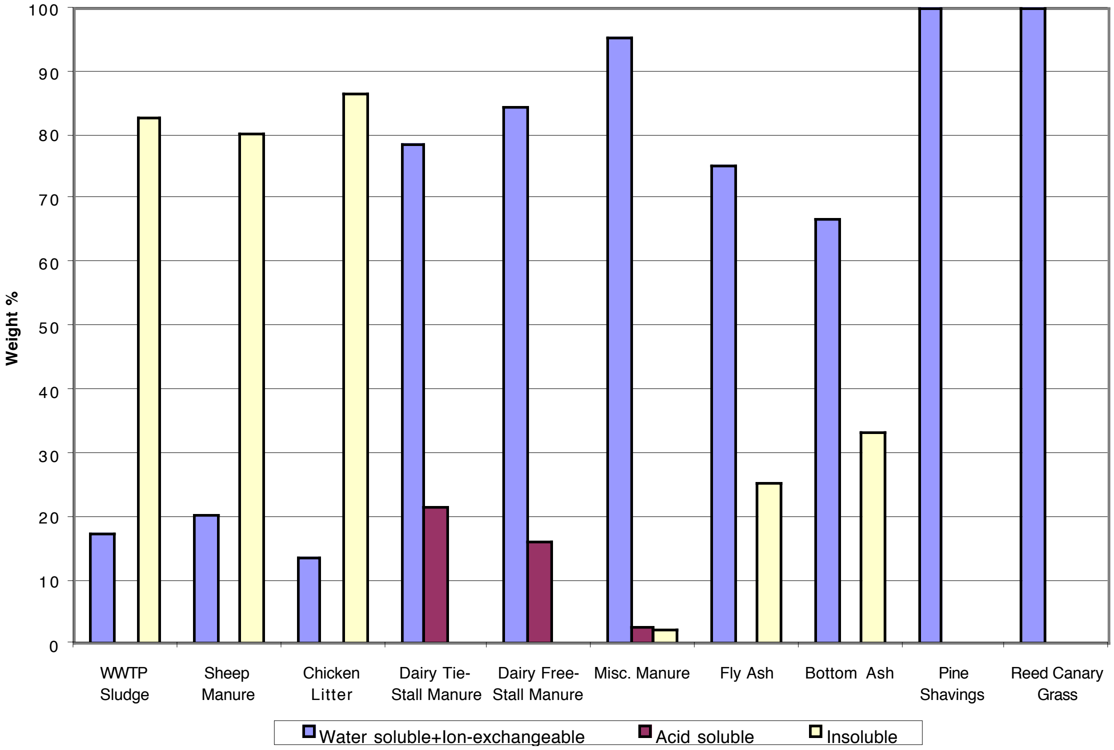


Figure 3-13. OCCURRENCE OF TITANIUM IN FEEDSTOCKS

In general, a significant portion of the alkali and alkaline earth elements occur in the water soluble/ion-exchangeable portion of the biofuels. Zevenhoven-Onderwater *et al.* (2000) reported similar results for forest residue, *Salix* (low Si) and *Salix* (high Si). The high percentage of alkali and alkaline earth elements in the water soluble/ion-exchangeable form is cause for concern given their potential for forming molten phases in the bed during CFB combustion. Extraneous quartz is fairly inert within the gas stream in the absence of volatilized alkalis and alkaline earth elements. Volatilized alkalis and alkaline earth elements can migrate into the silicate structure forming phases that have lower melting points. It is important not only to look at the elemental concentration on a fuel basis but to also consider the interaction of elements at the temperature regime for a given system to better asset potential fuel blends for a particular combustion system.

3.2 Thermodynamic Modeling to Predict Inorganic Phases

A series of fuel blends were used as input into a Gibbs free energy minimization program called FACTSage developed at the Facility for the Analysis of Chemical Thermodynamics (FACT)**,** Centre for Research in Computational Thermochemistry (CRCT), École Polytechnique de Montréal, Canada, and GTT Technologies (FACT, 2001). The program calculates equilibrium composition for a given system at a set of defined temperature and/or pressure conditions.

The biomass resource assessment determined the types, quantities, and temporal variations of different biomass waste materials produced at Penn State's University Park campus. Based on the assessment, an average biofuel and coal fuel blend was identified and is referred to as the Baseline Blend (Table 3-3). The coal identified is a medium volatile bituminous coal. The inorganic composition of potential fuel blends is given in Tables 3-4 and 3-5. The average fuel blend composition was used as input into the FACTSage Thermodynamic modeling program to determine the state of the inorganic phases present in the bed. In addition, the chemical fractionation data was used to determine a "reactive" fuel composition. A "reactive" fuel composition is defined as the weight percent of each element that is water soluble and/or ion-exchangeable. An average temperature of 1171K (898°C, 1650°F), to represent an average anticipated bed temperature, and a firing rate of 58.6 MW_t (200 MM Btu/h) were used.

Table 3-3. Percent Thermal Input of Proposed and Theoretical Fuel Blends Based on a Firing Rate of 58.6 MW_t (200 MM Btu/h)

% Thermal Input					
Fuel	**Baseline Blend**	**Chicken Litter**	**Manure Blend 1**	**Manure Blend 2**	**Manure-Coal Cofire**
Coal	83.8				84.9
Sewage Sludge	0.4				
Sheep Manure	0.1		59.0	25	3.9
Chicken Litter	0.0	100			
Dairy Tie-Stall Manure	0.4		21.5	25	4.0
Dairy Free-Stall Manure	0.0		8.1	25	3.4
Misc. Manure	0.3		11.7	25	3.9
Red Oak Shavings	8.4				
Pine Shavings	6.5				
Reed Canary Grass	0.2				

Table 3-4. Inorganic Analysis of Fuel Blends (fuel basis, as-fired)

Weight %					
Oxide	**Baseline Fuel Blend**	**Chicken Litter**	**Manure Blend 1**	**Manure Blend 2**	**Manure-Coal Cofire**
Al_2O_3	2.60	3.15	0.46	0.36	1.98
BaO	0.00	0.02	0.01	0.00	0.00
CaO	1.06	4.37	1.98	1.48	0.97
Fe_2O_3	1.87	1.39	0.32	0.28	1.41
K_2O	0.30	3.43	2.55	1.37	0.90
MgO	0.18	1.38	0.81	0.56	0.36
MnO	0.00	0.12	0.02	0.02	0.01
Na_2O	0.05	1.24	0.63	0.41	0.24
P_2O_5	0.13	4.82	1.35	0.95	0.56
SiO_2	6.19	13.60	13.41	17.80	12.99
SO_3	0.12	0.89	0.48	0.15	0.13
SrO	0.01	0.01	0.02	0.03	0.02
TiO_2	0.03	0.17	0.27	0.36	0.19
Ash %	12.54	34.50	22.31	23.77	19.72

3.2.1 Results of the Thermodynamic Modeling

The results of the thermodynamic model for the fuel blends are given in Table 3- 6. The compositional data were taken from Table 3-5.

Table 3-5. Inorganic Analysis of Fuel Blends (ash basis)

	Weight %				
Oxide	**Baseline Fuel Blend**	**Chicken Litter**	**Manure Blend 1**	**Manure Blend 2**	**Manure-Coal Cofire**
Al_2O_3	20.74	9.14	2.06	1.50	9.81
BaO	0.01	0.05	0.03	0.02	0.01
CaO	8.42	12.7	8.85	6.22	4.91
Fe_2O_3	14.93	4.04	1.42	1.16	7.13
K_2O	2.38	9.94	11.42	5.76	4.58
MgO	1.46	4.01	3.63	2.36	1.85
MnO	0.04	0.36	0.11	0.09	0.05
Na_2O	0.42	3.60	2.83	1.72	1.24
P_2O_5	1.06	14.0	6.07	4.01	2.82
SiO_2	49.32	39.4	60.11	74.90	65.86
SO_3	0.93	2.58	2.17	0.62	0.66
SrO	0.04	0.03	0.09	0.12	0.08
TiO_2	0.24	0.51	1.21	1.52	0.99

Table 3-6. Inorganic Phases Predicted at Equilibrium at 1171K using Total Ash Composition. (All phases are solid unless followed by *(l)* indicating a liquid phase. Liquid phases are also indicated in bold typeface.)

	Weight %				
Phase	**Baseline Blend**	**Chicken Litter**	**Manure Blend 1**	**Manure Blend 2**	**Manure-Coal Cofire**
SiO_2/tridymite	20.7	9.3	20.0	51.5	41.6
$CaAl_2Si_2O_8$/anorthite	32.4				5.5
Fe_2O_3/hematite	15.0	4.1	1.4	1.2	7.2
$Al_6Si_2O_{13}$/mullite	2.7				
$KAlSi_2O_6$/leucite	11.1	39.4	8.9	6.5	21.5
$Mg_2Al_4Si_5O_{18}$/cordierite	10.6				2.3
$NaAlSi_3O_8$	3.6				10.6
$CaSO_4$/anhydrite	1.6				1.1
$K_3Na(SO_4)_2$		3.5			
Na_2SO_4 (*l*)		**1.6**			
CaOMgOSiO$_2$/monticellite					
$K_2Si_4O_9$ (*l*)			**25.1**	**13.2**	
$Ca_3(PO_4)_2$	2.3	23.5	13.5	8.9	6.3
$Mg_3P_2O_8$		4.6			
$Na_3(PO_4)$		2.0			
$MgSiO_3$					3.8
$Na_2Ca_3Si_6O_{16}$			3.7	2.8	
MgOCaOSi$_2$O$_4$/diopside			2.4	2.7	
$Na_2Mg_2Si_6O_{15}$		12.1	20.2	11.8	
K_2SO_4			4.8	1.4	

The most basic scenario was to input the chemical analysis of the fuel blend in the oxide form as given in Table 3-5. The analysis is reported on an oxide basis; however, this does not mean that the pure oxides are present in the ash. At 1171K (898°C), the phases present in equilibrium are given in Table 3-6. In some cases, mineral names are assigned to chemical formula. This does not necessary imply any information regarding the crystallinity of the phase but only a match with regard to chemical composition. In addition, only the FACT database was used to calculate the phases present at the conditions described. Initally, all of the gas, liquid and solid phases contained in the FACT database were used (369 species). After initial runs, the database was customized to omit remote species.

In the Baseline Blend fuel, there are no liquid phases present at 1171K. All of the alkali earth elements are tied up in aluminosilicates that have melting points higher than 1171K. The coal provides a significant source of aluminum to favor the formation of aluminosilicates versus silicates that have lower melting points.

At equilibrium at 1171K, the chicken litter fuel contains the liquid phase Na_2SO_4 (1.6 wt. %) (Table 3-6). The chicken litter contains significant amounts of sodium as compared to the other fuels. The remaining alkali earth elements are divided into other silicates. Previous work conducted at Penn State involved combustion studies of chicken litter in a pilot-scale FBC during which significant clinkering occurred in the bed. As is common practice, kaolin clay was added to the fuel feed to reduce the occurrence of clinkering in the bed (Jawdy *et al.*, 2000; Virr 2001). Kaolinite ($Al_2Si_2O_5(OH)_4$) is the main constituent of kaolin clay. The net effect of the clay is to increase the aluminum in the ash that shifts the equilibrium composition away from the formation of phases having lower melting points. In addition, the kaolin also dilutes the concentration of alkali earth elements. The net effect is to shift the reaction in favor of forming aluminosilicates having higher melting points. Interestingly, calcium is not involved in the formation of melt phases. As mentioned earlier, calcium occurs predominantly in an acid soluble form in the chicken litter. Hald (1995) studied the addition of limestone on the formation of liquid phases during combustion of coal and straw and suggested that CaO was only a minor contributor to the formation of melt phases.

The extent to which organically-bound alkalis and alkaline earth elements volatilize depends on the combustion temperature, as suggested by the work by Helble *et al.* (1991a; 1991b). However, the volatility of sodium or presence of sodium volatiles in the gas stream decreases with temperature. The reason for this is that at higher temperatures the organically-bound sodium will react with silicate particles in the char and will not be released into the gas stream (Neville and Sarofim, 1985; Gallagher *et al.*, 1991). At combustion temperatures less than 1900K, sodium chloride and sodium cations are vaporized from the char. At temperatures greater than 1900K, inherent quartz begins to soften, allowing diffusion of sodium into the silicate structure. This reaction of sodium with inherent silicate particles at high temperatures usually results in the formation of molten silicate particles, which ultimately coalesce. The coalescence or agglomeration of silicate particles is greatly enhanced due to the incorporation of alkalis and alkaline earth elements.

Two manure blends utilizing no coal support were also studied. It is recognized that this does not necessarily represent a real scenario at Penn State but serves to evaluate the unique nature of biofuels. Each blend consisted of sheep, dairy tie-stall, dairy free-stall, and miscellaneous manure. Manure Blend 1 was based on similar feed rates for the dairy and miscellaneous manures (≈ 6,820 kg/h) and 13,545 kg/h feed rate for the sheep manure. The sheep manure has significantly higher levels of potassium, calcium and sodium than the other manures. Manure Blend 2 is based on equal thermal input by the different manures. Manure Blend 1 had significant amounts of liquid phase (≈ 25.1 wt. %) $K_2Si_4O_9(l)$ present at equilibrium. Manure Blend 1 contained approximately twice as much K_2O as Manure Blend 2. Manure Blend 1 had potassium contained within three species: $K_2Si_4O_9(l)$ contained 61% of the potassium; $KAlSi_2O_6(s)$ contained 17% of the total potassium; and $K_2SO_4(s)$ contained 22% of the potassium.

Manure Blend 2 had potassium contained within the same three species as Manure Blend 1 with 63% of the potassium in the liquid phase ($K_2Si_4O_9(l)$) which accounted for 13.2 weight percent of the total inorganic material. The high percentage of liquid phase is attributed to the low concentration of Al_2O_3 present in the fuel. Potassium aluminosilicates tend to have higher melting points than potassium silicates. Zevenhoven-Onderwater *et al.* (2000) defined a T_{15} (critical temperature) as the temperature at which 15 weight percent of the ash is present in a molten phase thereby enabling fly ash deposition in the flue gas pass or formation of sticky bottom ash and possible bed sintering and agglomeration.

The importance of alkali earth elements in fuels can be demonstrated by the SiO_2-K_2O system (Figure 3-14). SiO_2 (quartz) has a melting point of 1883K. However, the introduction of a minor amount of K_2O, *e.g.,* 0.02 mass fraction, into the system results in the formation of $K_2Si_4O_9(l)$ (9 weight %) at 1171K (as calculated by FactSage). $K_2Si_4O_9(l)$ is in equilibrium with $SiO_2(s4)$ (tridymite) up to 1732K. An increase in the mass fraction of K_2O to 0.2 increases the mass fraction of the liquid phase to 68% and ultimately leads to the formation of additional potassium silicate melt phases at lower temperatures with tridymite being consumed. Baxter and Jenkins (1995) have noted the impact of potassium

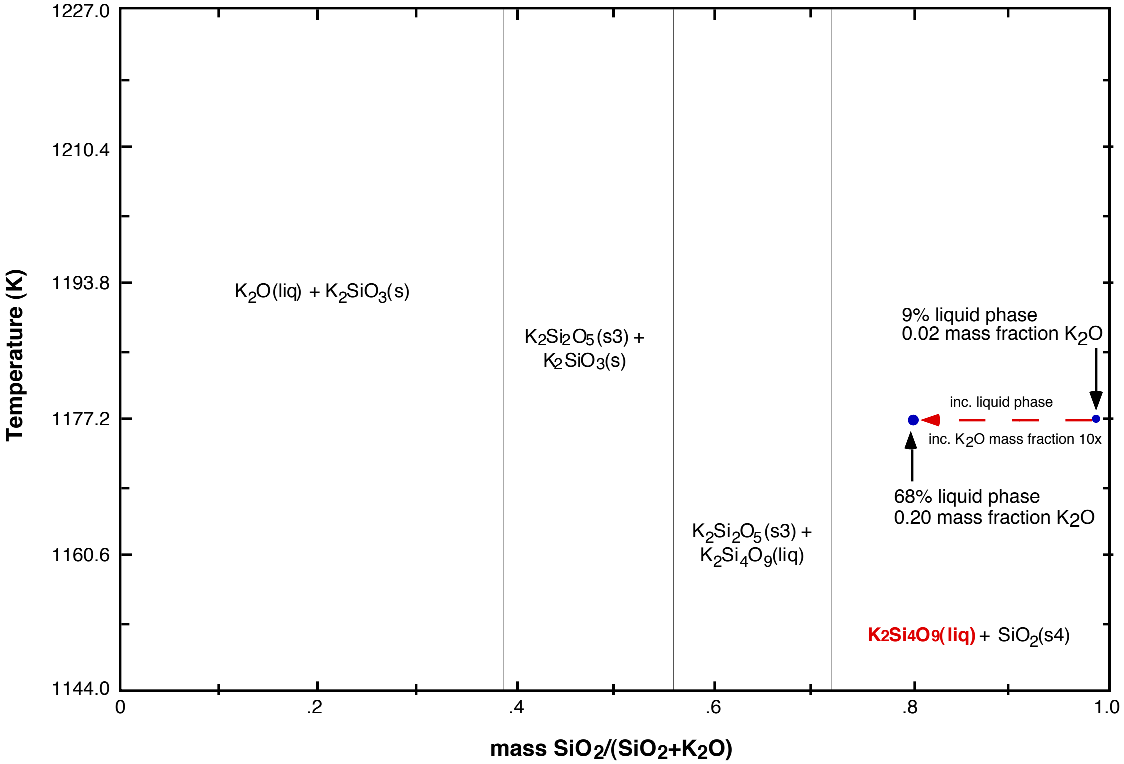


Figure 3-14. SiO_2-K_2O BINARY SYSTEM AT EQUILIBRIUM

in depressing the melting point of silicon. Baxter and Jenkins studied straw ash deposits and found that the molten region had a silicon to potassium ratio of less than 4:1 and a ratio over 25:1 in the granular region of the deposit.

It should be noted that the introduction of Al_2O_3 into a system results in a reduction or absence of the $K_2Si_4O_9$*(l)* phase. In Figure 3-15, the SiO_2-Al_2O_3 system is shown in which K_2O makes up 0.1 mass fraction of the total system.

At 0.02 mass fraction Al_2O_3, the liquid phase accounts for 33% of the total mass at equilibrium. Increasing the mass fraction of Al_2O_3 ten times to 0.20 reduces the mass fraction of liquid phase to 3%. Mass fractions were determined via the FactSage model. Increasing the mass fraction of Al_2O_3 to 0.22 eliminates the $K_2Si_4O_9$*(l)* phase. Mullite ($KAlSi_2O_6$) and leucite ($Al_6Si_2O_{13}$) solid phases are in equilibrium with tridymite. The presence of Al_2O_3 in the system favors the formation of potassium aluminosilicates that have higher melting points as compared to potassium silicates.

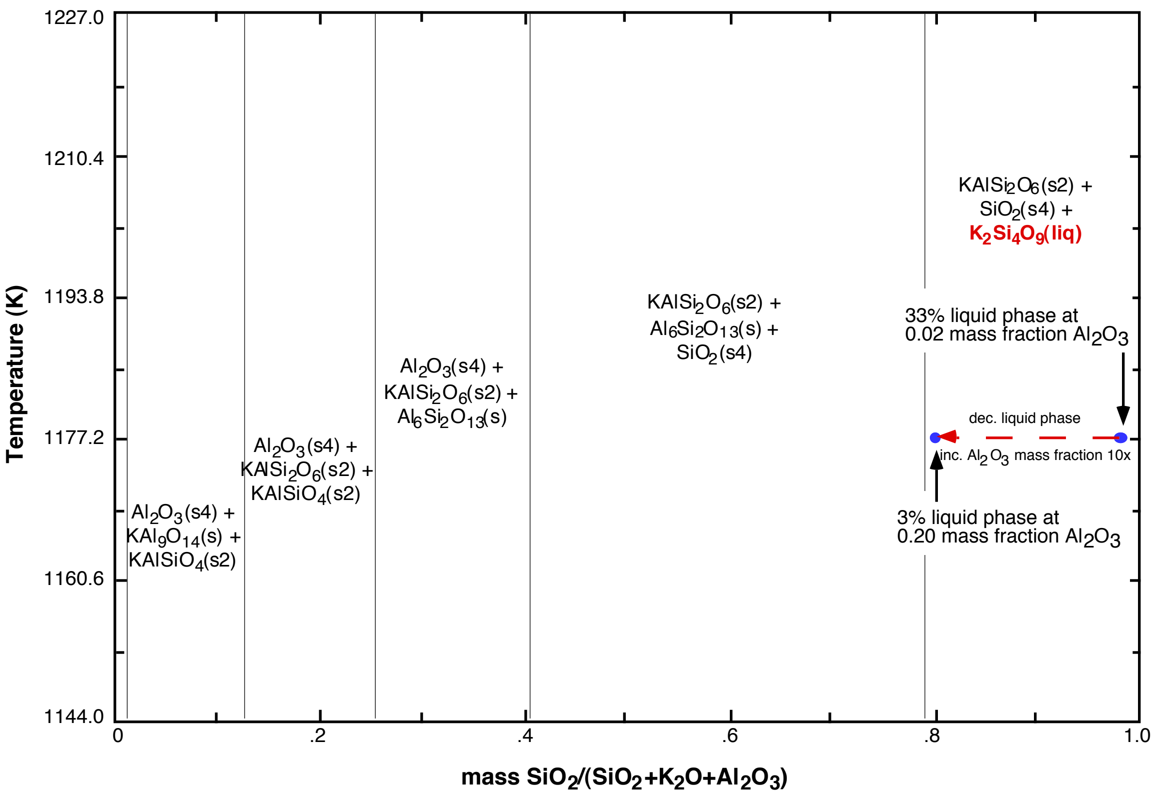


Figure 3-15. **SiO_2-Al_2O_3 BINARY SYSTEM AT EQUILIBRIUM AND 0.1 MASS FRACTION K_2O**

A manure cofire blend was also run in which coal provides 85% of the thermal input. No liquid phases were calculated to be present at the target temperature of 1171K (Table 3-6). The cofire of coal with the manure blend provides adequate aluminum and silicon to favor the formation of phases that incorporate the alkali earth elements that have higher melting points as compared to phases formed in Manure Blends 1 and 2.

Thermodynamically modeling of some additional coal-biomass blends was also conducted using a series of coal-switchgrass, coal-pine wood and coal-manure blends in various types of boilers, *i.e.,* fluidized bed combustors, pulverized coal combustors (dry-bottom) and cyclone-fired boilers (Falcone Miller *et al.*, 2002). Of specific interest is the formation of certain inorganic compounds that have low melting points and their viscosity. The composition of the melt phase determines its viscosity and surface tension. Ultimately the weight percent of melt phase, its viscosity, and surface tension determines its sintering potential in an FBC (Falcone *et al.*, 1984; Falcone and Kalmanovitch, 1987). FACTSage was used to determine the weight percent and composition of melt phases at various temperatures and a viscosity model developed at Penn State by Folkedahl (1997) was used to calculated viscosity as a function of temperature and composition. All of the fuel blends, except for the coal-manure blend, showed no liquid phase present at temperatures typical of FBCs (1,450-1,750°F). The coal-manure blend had a greater percentage of SiO_2 than the other fuels but less Al_2O_3 and Fe_2O_3. The coal-manure blend also had the highest percentage of K_2O, Na_2O and CaO. Calculation of T_{250} was also conducted at higher temperatures. The temperature at which a viscosity of 250 poises is reached is termed T_{250} and is recommended not to exceed 2,600°F (1,427°C). Traditionally, 250 poise has been cited as the maximum viscosity for satisfactory discharge of slag from a cyclone boiler/wet-bottom furnace and for sootblowing of waterwall deposits in dry-bottom boilers (Combustion Engineering, 1981). Details of this study related to the behavior of ash at elevated temperatures, are given in Falcone Miller *et al.* (2002).

3.2.2 Conclusions

The chemical fractionation methodology described in Appendix J was developed as a consequence of the extremely heterogeneous character, *i.e.,* grindability, density and wetability, of the various components that constitute a biofuel. The manner in which biofuels are acquired make it difficult to obtain representative samples or highly reproducible analytical results. This variability is compounded by seasonal variations in the character of biofuels is to be expected. Therefore, fluctuations in biofuel composition should be expected.

Analysis of both leachate and the solid residue was conducted to determine the occurrence of various elements in the biofuels. Potassium occurs predominately in water soluble/ion-exchangeable forms (≥95%) in all four manures and Reed Canary grass. Sodium is also present predominately in water soluble/ion-exchangeable form (≥ 90%) with the remaining sodium present in an insoluble form. Calcium in the fuels is either present in a water soluble/ion-exchangeable form or acid soluble form with the remaining calcium in the insoluble portion of the fuel. Aluminum and silicon remain in the insoluble portion of the fuel. Silicon is attributed to the presence of straw and dirt from the floor of dairy and poultry barns.

The biofuels presented demonstrate the impact that certain elements have on potential clinkering or fouling problems. The FactSage equilibrium calculations suggest that a cofire of biofuels with an appropriate nonfouling coal should not pose any problems in a CFB system given that the coal makes up a majority of the thermal input. Chicken litter was successfully fired in a pilot-scale CFB at Penn State only after the addition of kaolin clay reduced the presence of low melting phases in the bed. FactSage consistently predicted $K_2Si_4O_9(l)$ to be present at 1171K when biofuels having low aluminum levels and significant concentration of alkali earth elements. Only 10% (normalized with respect to

SiO_2 and Al_2O_3) of K_2O present in a system was enough to result in the formation of $K_2Si_4O_9(l)$ at equilibrium that could compromise a CFB system. Thermodynamically it appears that the baseline cofire blend being evaluated for the CFB boiler for cofiring biomass and other wastes along with coal-based fuels is feasible and that there is flexibility in the biofuel blends that can be handled.

4.0 CONCEPTUAL DESIGN

4.1 Overview

Penn State's OPP has developed a transition plan for building a new power plant that addresses the remaining life of the existing boilers, existing environmental issues, and projected steam demands. The transition plan involves a phased approach to install new coal-fired capacity and retire old boilers, both gas/oil and stoker systems.

The design concept for the new facility is based on installing three CFB boilers, each 200,000 lb steam/h, at the East Campus Steam Plant. The Phase I CFB will cofire biomass and coal and be used for campus heating needs. The ensuing phases (Phases II and III) will fire coal only and be upgraded to power production. During Phase II, the first CFB will also be converted to power production mode with minimal boiler modifications. The current target dates of operation are:

- Phase I – 2010
- Phase II – 2015
- Phase III – 2020

Foster Wheeler and Parsons teamed together and prepared a preliminary design and cost estimate of the new facility. Details of the design, including GA drawings, P&ID's, equipment and circuitry descriptions, and boiler performance predictions, along with a summary of the costs were provided to Penn State (Foster Wheeler 2002). In general terms, Foster Wheeler was responsible for the boiler island and Parsons was responsible for the balance of plant work.

The first phase consists of the first boiler and the common facilities required to allow economic expansion to the second and third phase. These common facilities include the steam and condensate piping to the existing loops, and the coal, limestone, and ash silos. The stack includes three flues to accommodate the three phases.

The first phase includes a CFB boiler capable of burning coal and biomass. Steam is generated at 250 psig and 540°F. The boiler in the first phase includes pressure parts capable of generating steam at 950 psig and 950°F.

The second phase includes a CFB boiler capable of burning coal and generating 200,000 lb steam/h at 950 psig and 950°F. In the second phase, the first boiler will be converted to the higher steam pressure and temperature. The second phase includes the addition of a back-pressure steam turbine generator capable of generating 14.5 megawatts. The steam turbine receives steam at 950 psig and 950°F and exhausts steam at 250 psig and 540°F.

The third phase includes a CFB boiler capable of burning coal and generating 200,000 lb steam/h at 950 psig and 950°F and the addition of a second back-pressure steam turbine generator capable of generating 7.2 megawatts.

The maximum biomass blend expected in Phase I is approximately 20% by heat input and 47% by weight, as discussed in Section 2.2. About half (≈10% by heat input) of this biomass is wood products, with the balance comprised of dairy manures (≈5% heat input) and other wastes. In general, at the low percentages of biomass and resulting alkalis, the fouling and corrosion potential is minimized. This is especially true in the low temperature (540°F) steam outlet conditions for the Phase I CFB boiler. In addition, the modeling performed in Section 3.2 indicates that agglomeration potential is low.

For the upgrade to power generation in Phases II and III, the fouling and corrosion potential is still low. Foster Wheeler has placed the high temperature final superheater (950°F) in the furnace to further mitigate any concerns. The high concentration of recirculating solids in the furnace has a “cleansing” effect on the heat transfer surface which keeps high alkali/chlorine content deposits off the high temperature surface.

The elevated levels of moisture and the odor of some of the biomass create a concern with the handling of biomass. The design and materials selection of the unloading and conveying equipment has been made to counter these concerns. A fully enclosed conveyor was selected to handle the multitude of moisture contents and fuel consistencies. The enclosed conveyor also reduces the potential odor areas to only the loading and unloading areas. Live bottom biomass fuel bins ensure the flowability of the fuel out of the bins. The live bottom consists of automated screws integral to the bins. In addition, bin height is kept to a minimum to prevent material compaction. Finally, stainless steel feed chutes ensures a smooth surface for the passage of biomass to the furnace.

A plan view of the three-boiler layout at the ECSP is shown in Figure 4-1. Figures 4-2 and 4-3 are the plan view and side view, respectively, of the first CFB boiler and auxiliaries.

4.2 Boiler Island Description

This section summarizes the equipment in the boiler island. Detailed descriptions, design basis, performance, and drawings are contained in the design package from Foster Wheeler (Foster Wheeler 2002).

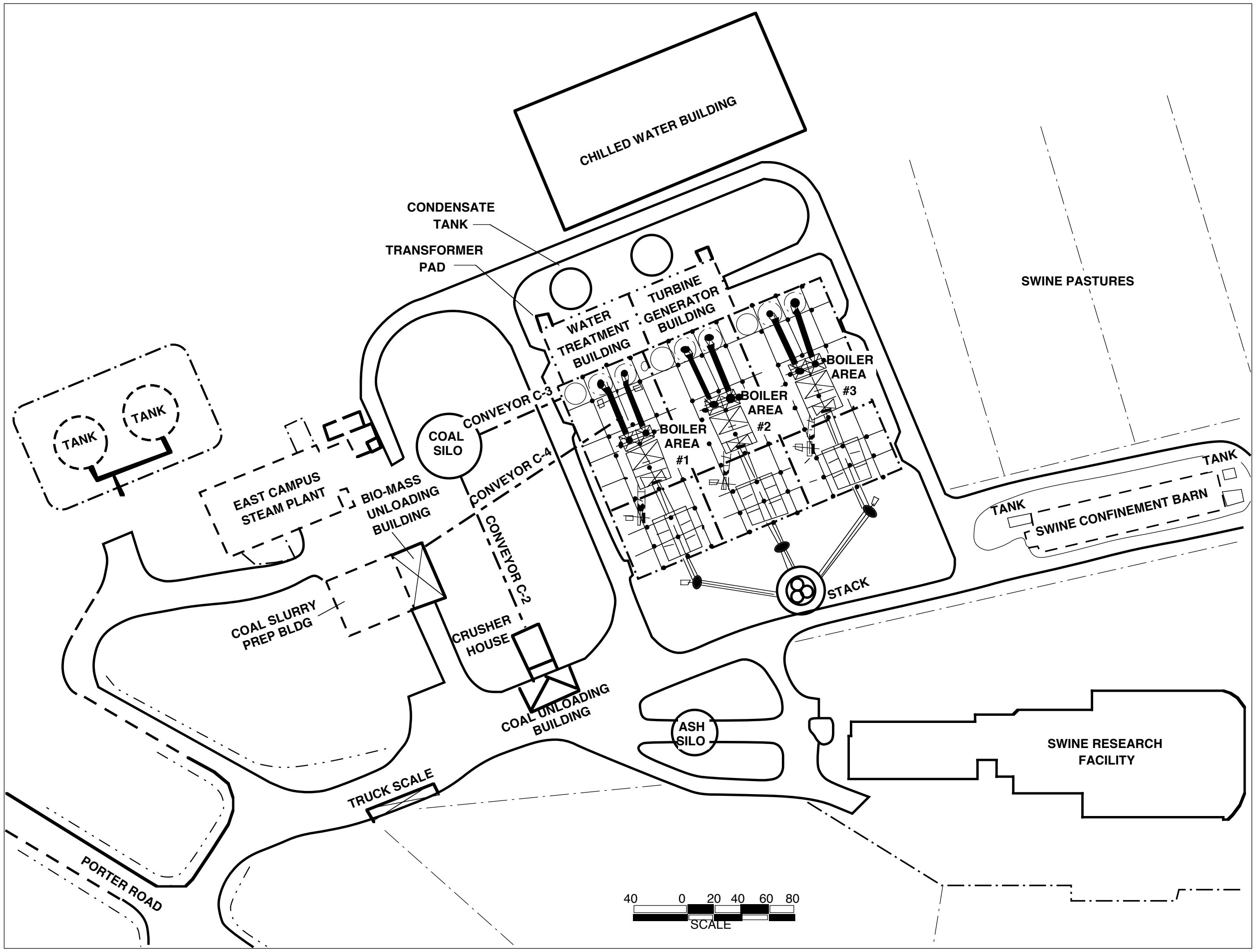


Figure 4-1. PLAN VIEW OF THE THREE-BOILER LAYOUT AT THE EAST CAMPUS STEAM PLANT

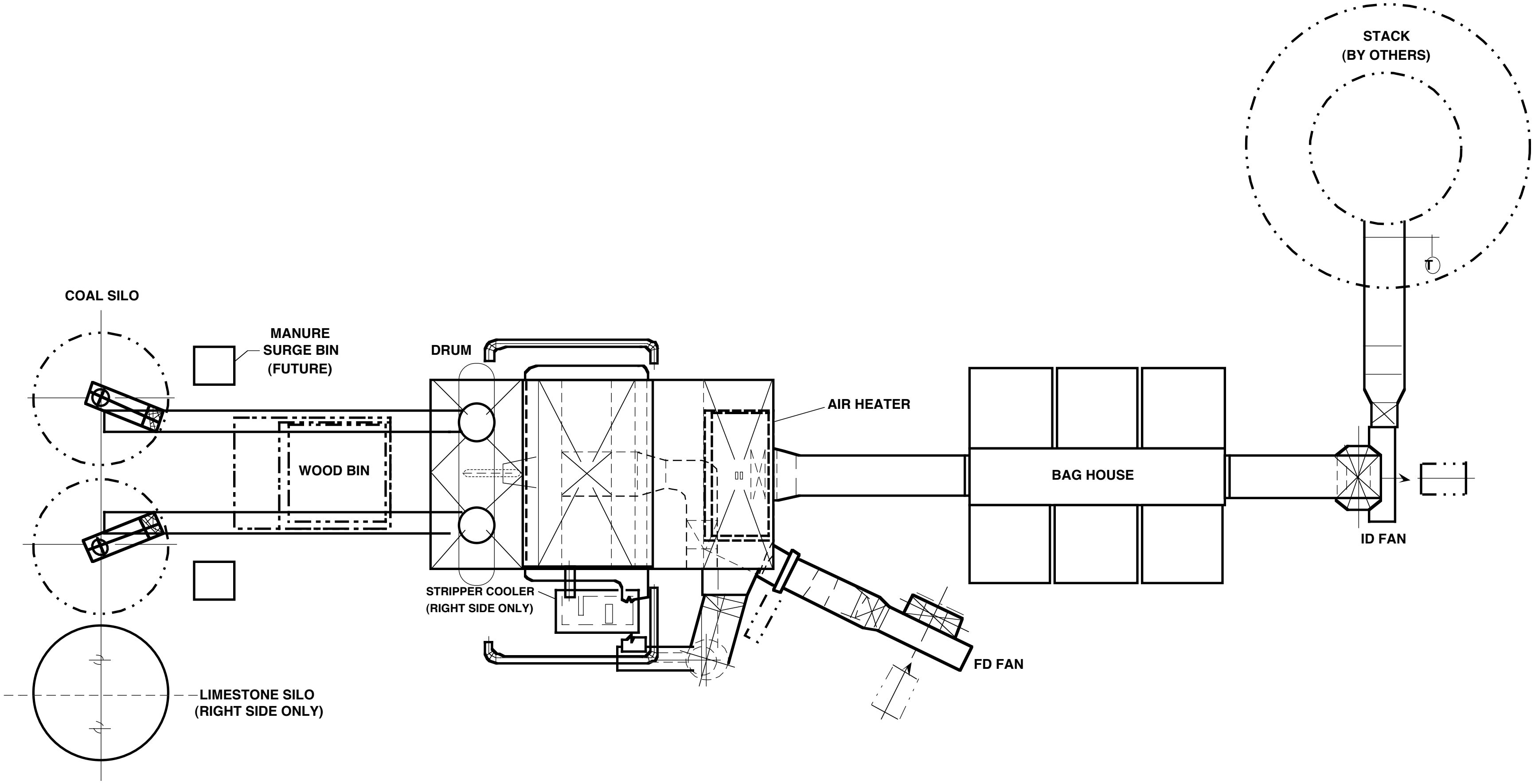


Figure 4-2. PLAN VIEW OF THE PHASE I CFB BOILER AND AUXILIARIES

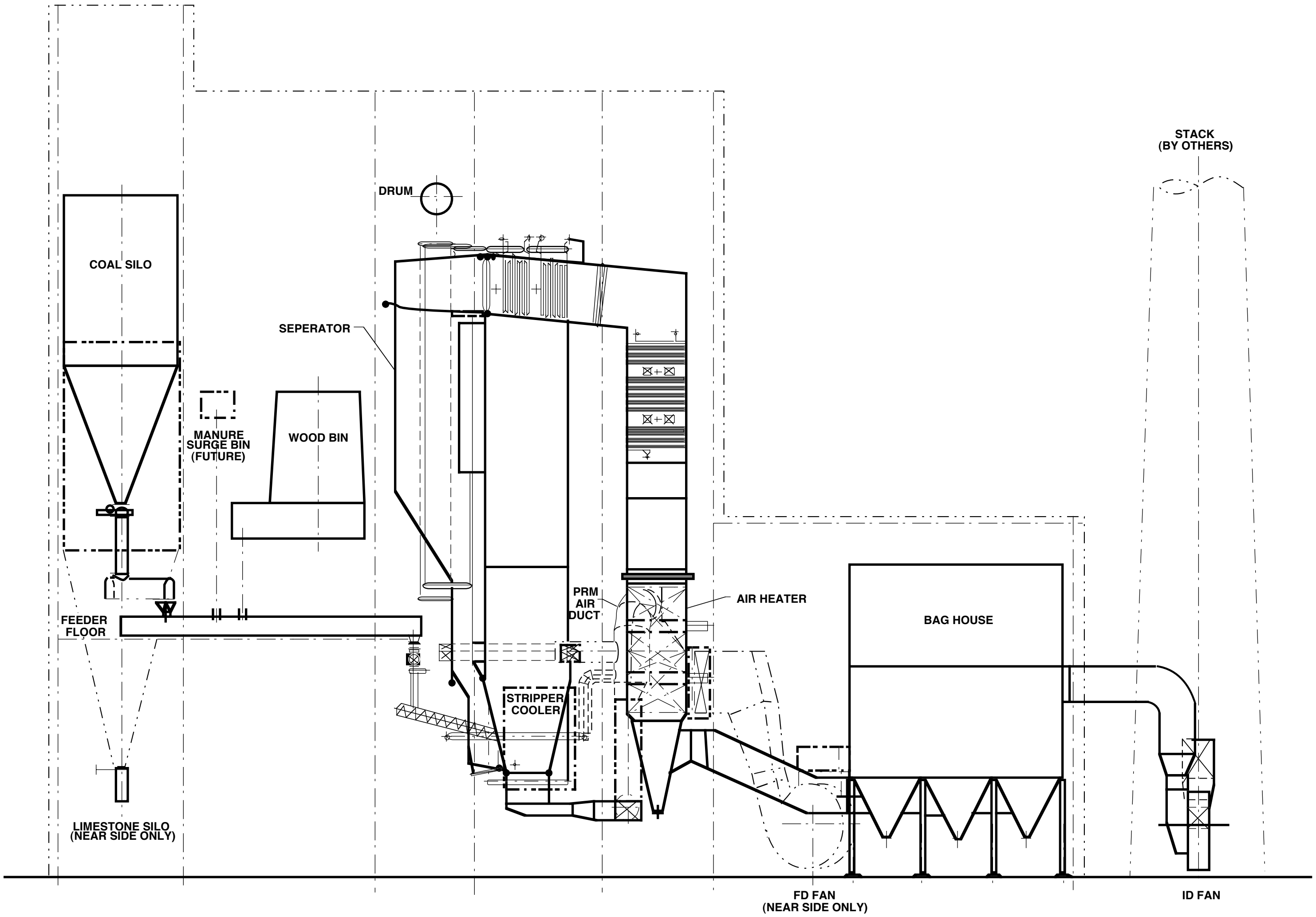


Figure 4-3. SIDE VIEW OF THE PHASE I BOILER AND AUXILIARIES

Foster Wheeler's Compact atmospheric CFB boiler (see Figure 4-4) was used in the plant design. This technology is based upon Foster Wheeler's proven atmospheric circulating fluidized bed combustion process.

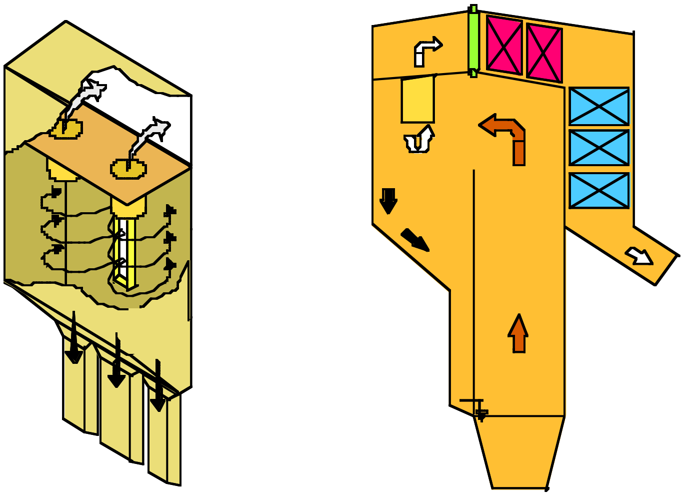


Figure 4-4. FOSTER WHEELER'S COMPACT ACFB BOILER

The key to the CFB boiler is its Compact separator, which is Foster Wheeler's state-of-the-art development to minimize plant capital and operating costs. The Compact separator is best described as a "square cyclone". The round refractory-lined plate cyclone of the traditional CFB is replaced with a rectangular separator. The separator, which is joined to the furnace without expansion joints, is fabricated with flat walls constructed from conventional water-cooled membrane panels and covered with a think refractory lining. Center gas inlet and gas outlets towards the sides impart a swirl to the gas and solids, allowing for solids separation just as in a cyclone. The Compact separator has been proven in over 20 commercial applications worldwide and the units in operation have demonstrated very high availability since start up. The Compact separator provides:

- the same proven reliability and performance demonstrated by over 150 Foster Wheeler atmospheric CFB units worldwide;
- the same fuel flexibility – all grades of coal, peat, wood waste, lignite, petroleum coke, sludge, bituminous gob, anthracite culm, tires, and bagasses; and
- the same clean-burning process resulting in air emissions which meet even the most stringent regulations in California.

4.2.1 Equipment

The boiler island for Phase I consists of the following main components:

- Compact CFB boiler with the following key features:
    1) Water-cooled compact separators
    2) Bare-tube economizer
    3) Steam drum
    4) Two convective superheaters
    5) Tubular air heaters
    6) Associated flues, ducts, and fans
    7) Top supported
- Pulse-Jet type baghouse for particulate control
- Two (2) coal day silos – 24 hour storage
- One (1) live bottom wood bin – 8 hour storage
- Two (2) future live bottom manure bins – 20 minute retention time
- One (1) limestone storage silo – 5 day storage
- Coal/biomass/limestone feeds, valves, and feed chutes
- One (1) bottom ash stripper cooler
- One (1) bottom ash handling system
- One (1) fly ash handling system
- One (1) ash storage silo – 5 day storage upon completion of Phase III (15 days Phase I and 7.5 days Phase II)
- One (1) bottom ash hydration system – reduces limestone consumption up to 20%
- Two (2) oil fired start-up burners – 50% MCR capacity
- One (1) concrete stack – with three inlet flues

Phase II of the CFB plant will add an additional 200,000 lb steam/h compact CFB boiler for power generation. Unit 1 will require the retrofit of a third superheater, located within the furnace as wing wall surface, to achieve the desired power operation. Biomass will only be fired in Phase I (Unit 1); therefore, there will be no biomass feed systems for Phases II and III. Also, the Phase I base CFB will fire only wood product biomasses. The retrofit of the manure and other biomass receiving, handling, and feed system will be part of the test program and cost discussed in Section 5.0.

4.2.2 Emissions

The CFB plant will utilize the following technology in order to meet the following predicted air emissions:

- NO_x emissions generated will be controlled to 0.20 lb/MM Btu utilizing the CFB combustion process that generates low NO_x emissions. Use of a NO_x reduction system (selective catalytic reduction; SNCR) is not required to meet the specified NO_x emissions for this project. To meet a future 0.10 lb/MM Btu limit, a simple SNCR can be installed utilizing urea or ammonia as the reagent.

- SO_x emissions will be controlled to 95% SO_2 capture (0.15 lb/MM Btu) by injecting prepared limestone into the CFB combustion process.
- CO emissions will be controlled to 0.15 lb/MM Btu utilizing the CFB combustion process, which generates low CO emissions by ensuring an even distribution of fuel in the furnace.
- Particulate emissions will be controlled to below 0.039 lb/MM Btu by passing the flue gas through a fabric filter baghouse prior to discharge to the exhaust stack.

4.2.3 Materials Handling and Balance-of-Plant Systems

The plant will be arranged to receive the coal and biomass by truck, which will be unloaded at the respective receiving building (see Section 4.3 for more details). Prepared limestone will be delivered by truck and blown to the prepared limestone storage via truck-mounted blowers.

The ash handling system will be designed to remove the bed and fly ash from the CFB and pneumatically convey the ash to a combined bottom/fly ash silo equipped with truck unloading equipment. The economics of segregating the bottom and fly ash to increase the potential for ash sales was weighed against the extra cost for an additional silo. Foster Wheeler selected a single silo to lower the capital cost. This can be revised at a later date if Penn State requires separation of ash.

The balance of plant includes systems for feedwater, closed cooling water, auxiliary steam, process steam, condensate, water treatment/supply, compressed air, fire protection and wastewater.

4.3 Fuel and Fuel Handling Systems

4.3.1 Overall Fuel Handling System

The fuel handling system for this design is comprised of separate coal and biomass systems. These two systems are separate and distinct and only meet local to the boiler. At the boiler, the biomass is mixed in the fuel feeder before being dropped together into the furnace via two (2) fuel chutes and screws. The systems are designed with the following general guidelines:

- Unit 1 will cofire biomass and coal;
- Units 2 and 3 will only fire coal;
- The coal handling system (receiving, crusher house, long-term silo) is sized for all three (3) units; and
- The biomass handling system:
  1) Is sized for one (1) unit only, Unit 1.
  2) The base biomass handling system is designed to receive, process, and convey both sized and unsized wood products (wood shavings, wood chips, and pallets).
  3) The optional future biomass system is designed to receive, process, and convey manures, Reed Canary grass, and sized plastics. This

system will be installed at a later date after start-up to fire alternative biomass fuels (see test program in Section 5.0).

4) Future liquid biomass feeds, such as swine waste, will be stored in a separate tank, pumped to the boiler house, and sprayed on the solid fuel just before the furnace feed chutes. This system will also be installed at a later date after start-up to test fire these alternative fuels.

4.3.2 Coal Handling System

Coal delivery will be by truck. Some specifications of the coal handling system are provided in this section with additional details in the design package from Foster Wheeler. Coal will be delivered 2 inch x 0 with no intermediate sizes removed and no more than 20% passing a 1/4-inch screen.

The coal handling system is based on the following rates, capacities, and frequencies. The firing rate per boiler is 12 tons/h (future mode, 100% coal firing). The truck unloading rate is 90 tons/h. The coal crushing rate is 90 tons/h (2 crushers @ 100% capacity. The coal feed rate to the day bins is 70 tons/h.

In Phase I, one week’s supply of coal will be unloaded in three 8-hour days. In Phase II, one week’s supply of coal will be unloaded in six 8-hour days. In Phase III, one week’s supply of coal will be unloaded in six 12-hour days. The coal day bin will be filled in 4 hours in Phase I, 8 hours in Phase II, and 12 hours in Phase III.

Coal storage in the long-term silo is 105,000 cubic feet active capacity. This equates to 200 hours of storage for Phase I, 100 hours for Phase II, and 67 hours for Phase III. Coal storage in the two (2) day bins totals 15,000 cubic feet or 24+hours.

The coal handling system utilizes pocket (steep-incline) belt conveyors, variable-speed belt feeders, magnetic separator, enclosed conveyor galleries, crusher house, unloading building, and dust collection.

The materials of construction are industrial grade and include stainless-steel liners at coal impact areas. The coal unloading building and crusher house have aluminum box-beam siding. The long-term coal storage silo is concrete. The day silos are lined with stainless steel in the conical portion. The furnace feed chutes are made of stainless steel.

The equipment downstream of each coal day silo consists of:

- a gravimetric feeder (capacity of 15 tons/h) for weighing the coal;
- a volumetric feeder (capacity of 15 tons/h) for allowing the biomass fuels to be introduced to the coal; and
- a rotary airlock, screw feeder, and furnace drop chute/screw feeder.

4.3.3 Biomass Handling System

4.3.3.1 Biomass Receiving

The biomass will be unloaded in the biomass unloading building. The unloading locations will depend on the type of biomass being delivered. The base system will consist of unloading hoppers #1 and #2 for receiving the wood products. The optional future system will require a building annex with the unloading hopper #3 for receiving manure, grass, and other biomass. The optional future system will also require a pump and piping for transporting the swine waste from Penn State's current storage tank to the boiler house.

Hopper #1 will direct unsized material such as pallets to a wood hog for sizing. This hopper will be fed with a front-end loader. Wood hog will be sized to assure uniform product. Material will discharge from the wood hog to a belt conveyor (labeled C-4).

Hopper #2 will receive sized material from a walking-floor truck, which will back into position to discharge into this hopper. The bottom of this hopper will be fitted with a vibrating feeder to feed material to the belt conveyor C-4.

Hopper #3 (future installment) will be at floor level to receive manure, grass, and other biomass. This hopper will be provided with a grating and a belt feeder to feed materials to the belt feeder C-4. This equipment will be in an extended annex of the building.

The base unloading building will be approximately 60 feet long, 30 feet wide, and 20 feet high. The future annex for hopper #3 will add an additional 30 feet to the length. At this size, there will be limited storage and the walking-floor truck will be partially outside when dumping. The building can be extended in width should additional receiving storage be needed. The reclaim tunnel that houses conveyor C-4 will be approximately 12 feet wide, 12 feet deep, and the length of the building.

4.3.3.2 Biomass Conveying to the Boiler House

All of the biomass feeds will be transferred to the boiler house via a totally enclosed Sicon belt conveyor (C-4) rated at 50 tons/h. The Sicon is an innovative conveyor that is ideal for conveying wood chips and the variety of future materials expected for the plant. The Sicon consists of a totally enclosed belt held between two guide/support rollers. The belt is folded to form a closed, pear-shaped bag, which holds the material. The advantages of this conveyor include:

- the ability to maneuver around tight corners and climb steep inclines without transfers;
- the flexibility of multiple loading and unloading discharge points;
- low noise and odor level; and
- elimination of dust and spillage.

4.3.3.3 Biomass Storage and Handling Local to the Boiler

The Sicon conveyor will carry and deliver the biomass to the single wood live-bottom bin or the two (2) future live-bottom manure bins. From the live-bottom discharge screws in the bins, the biomass drops onto the coal volumetric feeder and then into the air-assisted furnace feed chutes and screw feeders.

4.3.3.4 Overall Biomass Feed System Listing

Details of the biomass feeding system are contained in Foster Wheeler's design package (Foster Wheeler 2002). A listing of the items includes:

- unloading building;
- wood hog, 150 tons/h;
- wood hog inlet hopper #1;
- vibrating feeder;
- truck unloading hopper #2 (to receive sized material from walking-floor trucks);
- vibrating feeder;
- manure unloading hopper #3 (future);
- belt feeder (future);
- Sicon biomass conveyor C-4, 50 tons/h;
- magnetic separator;
- live-bottom wood bin, 3,900 cubic feet (8 hours storage);
- two (2) live-bottom manure bins, 100 cubic feet (20 minute storage) each;
- two (2) screw feeders, 50 tons/h;
- dust collection at screen/hog area; and
- electrical devices including zero-speed switches, E-stop pullcord switch, belt alignment switches, chute plug switches, start-up warning horns, and local pushbutton stations.

5.0 PRELIMINARY TEST PROGRAM

5.1 Introduction

A preliminary test plan has been prepared. If the decision is made to proceed with the CFB boiler and the test program is funded by an agency such as DOE, a detailed test plan will then be generated. The test program will be a combined engineering – agriculture – science effort. The primary participants (*i.e.*, the project team) will be personnel from OPP, The Energy Institute, College of Agriculture's farm services, and Foster Wheeler.

5.2 Purpose

The objective of the preliminary test plan is to establish a viable multifuel cofiring test program in support of OPP's desire to replace its aging coal-fired fleet of stoker boilers with an environmentally friendly CFB boiler. The test program will demonstrate the combustion impacts of multifuel cofiring on the CFB boiler with particular attention to the operational and environmental impacts, as well as issues related to the biofuels themselves. The following operational impacts on the boiler and associated equipment will be evaluated:

- Capacity (ability to meet campus steam demands);
- Efficiency (unburned carbon, air heater exit temperature, excess air requirements, and other losses);
- Heat transfer surfaces;
- Slagging and/or fouling;
- Erosion and/or corrosion;
- Combustion and operational stability and reliability;
- Bed material inventory including quality and sizing;
- Limestone consumption;
- Fly ash and bottom ash collection and removal, and chemical composition and characteristics for commercial uses;
- SCR catalyst life, potential for biofuel constituent poisoning;
- Overall system economics; and
- Additional test and measurement equipment.

Environmental impacts or pollutants that will be evaluated include:

- NO_x;
- SO_x;
- CO_2;
- CO;
- Particulate matter;
- Opacity; and
- Trace elements.

Issues related to the use of the biofuels will also be evaluated. These include:

- Supply reliability;
- Consistency/quality;
- Transportation – logistics/costs/pollution;
- Storage;
- Preparation;
- Handling – getting the biofuels into the unit; and
- Procurement structure for external biofuel supplies.

5.3 Program Duration and Description

The test program schedule is for eight years and contains fundamental and pilot-scale support and full-scale demonstration and testing. Figure 5-1 shows the schedule for the boiler design, construction, and operation as well as the fundamental and pilot-scale support. There will be a three-year period starting upon award of the CFB boiler plant

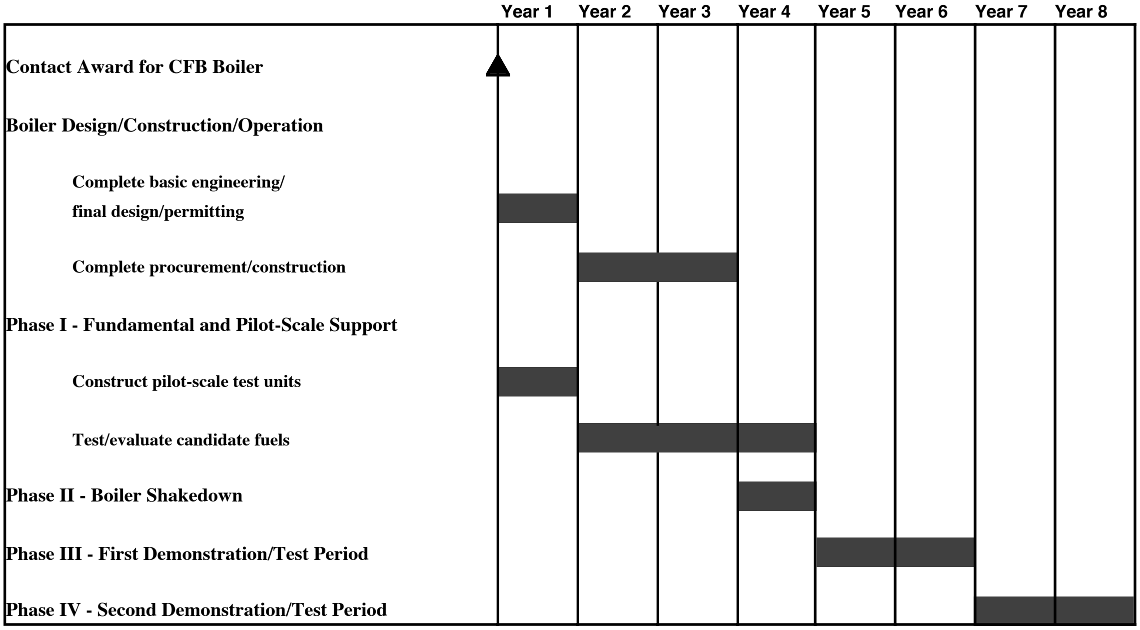


Figure 5-1. **SCHEDULE FOR BOILER DESIGN, CONSTRUCTION, AND DEMONSTRATION TEST PERIODS**

contract where the basic engineering, final design, and permitting will be completed during Year 1 and the procurement and construction will be performed during Years 2 and 3. This will be followed by a one-year period of boiler shakedown firing coal and testing various components (Year 4) and two two-year periods of demonstration and testing (Years 5 and 6 and Years 7 and 8). In addition, fundamental and pilot-scale activities will be performed in support of the demonstrations. These will be conducted during Years 1 through 4. For ease of discussion, the test program is presented in four phases:

- Phase I – Fundamental and Pilot-Scale Support;
- Phase II – Boiler Shakedown;
- Phase III – First Two -Year Demonstration/Test Period; and
- Phase IV – Second Two -Year Demonstration/Test Period.

5.3.1 Phase I – Fundamental and Pilot-Scale Support

Fundamental and pilot-scale support activities will be performed in support of the demonstrations/testing. The activities will include constructing two or more pilot-scale FBC test units to perform a series of studies including, but not limited to, cold-flow modeling, combustion performance and emissions evaluations, deposition and agglomeration assessments through testing and modeling, detailed fuel characterizations (*e.g.*, chemical fractionation analysis), and fuel evaluations. These activities will be performed during Years 1 through 4 and will be performed by a combination of graduate research assistants, faculty, and staff from The Energy Institute and Farm Services.

It is the intent that during the initial stages of the program, all potential fuels will be evaluated at the pilot-scale before use in the full-scale CFB. This is the modus operandi that The Energy Institute has operated under when performing similar programs for government/industry-funded projects, which consist of demonstration-scale testing in the field (*e.g.*, 35 MW_e cogeneration facility to evaluate sorbent performance of a suite of limestones and dolomites (Morrison *et al.*, 1994)) or using Penn State's demonstration boiler system (*i.e.*, 20 MM Btu/h boiler system integrated in to the University's steam distribution system used to evaluate various coal-based fuels (Miller *et al.*, 1997a; Miller *et al.*, 1997b; Miller *et al.*, 2000a). In both cases, either a bench-scale CFB or a pilot-scale boiler (*i.e.*, 2 MM Btu/h firing rate) were used to ensure that no major complications would be encountered at the larger scale, whether it was system performance or Pennsylvania Department of Protection regulatory compliance. This is especially important in the proposed project since the CFB boiler will be one of Penn State's base-loaded units.

5.3.2 Phase II – Boiler Shakedown

Boiler shakedown will be performed for a period of six months to one year (Year 4 of the test program). This time will be used to shake down the boiler and its related system components, and refine any system components, if required. This time period will also allow the plant operations personnel (*i.e.*, OPP personnel) to become familiar with the boiler and its related system components, and to establish a database archive for coal combustion. As part of this database archive, a full load performance test including stack testing, sampling (coal, limestone, fly ash and bottom ash sampling) and analyses while firing only coal will be conducted prior to commencing the biofuel testing.

It is essential that the existing biofuel transportation, storage, and preparation process investigations and testing take place during this time. This will include bench- and pilot-scale testing (see previous section) at Energy Institute facilities as well as at the new boiler installation site. In addition, computer modeling of the various process parameters will also be conducted on campus at various support facilities. The University's diverse professional staff and graduate students will be used to support these efforts as well as outside expertise from Foster Wheeler.

The ability to add a by-pass flue gas duct upstream of the baghouse has been included in the basic design of the unit to test the affect of the biofuels on the operation and reliability of emission reduction systems. This duct will be used to allow for either slipstream and/or full-scale testing of various emissions reduction systems such as advanced SCR systems, wet/dry scrubbers, and various barrier (including ceramic) filter systems.

Foster Wheeler will be retained to perform continuing support to the University during the test period, specifically when plant modifications and/or upgrades are required.

5.3.3 Phase III – First Two-Year Demonstration/Test Period

Phase III will be for a period of two years (Program Years 5 and 6) to determine the various mixtures of fuels that can be combusted in the CFB boiler without affecting the unit's reliability to produce steam for the campus. During this phase, there will be a more extensive investigation into the biofuels preparation, storage, and conveying systems, in addition to focusing on the various mixtures, methods and quantity of biofuels to inject into the combustion zone of the boiler. The fuels tested in this phase will primarily include those identified in the feasibility study.

5.3.4 Phase IV – Second Two-Year Demonstration/Test Period

Phase IV is schedule for a period of two years (Program Years 7 and 8). Again, testing of various mixtures of biofuels with coal and/or other waste fuels will be conducted, but as the University's experience base grows, so will its ability to combust more difficult fuel mixtures that may or may not affect the boiler's reliability. These fuels will be selected in conjunction with DOE and may be shipped in from outside of the region. Currently OPP is considering that, at the end of this second test period, a second CFB boiler will have been brought on line to allow the University a greater flexibility in its future test program.

5.4 Operational/Design/Reporting Assumptions

5.4.1 Operational Assumptions

The CFB boiler will be maintained and operated by OPP. University professional personnel and graduate students, primarily from The Energy Institute and the Energy and GeoEnvironmental Engineering Department (both within the College of Earth and Mineral Sciences) but also from the College of Agricultural Sciences, will support OPP personnel during testing. However, as with any testing at Penn State, when funded research/testing is being performed for a sponsor, they may have some of their own technical personnel present during the test period. In addition, Foster Wheeler will assist in the program as a project consultant/advisor.

OPP has dictated that the CFB boiler must reliably produce steam per the campus demands. Therefore, OPP has placed the following conditions on any testing that might be conducted on this new unit:

- Testing can not impair the operation capability or reliability of the CFB boiler to meet the campus steam requirement;
- Testing must by controlled by OPP and testing will be delayed or halted for any reason, if in OPP's opinion, the unit will not be able to meet its obligations to supply steam to the campus;
- Unless a variance is issued, no testing can be commenced that will potentially violate the operating permit for this unit;
- All test programs will be reviewed and approved by OPP prior to their initiation; and
- Strict monitoring procedures of the unit's emissions will be adhered to and recorded.

It should be noted that all testing will be done in a systematic manner following specific rules and regulations as agreed upon between OPP and the program manager with input from other members of the project team. Prior to performing any test, a test matrix will be developed and agreed to between all of the parties including DOE. This is to ensure that the scope of work to be accomplished during each test has the greatest chance of success, minimizing the potential for costly errors and accidents.

All testing will be conducted to avoid potential upsets in the boiler's operation. The testing will commence with coal firing only. The unit will be stabilized at a load less than its MCR rating. The unit is to operate at this point for a minimum period (usually 8 hours) and a set of baseline data will be taken. Following this period the biofuel(s) to be tested will be introduced into the boiler at minimum quantities and gradually increased to the maximum amount agreed to for the test campaign. Following completion of the test period, the biofuel(s) will be gradually backed out until the minimum amount is reached. At that time, the unit will again be fired only on coal for a minimum period (usually 8 hours) and another baseline set of data taken.

Whenever possible, data acquisition will be done by an automated system. Sampling of fuels, limestone and ashes will be conducted by trained University personnel, either staff from The Energy Institute or OPP operational staff. The following typical data and samples will be collected during each test campaign:

- Electronically available data from the system controls and data logger;
- Manually collected data from the control room or locally mounted instrumentation not normally collected by the data logger;
- Fuel samples – coal and all biofuels;
- Limestone samples; and
- Fly ash and bottom ash samples – besides the standard oxides, the ash samples will be tested for trace element including arsenic, chromium, lead, mercury, nickel, and selenium.

5.4.2 Design Assumptions

There are specific limitations to the existing CFB unit design as to the variety of biofuels that can be combusted with the present configuration. The CFB boiler plant is designed to receive, store, process, and handle the base fuel, *i.e.*, coal, in addition to the limestone, fly ash, and bottom ash. Additionally, a simple biofuel feed train consisting of a wood storage silo with double outlet screw feeders has been designed as part of the base system. The screw feeders dump the wood fuel onto either of the two coal conveyors. These conveyors direct the fuel mixture through rotary valves directly into the CFB boiler combustion chamber (Section 6.1, Table 6-2).

Any additional biofuel feed systems requirements will be designed, purchased, constructed, and commissioned as a part of that specific test requiring a modification and/or addition to the existing biofuel feed systems. Thus, the costs to perform such tests must also include the cost for the biofuel feed system modification and/or addition. For example, the manure feeding systems with multiple feeders (*e.g.*, swine waste and solid manures) are part of the proposed test program and their cost estimates are contained in the budget section.

Special materials for erosion and/or corrosion testing including test coupons, slagging and fouling probes, heat flux meters, *etc.* must be funded as required for each test that requires such items. This would also include any modifications and/or additions for any existing or new controls and instrumentation. Again, since these are proposed in the test program, their estimated costs are contained in the budget section.

As mentioned previously, the unit has been designed and laid out to accommodate the addition of an emission reduction system prior to the baghouse. There are two stub duct sections designed into the existing unit's outlet ducting (upstream of the baghouse) that will allow for either full or slip-stream system testing without affecting the integrity of the CFB boiler to maintain its full load capabilities. Presently, it is envisioned that the following emissions reduction testing will take place:

- Honeycombed microfiltration membrane coated barrier filter system – for simultaneous particulate matter and trace element emissions reduction – specifically mercury and lead;
- Advanced SCR system – testing of poison resistant catalyst for NO_x control with units cofiring coal and various biofuels; and
- Electrostatic Precipitators (ESP) – affect on collection efficiency when cofiring coal and various biofuels.

As with the biofuel feed systems and advanced instrumentation packages, the costs of the components for the emissions reduction testing have been determined separately from the base unit and contained in the budget section (Section 6.2).

5.4.3 Reporting

The project team, under the direction of the program manager, will be responsible for all customer contact as it relates specifically to the preparation and issuance of any test reports. The program manager and project team are responsible to ensure that all required data and sampling is conducted during each test period as required to fulfill all test and contractual requires. Sufficient data will always be collected to allow for a heat and material balance closure to be performed for each test.

The unit will be inspected (if at all possible) following any major testing phase. This is vital to understand the affects of the biofuels as to slagging and fouling, as well as erosion and corrosion. Note that sootblowing will be kept at a minimum or stopped all together to help define any accelerated rate of slagging or fouling within the unit.

The plant operators and maintenance staff will also keep a daily shift log to record the unit's (including auxiliary equipment) operational characteristics and maintenance requirements. These might be subjective or quantifiable observations, but they will be recorded for future comparison to the operational teat data. Daily shift logs will also be kept for the biofuel related components, *i.e.*, transportation, storage, preparation, and handling systems.

6.0 SYSTEM/PROGRAM ECONOMICS

6.1 System Cost Summary

Cost estimates were prepared by Foster Wheeler for the three-boiler system, power upgrade, and future biomass facilities. The cost estimates are summarized in Tables 6-1 and 6-2.

Notes relevant to Foster Wheeler's cost estimates are:

- the costs are budget estimates and not an offer to sell;
- the costs are presented as present day with no escalation included;
- any insurance, taxes, permits, and bonds are excluded;
- utilities for construction must be provided by Penn State;
- water supply must be provided by Penn State;
- demolition is excluded;
- removal of any contaminated soil (if present) is not included;
- land acquisition is excluded;

Table 6-1. Cost Estimate for the Three-Phase Boiler System Installation

$ IN MUSD	**Phase I**	**Phase II**	**Phase III**
CFB BOILER			
Boiler Supply	$24.50	$15.10	$15.10
Boiler Construction/Commissioning	$21.00	$21.00	$21.00
TTL CFB	$45.50	$36.10	$36.10
BOP ENGINEERING & SUPPLY			
Mechanical	$7.80	$4.00	$3.20
Civil	$0.50	$0.20	$0.20
Piping	$1.00	$0.60	$0.30
Electrical	$1.60	$0.60	$1.10
I&C	$0.50	$0.40	$0.40
Site Work	$0.30	$0.10	$0.10
TTL Equipment	$11.80	$5.90	$5.30
Home Office Labor	$2.10	$0.80	$0.70
Contingency/Miscellaneous	$2.40	$1.20	$1.10
TTL BOP ENGINEERING & SUPPLY	$16.30	$7.80	$7.10
BOP CONSTRUCTION			
Mechanical Systems	$0.20	$0.70	$0.60
Civil	$1.50	$0.50	$0.50
Piping	$1.70	$1.10	$0.80
Electrical	$0.50	$1.00	$1.00
I&C	$1.20	$0.50	$0.50
Misc	$0.60	$0.10	$0.10
TTL Equipment Construction	$5.70	$3.90	$3.50
Construction & Commissioning Management	$2.00	$2.00	$2.00
Contingency/Miscellaneous	$1.60	$0.90	$0.80
TTL BOP CONSTRUCTION	$9.20	$6.90	$6.30
OVERALL TOTAL	**$71.00**	**$50.80**	**$49.50**

Table 6-2. Cost Estimates for the Options

	OPTION A	**OPTION B**
$ IN MUSD	Power Upgrade	Future Biomass
CFB BOILER		
Boiler Supply	$0.21	$0.62
Boiler Construction/Commissioning	$0.64	$1.20
TTL CFB	$0.85	$1.82
BOP ENGINEERING & SUPPLY		
Mechanical Systems		
Civil		$0.10
Piping	$0.04	$0.05
Electrical		$0.02
I&C	$0.10	$0.10
Site Work		
TTL Equipment	$0.14	$0.27
Home Office Labor	$0.08	$0.15
Contingency/Miscellaneaous	$0.10	$0.10
TTL BOP ENGINEERING & SUPPLY	$0.32	$0.52
BOP CONSTRUCTION		
Mechanical Systems		
Civil		$0.18
Piping	$0.04	$0.05
Electrical		$0.04
I&C	$0.05	$0.05
Misc		
TTL Equipment Construction	$0.09	$0.32
Construction & Commissioning Management	$0.05	$0.25
Contingency/Miscellaneous	$0.10	$0.25
TTL BOP CONSTRUCTION	$0.24	$0.82
OVERALL TOTAL	**$1.41**	**$3.16**

- all building siding and roofing must be provided by Penn State;
- Penn State's cost for project management are excluded; and
- the power upgrade and future biomass equipment costs are on a per boiler basis.

Penn State further refined the project costs by phase to include the items that Foster Wheeler did not address along with several other items. These costs are summarized in the following sections.

6.1.1 Costs for the Phase I Transition

A summary of the costs for the Phase I boiler plant transition, including the biomass storage and handling systems, is:

CFB boiler and auxiliaries	$71,000,000
Biomass systems	$3,160,000
Upsize Curtin road steam line	$6,000,000
Enclose CFB boiler	$1,535,000
Replace #5 boiler (gas/oil) at the WCSP	$3,150,000
Build swine research confinement building	$2,100,000
Electric transformer	$50,000
Support staff area	$1,000,000
Equipment	$300,000
Zoning and environmental permits	$650,000
Penn State Project Management	$2,670,000
Escalation 2003-2006 @ 3% per year	$8,495,000
TOTAL	$100,110,000

6.1.2 Project Costs for the Phase II Transition

A summary of the costs for the Phase II boiler plant transition is:

CFB boiler and steam turbine generator	$51,000,000
Power upgrade for CFB boiler #1 (Option A in Table 6-2)	$1,410,000
Central Chilled Water	$20,000,000
New steam main to campus	$11,500,000
Enclose CFB boiler	$935,000
Install electric substation	$4,500,000
Zoning permit	$258,000
Penn State Project Management	$2,690,000
Escalation 2003-2011 @3% per year	$18,088,000
TOTAL	$116,621,000

6.1.3 Project Costs for the Phase III Transition

A summary of the costs for the Phase III boiler plant transition is

CFB boiler and steam turbine generator	$50,000,000

• Central Chilled Water	$6,000,000
• Enclose CFB boiler	$1,535,000
• Install gas/oil boiler at WCSP	$3,500,000
• Zoning permit	$256,000
• Penn State Project Management	$29,579,000
• Escalation 2003-2016 @ 3% per year	$25,716,000
TOTAL	$92,710,000

6.2 Preliminary Test Program Budget

A preliminary budget was prepared for the test program discussed in Section 5.0. The budget was developed assuming a start date of January 1, 2004 (*i.e.*, contract award for the CFB boiler in Year 1 as shown in Figure 5-1) and includes escalations for each year. The preliminary budget includes faculty, staff, graduate and undergraduate research assistants, tuition, materials and supplies, equipment, and a subcontract to Foster Wheeler for consultation throughout the program. The costs include equipment for slip-stream emissions testing discussed in Section 5.4.2). A summary of the research and development budget is:

• Year 1; construct pilot-scale test units	$1,069,511
• Years 2-4; test/evaluate candidate fuels	$2,161,131
• Years 5 and 6; first demonstration test period	$4,449,922
• Years 7 and 8; second demonstration test period	$1,527,621
TOTAL	$9,208,185

In addition to these costs, Option B from Table 6-2 (and Section 6.1.1), which is the installation of the biomass storage and handling systems, should be included in the test program budget. This cost is $3,453,000 (with escalation).

7.0 CONCLUDING STATEMENTS

The Pennsylvania State University, utilizing funds furnished by the U.S. Department of Energy's Biomass Power Program, investigated the installation of a CFB bed boiler at Penn State's University Park campus for cofiring multiple biofuels and other wastes with coal, and developing a test program to evaluate cofiring biofuels and coal-based feedstocks. The study was performed using a team that included personnel from Penn State's Energy Institute, Office of Physical Plant, and College of Agricultural Sciences; Foster Wheeler Energy Services, Inc.; Foster Wheeler Energy Corporation; Parsons Energy and Chemicals Group, Inc.; and Cofiring Alternatives.

Penn State performed the cost-shared project with DOE in order to explore the possibility of realizing the benefits of a CFB boiler steam plant. The benefits, as identified by OPP, include:

- Continuing the use of coal, which is the most economical and readily available fuel source for Penn State;
- Reducing the airborne pollutants from the combustion of coal;
- Reducing the amount of agricultural and other biomass waste products of which disposl is becoming more difficult and expensive;
- Using waste biofuels, which reduces the amount of CO_2 being emitted; and
- Realizing some emissions credits using a state-of-the-art CFB in place of aging stokers.

The activities included assessing biomass resources at the University Park campus and surrounding region, collecting and analyzing potential feedstocks, assessing agglomeration, deposition, and corrosion tendencies, identifying the optimum location for the boiler system through an internal site selection process, performing a three CFB boiler design, determining the costs associated with installing the boiler system, developing a preliminary test program, determining the associated costs for the test program, and exploring potential emissions credits when using the biomass CFB boiler.

The biomass resource assessment identified the wastes and by-product streams at Penn State along with wood wastes from sawmills and secondary wood processors in the surrounding region. Approximately twenty different biomass, animal waste, and other wastes were identified, collected, and analyzed. These potential feedstocks included the following: animal wastes such as dairy tie-stall and free-stall manure (mixed with leaves and brush to make it stackable), beef manure, horse manure, poultry litter, sheep manure, and swine waste; wood waste and brush; pallets; Reed Canary grass grown on Penn State's wastewater treatment facility's effluent spray field; bottom and fly ash from Penn State's stoker boilers; agricultural plastics including horticulture hard plastics and plastic bags, bale tarps, and silo bunker covers; used oil; tires; wood shavings and chips from the surrounding region; coal/paper pulp pellets from a nearby paper mill; and sewage sludge. Sufficient biomass materials were identified to provide ≈20% of the fuel feed (on a thermal basis) to a CFB boiler without adversely affecting the wood wastes collected from the region (*i.e.*, there will be a low impact on the quantity of wood wastes available for other uses).

A comprehensive evaluation of the effect of the inorganic elements in the fuel feedstocks on agglomeration, deposition, and corrosion was performed. This included bulk analysis, chemical fractionation to identify the solubility of the various inorganic constituents, and thermochemical modeling. The results indicated that a cofire blend of biofuels with an appropriate nonfouling coal should not pose any problems in the CFB system given that the coal makes up a majority of the thermal input. Corrosion, agglomeration, and deposition were shown not to be a problem.

The main OPP office that participated in this study was Engineering Services. However, the study was performed while working closely with OPP's Director of Campus Planning and Design who was responsible for the internal site selection process to identify the optimum site for the boiler system. This was done employing a formal procedure that is used for siting any new construction project. In addition, the University's master plan (a 20-year forecast/plan) was used to ensure that the site and production capacity of the boiler plant met with the long-range plans. Through this process, it was determined that three boilers were needed and a 15-year boiler plant transition plan was developed. It was decided to incorporate three CFB boilers into the transition plan.

The three CFB boiler system, based on the boiler plant transition plan, was designed and costed by Foster Wheeler with assistance from Parsons. The design was based on the installation of a CFB boiler every five years with the first boiler capable of cofiring coal and biomass. Foster Wheeler's Compact atmospheric CFB boiler was used in the plant design. OPP used Foster Wheeler's costs when determining the overall costs for the boiler plant transition plan.

A multiyear test program was also developed as part of the study. This preliminary program included fundamental, pilot-scale, and demonstration-scale testing. The boiler has been designed to accommodate special materials for erosion and/or corrosion testing including test coupons, slagging and fouling probes, and heat flux meters. The system has been designed to accommodate the addition of an emissions reduction system (*e.g.*, ceramic or metallic filters, advanced SCR systems, and ESPs) prior to the baghouse. There are two stub duct sections designed into the existing unit's outlet ducting (upstream of the baghouse) that will allow for either full or slip-stream testing without affecting the integrity of the CFB boiler to maintain full load capabilities.

A preliminary investigation into emissions credits and other benefits to the University was conducted. Reductions in NO_x, SO_2, and CO_2 will be realized through the installation of the CFBs and phasing out of the stokers. For example, when the first CFB boiler is brought on line, there will be reductions of 97, 1,700, and 49,820 tons of NO_x, SO_2, and CO_2 each year, respectively.

NO_x emissions will decrease from 310 tons/year to 213 tons/year when the first CFB is brought on line and the equivalent of two stoker boilers are removed from service. Since New Source Review will not be triggered, this reduction of 97 tons translates into \$776,000 of NO_x credits (using a conservative value of \$8,000/ton of NO_x). Similarly, when the second CFB is brought on line, the equivalent of two stoker boilers will be removed from service and there will be an additional 95 tons of NO_x net decrease. Using the same credit of $8,000/ton of NO_x removed, which is likely to be very conservative for actions tens years in the future, translates into a credit of $760,000.

Credits for SO_2 will also be allowable although the value of SO_2 credits is much lower than NO_x credits. SO_2 emissions will be reduced by ≈1,700 tons/year with a potential credit of ≈$234,970/year (based on a December 2002 allowance price of $138.22/ton). As regulations for reducing SO_2 emissions continue to be implemented (*e.g.*, consequence of Clear Skies Initiative or future fine particulate regulation), it is likely that SO_2 allowances will increase over today's prices.

Emission credits for CO_2 and possibly mercury are unknowns at this time. However, it is very likely that they too will have economic value in the not too distant future. For example, mercury removal has been valued at $1,000/ton removed (and may even be higher). It has been documented that mercury emissions from CFBs are extremely low with the mercury being tied up in a stable form in the ash (ARIPPA 2002). CO_2 banks have been set up in Europe and one will begin operation in Chicago (*i.e.*, Chicago Climate Exchange) in March 2003 with American Electric Power as one of the founding members (AEP 2003). Estimates of CO_2 credits vary (from $1 to $800/ton) but if a value of $6/ton (current price in Europe) is used, a credit of $298,920 can be realized from the CFB cofiring 20% biomass.

In addition, Penn State recently performed stack testing on the coal-fired stokers and measured HCl emissions of 120 tons/year. Beginning April 2004, facilities emitting >10 tons HCl/year will be required to install control technology for reducing HCl emissions (*i.e.*, Maximum Allowable Control Technology). This will not be a concern with a circulating fluidized bed boiler however, as they have been shown to retain >99% of acid gases such as HCl [Rickman, *et al.*, 1985].

It was the intention to assess availability of external (to the University) funding for the system and test program when the project was proposed in February 2000; however, this aspect of the project was not performed in detail. Prior to submission of this final report, DOE has determined that cofiring technology is commercial and the Biomass Feedstock Program, one source of potential funding, has been discontinued. In addition, the business and political climates have changed in the last approximate three years, and there is now less emphasis on cofiring biomass. Biomass related activities have shifted to biorefinery technologies. This may change in the future however, should a renewable energy standard/portfolio be passed by Congress as part of an energy bill.

The boiler plant transition plan is currently under internal review. A decision on whether or not to proceed with it, or a modified version of it, will be made at a later date.

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APPENDIX A. POTENTIAL SAWDUST SUPPLIERS – TOTAL LISTING

POTENTIAL SAWDUST SUPPLIERS FOR PENN STATE COMBUSTOR — Selected by Distance

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Correctional Industries PA Dept. Corrections	0	Box A Bellefonte, PA 16823	10		814-355-4874 ext 251	Greg Day
Francis R Bartley	0	RD2, Box 98 Bellefonte, PA 16823	10		814-355-1775	Francis Bartley
H & R Sawmill		RD Julian, PA 16844	10		~~814-863-3049~~	Phone not in service.
Robinson Lumber Company	20	776 Lucas Road Bellefonte PA 16823	10	$15 delivered	814-355-9583	Richard N. Robinson
Thomas Timberlands Enterprises	40/300	Box 5075, Route 26 Pleasant Gap, PA 16823	10	$10.50/13.33 delivered	814-359-2890	BJ & Richard Thomas, sawdust/chips
Dunkelberger Lumber	0	RD1, Box 510 Centre Hall, PA 16828	12		814-366-1012	Out of business
Miller Lumber		RD1, Box 491 Petersburg, PA 16669	14		~~814-667-2478~~	Can t make contact (phone is fax).
Wert Company		474 Gravel Point Road Howard, PA 16841	22		814-625-2168	No answer.
B & S Logging & Lumber		205 Havice Valley Rd, Milroy, PA 17063	23		~~717-667-0050~~	Phone not in service.
Hulburt & Savitts Lumber	0	P.O. Box 14 Reedsville, PA 17084	24		717-667-3306	Stanley Savitts — out of business
Peachey s Wood Products	70	209 Sawmill Road Reedsville, PA 17084	24	$4.25	717-667-9373	John Peachey
Saw-rite Sawmill	30/60	74 Airstrip Drive Millheim, PA 16854	24	$10/$13 delivered	814-349-1210	Sam Stoltzfus, sawdust/chips
Allensville Planing Mill, Inc.	0	108 E Main St Allensville, PA 17002	25		717-483-6386	John Foster
Big Valley Hardwood	0	296 Whispering Oaks Rd, Allensville, PA 17002	25		717-483-6440	Joe Peachey
J M Wood Products	25	HC 61, Allensville, PA 17002	25	$3.00	717-483-6700	Dave Zook
J & S Lumber		1341 Front Mountain Rd, Belleville, PA 17004	26		717-483-6000	
Kaufman s Mulch	0	42 Maple Street Belleville, PA 17004	26	$10.50 delivered	717-667-6317	Pete Kaufman, generates 250 tpw sawdust — would sell excess above that.
Kish Lumber	25	157 Sawmill Road Belleville, PA 17004	26	$2.15	717-667-6157	Dave Byler
Midway Forestry Products		762 Barrville Rd, Belleville, PA 17004	26		717-667-6771	No voicemail — no contact

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Kephart Bros Lumber Co.	50	RD1 Osceola Mills, PA 16666	29		~~814-853-3333~~	Gene & Morris Kephart Phone number incorrect.
W D Krause & Sons, Inc.		Route 53 Osceola Mills, PA 16666	29		~~814-339-7660~~	Wrong number — can t make contact.
Alexandria Wood Products	0	Brickyard Road PO Box 357 Alexandria, PA 16611	30		814-669-4469	E. Gary O Brien
C L Price Sawmill & Planning	40/40	319 W Alley St, Aaronsburg, PA 16820	30	$4.00FOB/ $15.00 delivered	814-349-4431 814-349-5505	C. L., Dennis and Fred Price — sawdust/slabs
McCabe & Sons Lumber	20	HC1 Box 26 Alexandria, PA 16611	30	$4.50	814-832-2046	Roy McCabe
Meeker Lumber Company	40/40	HC 21A Moshannon, PA 16859	30	$2.00/$0	814-387-6342	Bruce Meeker — sawdust/slabs
American Hickory Corp	0	Lewistown, PA 17044	31	$2.00	717-543-6070	Mark Colwell —generates 100 tpw — may consider supplying in future
CHJ Lumber	30	Box 187 Allport, PA 16921	31	$2.00	814-345-5271	Clark Hubler
Donald Hoffmaster	10	Box 290A Huntingdon, PA 16652	32	$0	814-667-2472	Don Hoffmaster
Grove Lumber, Inc.		RD1 Box 188 Huntingdon, PA 16652	32		814-627-2921	Roger Grove
Urbanik Lumber	25/75	Box 195 Clarence, PA 16829	33	$10.00 delivered	814-387-6939	Sam Urbanik — sawdust/slabs
S & S Sawmill		Box 80, Rebersburg, PA 16872	34			Can t make contact.
Swistock Contracting		PO Box 145 Houtzdale, PA 16651	34		814-378-8621	
Phillip’s Wood Products	60	RD 2 Mill Hall PA 17751	37	$3.00	570-726-3515	Carl & Tina Phillips
Byler Brothers Sawmill		RD1, Box 115F Mill Hall, PA 17751	37			Can t make contact.
Independent Lumber	0	RR1 Box 328 Woodland, PA 16881	37		814-857-7143	No longer saws timber.
Max Forcey Lumber Company	0	RR 1 Box 214 Woodland, PA 16881	37		814-857-5002	Terry Forcey, Jr.
Maines Lumber Company	0	RR1 Box 231 Woodland, PA 16881	37		814-857-7751	No longer saws timber.
Pennsy Lumber Products	40	RD1, Box 204A Williamsburg, PA 16693	37	$12.50	814-832-3404	Jerry Lower

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Pine Creek Lumber, Inc.	45	60 Lizardville Road RD1, Box 35B, Mill Hall, PA 17751	37	$5.50	570-726-7795	Darrel Reibson
Walker Lumber & Supply Company	45	Bigler PA 16825	37	$16 delivered	814-857-7642	Mark Shaw
Wetzel Bros Lumber Co., Inc.	1	RD1, Box 268E Mill Hall, PA 17751	37		570-726-3473	
J M Smith & Son Lumber		RD 1, Box 70 McVeytown, PA 17051	40		814-542-9877	James M. Smith
J E Culbertson Co, Inc.	25	P.O. Box A Mill Creek, PA 17060	40	$0	814-643-4519	Pat Rux
Grubco	50	RD1, Box 57A Hesston, PA 16647	40	$7.00	814-658-3291	Mike Grub
K M Smith & Son		90 Pine Hill Rd, McVeytown, PA 17051	40		814-542-9936	No answer — no voicemail.
Kim Brion Lumber			40		570-769-1634	Replaces Saylor Lumber
Parchey s Sawmill	0	RD2, Box 138-1A McVeytown, PA 17051	40		717-899-6062	Out of business
Saylor Lumber	0	RD1, Box A344 Lock Haven, PA 17745	40		~~570-769-6567~~	Phone disconnected-Out of business per Peg Saylor
Spigelmyer Lumber	45	2316 Hawstone Rd, Lewistown, PA 17044	40	$4.00 FOB $10.50 delivered	717-248-6555	Toby Spigelmyer
Zook Lumberworks	6	RD2, Box 223 McVeytown, PA 17051	40		717-899-6543	No answer — no voicemail.
Dean P Otto Lumber		RR 3 Altoona, PA 16601	42		814-944-5447	Retired — out of business.
Ed s Logging		RD1, Box 214 Olanta, PA 16863	42		814-236-3279	
Robbins Lumber Co	40	RR 1, Olanta, PA 16863	42	$3.50 FOB $15.00 delivered	814-236-3384	Lynn Robbins
Suter’s Portable Bandsaw Mill	0	306 Aldrich Ave, Altoona, PA 16601	42		814-943-3326	Steve Suter
Anthonic Lumber Co		Route 53, Glen Hope, PA 16645	44	$14.00	814-672-5100	Ray Coates
Garner Lumber Co	0	P.O. Box 462 James Creek PA 16657	44		814-658-3700	J. Robert Garner, generates 80 tpw, may consider supplying in future
Greenwood Lumber Company	25	RR1 Box 378 Morrisdale, PA 16858	44		814-345-4160	Dan Curley

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Kitko Wood Products, Inc.	20	Route 53 Box 3 Glen Hope PA 16645	44	$12.00	814-672-3606	Robert Kitko, Ken
Lyle McVey Lumber		280 McVey Road Mount Union, PA 17066	44	$0	814-542-4887	Lyle McVey
J W Kitko & Sons	20	Route 53, Rose St Glen Hope, PA 16645	44	$0 FOB $6.50 delivered	814-672-3590	Chuck Kitko
Samuel J McMath	0	RD, Box 140 Mount Union, PA 17066	44		814-542-4779	Out of business.
Smith Bros. Sawmill	40	Route 522, S. Mount Union PA 17066	44	$0	814-542-8320	Bernard Smith
Crown Hardwood West	0	RR 5, Mifflintown, PA 17059	45		717-436-9677	Monty Syjud
Gray s Pallets	150/20/40	Mifflintown, PA 17059	45	$0/$0/$0	717-436-8585	Jill Swartz, sawdust/chips/slabs
Kovalick Lumber Co	60	RD1, Box 258 Frenchville, PA 16836	45	$13.60 delivered	814-263-4928	Richard Kovalick
Quehanna Hardwoods, Inc.	0	Box 297 Frenchville, PA 16836	45		~~814-263-4919~~	Out of business per Son, Ed Plubell 814-263-4145
R H Morgan Lumber Co.	20	HCR 60, Box 370 Orbisonia PA 17243	45	$8.00 delivered	814-447-5662	Ramon & Linda Morgan & Clyde Cisney
Treen Box & Pallet Corp	100	Mifflintown, PA 18966	45	$4.50	717-535-5800	Vernon Troyer
Bickel Wood Products, Inc.	90	E Ohio St, Box 416 McClure, PA 17841	46		~~717-658-8343~~	Phone disconnected, presumed out of business
Fishel s Pallet Mill	35	Box 37 Blandburg, PA 16619	46		814-687-4251	
HC 67		Mifflin, PA 17058	46		~~717-734-3291~~	J.M. Junk — phone disconnected presumed out of business
Snook’s Rhine & Arnold Sawmill	0	RR 2 Box 807, Mc Clure, PA 17841	46		570-658-3410	Robert Snook
Wood Chips, Inc.	120	Route 150 Avis, PA 17721	46		717-769-6441	James H. Maguire — Phone number is a fax — can t make contact.
Helsel Lumber Mill, Inc.	0	3446 Johnstown Road RD2, Box 173 Duncansville, PA 16635	47	$4.00	814-696-0869	Joel Jackson — may consider supplying inthe future.
Shomo Lumber Company		241 Shadey Lane Fallentimber, PA 16639	47		814-687-3875	
Railaworks Wood Products (formerly H P Mc Ginley, Inc.)		Box 251 Route 235 McAlisterville, PA 17049	50		717-463-2131	Doug Ryan
J C McGough & Son		RD Dysart, PA 16636	51		814-674-8914	Edgar J. McGough

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Weber Lumber	50	RD1, Box 426 Ashville, PA 16613	51		814-674-5124	
James Shallenburger Lumber	60	527 Mountain Road RD1, Box 43 McAlisterville, PA 17049	52		717-463-2546	James Shallenberger
Ralph A Hepner Lumber		RD1, Box 140 McAlisterville, PA 17049	52		717-463-2439	
D W Shadel Logging & Lumber		11 Cody Ln, Mc Alisterville, PA 17049	52		717-463-9818	
Heeter Lumber Co	17	RD1, Box 148 Beavertown, PA 17813	52		717-658-3292	John D. Heeter
Appleton Papers, Inc.	120	100 Paper Mill Road Roaring Spring, PA 16673	54		814-224-6411	wood fines
George S Rabenstein & Son	6	PO Box 236 Orbisonia, PA 17243	54		814-447-3465	
High Point Hardwoods		1070 Dogwood Lane Roaring Spring, PA 16673	54		814-224-4171	
Seven D Wholesale		302 Saint Thomas St. Gallitzin, PA 16641	54		814-886-8352	
Van Voorhis Lumber		Tannery Road Penfield, PA 15849	54		814-637-5388	
Weaver Brothers Lumber	55	RD1, Box 188 Beaver Springs, PA 17812	54		570-658-8371 or (658-7740)	Mel & Abe Weaver
Lee Brothers Lumber Company		RR1 Box 448 Grampian, PA 16838	55		814-236-2809	
Stanley Woodworking	0	White Top Road Middleburg, PA 17842	56		570-837-6434	Tom Fitzgerald (generates 150 tpw — all committed)
Brumbaugh Lumber	30	RD1 Box 1068 Mapleton Depot, PA 17052	57	$9.00 delivered	814-542-8880	Chester Brumbaugh
Wood Word Forest Products	25	RD1, Box 458 Linden, PA 17744	57		717-322-1312	
Blair Sterer Rough Lumber Products		RD1 Saxton, PA 16678	58		814-658-3400	
Brode Lumber	6	RD1 Saxton, PA 16678	58		814-653-3624 or 814-635-3436	
Dean W Brouse & Sons Lumber		E Main St Ext, Kreamer, PA 17833	58		570-374-7695	
Dressler Lumber		RR 2, Millerstown, PA 17062	59		717-444-7402	
Juniata Forest Products		RR 1, Millerstown, PA 17062	59		717-567-7226	

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Meiser Lumber Co	75	Drawer F Millerstown, PA 17062	59		717-589-3122	Mike Meiser
Bowser Lumber Co.		Route 36 N, RR1, Box 240 Mahaffey, PA 15757	60		814-277-9956	Ron or Ed
George W Long & Sons Lumber Co.	50	RR 1, Box 1 Patton, PA 16668	60		814-674-3615	Joseph A. Long, Robert
Lynn L Bouch	10	RD1, Box 149 Mahaffey, PA 15757	60		814-277-6087	
Snyder Lumber Co	200	RD1, Box 717 Mahaffey, PA 15757	60		814-277-6640	
White Lumber Co	10	Mahaffey, PA 15757	60		814-277-6098	
Roy Miller		RD 1 Mahaffey, PA 15757	60		814-277-6055	
Nora White & Son		RR 2 Mahaffey, PA 15757	61		814-277-6093(also 8870)	Ted
Wade Cisney Lumber Company, Inc.		Box 75, HCR 61B Shade Gap, PA 17255	61		814-542-9757	Wade Cisney
Ralph Stuck Lumber		Box 23 Richfield, PA 17086	62		570-539-8666	Harold Stuck
A D Renninger Lumber Co	75	PO Box 95 Richfield, PA 17086	62		717-694-3351	
Delbert L Renninger & Sons Wood Products	180	RD1, Box 118 Richfield, PA 17086	62		717-539-8120	
E & E Lumber Company, Inc.		RD 1, Box 29 Loretto, PA 15940	62		814-886-4440	Eugene F. Krug
Hoffman Brothers Lumber, Inc.	90	RR1 Box 86 Richfield, PA 17086	62		717-694-3340	Delbert Hoffman
R J Junk Lumber		RR 1 Box 444, Honey Grove, PA 17035	62		717-734-3838	
Sherwood Sawmill	1	RD2, Box 177 Dubois, PA 15801	62		814-371-9492	
Strawser Brothers Logging		Star Route 35, Richfield, PA 17086	62		717-694-3117	
Walter L Stuck Sawmill		Hc 72 Box 19, Richfield, PA 17086	62		570-539-4481	
A & L Woods, Inc.	60	Mount Pleasant Mills, PA 17853	64		717-539-8922	
Babcock Lumber Co.		421 S. West Street Ebensburg, PA 15931	64		814-472-6911	

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Carey Lumber & Pallet	5	Box 179, HC-31 Williamsport, PA 17701	64		717-435-5051	
Fred Sherry Lumber Company	8	RD2, Box 123 Ebensburg, PA 15931	64		814-948-7468	Ken
Keystone Land & Timber Co.	50	RD1, Box 701 Portage, PA 15946	64		814-495-9398	
Long s Hardwoods, Inc.		3133 New Germany Road Ebensburg, PA 15931	64		814-472-4740	
Louis Long Lumber Company, Inc.		1984 New Germany Road RR 3, Box 299 Ebensburg, PA 15931	64		814-472-9219	Joe Seliga
Martindale Lumber Co.	75	1047 Puritan Road, Box 207 Portage, PA 15946	64		814-736-3032	Ray McCabe
Portzline's Pallets		RR 2 Box 197, Mt Pleasant Mills, PA 17853	64		717-694-3274	
R J Hoffman & Sons	50	RD 2, Box 350 Mt. Pleasant Mills, PA 17853	64		717-539-2428	Rudolph J. Hoffman
Troyer's Saw Mill		RR 1 Box 229, Mt Pleasant Mills, PA 17853	64		570-539-8167	
Goshorn Lumber Company		HCR 62, Box 62 Neelyton, PA 17239	65		814-259-3716	Randy Goshorn
Mundricks Sawmill		RR 2 Box 281, Jersey Shore, PA 17723	65		570-745-3625	
Palmer Wetzel Lumber Co		RR 3, Jersey Shore, PA 17723	65		570-398-7771	
Steele s Lumber Co.	50	Box 79 Riddlesburg, PA 16672	66		814-928-4497	James & Donald Steele
Superior Wood Products		RD 1, Box 258 Summerhill, PA 15958	67		814-472-9348	
D L Bussard Forest Products		RR 2 Hopewell, PA 16650	67		814-652-5566	
G & S Lumber Co	140	HCR 61, Box 51 Blairs Mills, PA 17213	67		814-259-3763	
Samuel M Koban		RD1, Box 258 Summerhill, PA 15958	67		814-482-9348	
Clugston Lumber		RR1 Box 190 East Waterford, PA 17021	70		717-734-3215	
George White Planing Mill		Main Street East Waterford, PA 17021	70		717-734-3816	

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
John M Fink Lumber		HC 31, Box 179 Williamsport, PA 17701	70		717-435-5051	
Lauchle Logging & Lumber	4	RD1, Box 110 Montoursville, PA 17754	70		570-435-3352	
McNaughton & Sons Lumber		RR 1, Elliottsburg, PA 17024	70		717-582-2543	
Robinson Lumber Co	8	RD1 Elliottsburg, PA 17024	70		717-789-3265	
Wingate Lumber Co	25	RD1, Box 176 East Waterford, PA 17021	70		717-734-3812	Roy Wingate
Feaster Lumber Co.	80	RD1 New Paris, PA 15554	71		814-839-2648	
Highland Land & Minerals Inc		100 Merodith Rd, Kersey, PA 15846	71		814-885-8600	
Kuhns Bros. Lumber Company, Inc.	140	Route 2, Box 406 Lewisburg, PA 17837	71		717-568-1412	Larry Kuhns
Rummel Brothers		112 Red Mill Road Belsano, PA 15922	71		814-749-7021	
Winter Lumber Co		6765 Pleasant Valley Rd, Cogan Station, PA 17728	71		570-435-2231	
Doliveira Lumber Co.	3	430 Expedite Road RD1, Box 144 Nanty Glo, PA 15943	72		814-749-0910	James Doliveria
Rorabaugh Lumber Co	15	Box 321 Burnside, PA 15721	72		814-845-2277	Roger D. Rorabaugh
Amberson Valley Lumber Products	10	17891 Cold Spring Rd Spring Run, PA 17262	73		717-349-7359	
Merritt Burdge Company		17891 Cold Spring Rd. Spring Run, PA 17262	73		717-349-7359	
Rosenberry Bros. Lumber Co., Inc.		Drawer A Fannettsburg, PA 17221	74		717-349-7196	Glen Rosenberry
Eagle Mountain Lumber Company		15568 E. Fannettsburg Road Box 332 Fannetsburg PA 17221	74		717-349-2375 or 349-2862	John C. Rosenberry
Ondrizek Lumber Co.		Box 46 Strongstown, PA 15957	74		814-749-0996	Ted Ondrizek
Shirk’s Lumber		RR 1, Liverpool, PA 17045	74		570-539-8430	
Weaver s Sawmill	30	RD2, Box 649 Liverpool, PA 17045	74		717-444-2232 Earl/-7772 Ivan/ -0186 John	
J Nevin White Lumber Company	40	P.O. Box 99 Duncannon PA 17020	75		717-957-2182	J. Nevin White

J Nevin White Lumber Co	40	RD3, PO Box 99 Duncannon, PA 17020	75		717-834-4242	
Krumenacker Lumber Co.	25	327 Krumenacker Lane RD1, PO Box 24 Carrolltown, PA 15722	75		814-948-6858	Dave Krumenacker

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APPENDIX B. POTENTIAL SAWDUST SUPPLIERS – PHONE SURVEY SHORT LIST BY ALPHABET (TABLE)

POTENTIAL SAWDUST SUPPLIERS FOR PENN STATE COMBUSTOR
Phone Survey Short List by alpha — Table

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
*American Hickory Corp	0	Lewistown, PA 17044	31	$2.00	717-543-6070	Mark Colwell —generates 100 tpw — may consider supplying in future
Brumbaugh Lumber	30	RD1 Box 1068 Mapleton Depot, PA 17052	57	$9.00 delivered	814-542-8880	Chester Brumbaugh
C L Price Sawmill & Planning	40/40	319 W Alley St, Aaronsburg, PA 16820	30	$4.00FOB/ $15.00 delivered	814-349-4431 814-349-5505	C. L., Dennis and Fred Price — sawdust/slabs
CHJ Lumber	30	Box 187 Allport, PA 16921	31	$2.00	814-345-5271	Clark Hubler
*Garner Lumber Co	0	P.O. Box 462 James Creek PA 16657	44		814-658-3700	J. Robert Garner, generates 80 tpw, may consider supplying in future
Gray s Pallets	150/20/40	Mifflintown, PA 17059	45	$0/$0/$0	717-436-8585	Jill Swartz, sawdust/chips/slabs
Grubco	50	RD1, Box 57A Hesston, PA 16647	40	$7.00	814-658-3291	Mike Grub
*Helsel Lumber Mill, Inc.	0	3446 Johnstown Road RD2, Box 173 Duncansville, PA 16635	47	$4.00	814-696-0869	Joel Jackson — may consider supplying inthe future.
J E Culbertson Co, Inc.	25	P.O. Box A Mill Creek, PA 17060	40	$0	814-643-4519	Pat Rux
J M Wood Products	25	HC 61, Allensville, PA 17002	25	$3.00	717-483-6700	Dave Zook
J W Kitko & Sons	20	Route 53, Rose St Glen Hope, PA 16645	44	$0 FOB $6.50 delivered	814-672-3590	Chuck Kitko
*Kaufman s Mulch	0	42 Maple Street Belleville, PA 17004	26	$10.50 delivered	717-667-6317	Pete Kaufman, generates 250 tpw sawdust — would sell excess above that.
Kish Lumber	25	157 Sawmill Road Belleville, PA 17004	26	$2.15	717-667-6157	Dave Byler
Kitko Wood Products, Inc.	20	Route 53 Box 3 Glen Hope PA 16645	44	$12.00	814-672-3606	Robert Kitko, Ken
Kovalick Lumber Co	60	RD1, Box 258 Frenchville, PA 16836	45	$13.60 delivered	814-263-4928	Richard Kovalick
McCabe & Sons Lumber	20	HC1 Box 26 Alexandria, PA 16611	30	$4.50	814-832-2046	Roy McCabe

POTENTIAL SAWDUST SUPPLIERS FOR PENN STATE COMBUSTOR

Phone Survey Short List by alpha — Table

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Meeker Lumber Company	40/40	HC 21A Moshannon, PA 16859	30	$2.00/$0	814-387-6342	Bruce Meeker — sawdust/slabs
Peachey s Wood Products	70	209 Sawmill Road Reedsville, PA 17084	24	$4.25	717-667-9373	John Peachey
Pennsy Lumber Products	40	RD1, Box 204A Williamsburg, PA 16693	37	$12.50	814-832-3404	Jerry Lower
Phillip's Wood Products	60	RD 2 Mill Hall PA 17751	37	$3.00	570-726-3515	Carl & Tina Phillips
Pine Creek Lumber, Inc.	45	60 Lizardville Road RD1, Box 35B, Mill Hall, PA 17751	37	$5.50	570-726-7795	Darrel Reibson
R H Morgan Lumber Co.	20	HCR 60, Box 370 Orbisonia PA 17243	45	$8.00 delivered	814-447-5662	Ramon & Linda Morgan & Clyde Cisney
Robbins Lumber Co	40	RR 1, Olanta, PA 16863	42	$3.50 FOB $15.00 delivered	814-236-3384	Lynn Robbins
Robinson Lumber Company	20	776 Lucas Road Bellefonte PA 16823	10	$15 delivered	814-355-9583	Richard N. Robinson
Saw-rite Sawmill	30/60	74 Airstrip Drive Millheim, PA 16854	24	$10/$13 delivered	814-349-1210	Sam Stoltzfus, sawdust/chips
Smith Bros. Sawmill	40	Route 522, S. Mount Union PA 17066	44	$0	814-542-8320	Bernard Smith
Spigelmyer Lumber	45	2316 Hawstone Rd, Lewistown, PA 17044	40	$4.00 FOB $10.50 delivered	717-248-6555	Toby Spigelmyer
Thomas Timberlands Enterprises	40/300	Box 5075, Route 26 Pleasant Gap, PA 16823	10	$10.50/13.33 delivered	814-359-2890	BJ & Richard Thomas, sawdust/chips
Treen Box & Pallet Corp	100	Mifflintown, PA 18966	45	$4.50	717-535-5800	Vernon Troyer
Urbanik Lumber	25/75	Box 195 Clarence, PA 16829	33	$10.00 delivered	814-387-6939	Sam Urbanik — sawdust/slabs
Walker Lumber & Supply Company	45	Bigler PA 16825	37	$16 delivered	814-857-7642	Mark Shaw

*Not willing to supply sawdust right now but may consider supplying sawdust in the future.

02/28/01

APPENDIX C. POTENTIAL SAWDUST SUPPLIERS – PHONE SURVEY SHORT LIST BY DISTANCE (TABLE)

POTENTIAL SAWDUST SUPPLIERS FOR PENN STATE COMBUSTOR
Phone Survey Short List by distance - Table

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Robinson Lumber Company	20	776 Lucas Road Bellefonte PA 16823	10	$15 delivered	814-355-9583	Richard N. Robinson
Thomas Timberlands Enterprises	40/300	Box 5075, Route 26 Pleasant Gap, PA 16823	10	$10.50/13.33 delivered	814-359-2890	BJ & Richard Thomas, sawdust/chips
Peachey s Wood Products	70	209 Sawmill Road Reedsville, PA 17084	24	$4.25	717-667-9373	John Peachey
Saw-rite Sawmill	30/60	74 Airstrip Drive Millheim, PA 16854	24	$10/$13 delivered	814-349-1210	Sam Stoltzfus, sawdust/chips
J M Wood Products	25	HC 61, Allensville, PA 17002	25	$3.00	717-483-6700	Dave Zook
*Kaufman s Mulch	0	42 Maple Street Belleville, PA 17004	26	$10.50 delivered	717-667-6317	Pete Kaufman, generates 250 tpw sawdust — would sell excess above that.
Kish Lumber	25	157 Sawmill Road Belleville, PA 17004	26	$2.15	717-667-6157	Dave Byler
C L Price Sawmill & Planning	40/40	319 W Alley St, Aaronsburg, PA 16820	30	$4.00FOB/ $15.00 delivered	814-349-4431 814-349-5505	C. L., Dennis and Fred Price — sawdust/slabs
McCabe & Sons Lumber	20	HC1 Box 26 Alexandria, PA 16611	30	$4.50	814-832-2046	Roy McCabe
Meeker Lumber Company	40/40	HC 21A Moshannon, PA 16859	30	$2.00/$0	814-387-6342	Bruce Meeker — sawdust/slabs
*American Hickory Corp	0	Lewistown, PA 17044	31	$2.00	717-543-6070	Mark Colwell —generates 100 tpw — may consider supplying in future
CHJ Lumber	30	Box 187 Allport, PA 16921	31	$2.00	814-345-5271	Clark Hubler
Urbanik Lumber	25/75	Box 195 Clarence, PA 16829	33	$10.00 delivered	814-387-6939	Sam Urbanik — sawdust/slabs
Phillip’s Wood Products	60	RD 2 Mill Hall PA 17751	37	$3.00	570-726-3515	Carl & Tina Phillips
Pennsy Lumber Products	40	RD1, Box 204A Williamsburg, PA 16693	37	$12.50	814-832-3404	Jerry Lower
Pine Creek Lumber, Inc.	45	60 Lizardville Road RD1, Box 35B, Mill Hall, PA 17751	37	$5.50	570-726-7795	Darrel Reibson
Walker Lumber & Supply Company	45	Bigler PA 16825	37	$16 delivered	814-857-7642	Mark Shaw

POTENTIAL SAWDUST SUPPLIERS FOR PENN STATE COMBUSTOR

Phone Survey Short List by distance - Table

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
J E Culbertson Co, Inc.	25	P.O. Box A Mill Creek, PA 17060	40	$0	814-643-4519	Pat Rux
Grubco	50	RD1, Box 57A Hesston, PA 16647	40	$7.00	814-658-3291	Mike Grub
Spigelmyer Lumber	45	2316 Hawstone Rd, Lewistown, PA 17044	40	$4.00 FOB $10.50 delivered	717-248-6555	Toby Spigelmyer
Robbins Lumber Co	40	RR 1, Olanta, PA 16863	42	$3.50 FOB $15.00 delivered	814-236-3384	Lynn Robbins
*Garner Lumber Co	0	P.O. Box 462 James Creek PA 16657	44		814-658-3700	J. Robert Garner, generates 80 tpw, may consider supplying in future
Kitko Wood Products, Inc.	20	Route 53 Box 3 Glen Hope PA 16645	44	$12.00	814-672-3606	Robert Kitko, Ken
J W Kitko & Sons	20	Route 53, Rose St Glen Hope, PA 16645	44	$0 FOB $6.50 delivered	814-672-3590	Chuck Kitko
Smith Bros. Sawmill	40	Route 522, S. Mount Union PA 17066	44	$0	814-542-8320	Bernard Smith
Gray s Pallets	150/20/40	Mifflintown, PA 17059	45	$0/$0/$0	717-436-8585	Jill Swartz, sawdust/chips/slabs
Kovalick Lumber Co	60	RD1, Box 258 Frenchville, PA 16836	45	$13.60 delivered	814-263-4928	Richard Kovalick
R H Morgan Lumber Co.	20	HCR 60, Box 370 Orbisonia PA 17243	45	$8.00 delivered	814-447-5662	Ramon & Linda Morgan & Clyde Cisney
Treen Box & Pallet Corp	100	Mifflintown, PA 18966	45	$4.50	717-535-5800	Vernon Troyer
*Helsel Lumber Mill, Inc.	0	3446 Johnstown Road RD2, Box 173 Duncansville, PA 16635	47	$4.00	814-696-0869	Joel Jackson — may consider supplying inthe future.
Brumbaugh Lumber	30	RD1 Box 1068 Mapleton Depot, PA 17052	57	$9.00 delivered	814-542-8880	Chester Brumbaugh

*Not willing to supply sawdust right now but may consider supplying sawdust in the future.
02/28/01

APPENDIX D. POTENTIAL SAWDUST SAWMILLS– PHONE SURVEY SHORT LIST BY ALPHABET (TEXT)

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

*American Hickory Corp 717-543-6070
Lewistown, PA 17044

Contact: Mark Colwell

Directions: 31 miles — Take Route 322E to the Burnham exit. Go through Burnham (3 lights) and turn left onto 522 N or E. Go 6 miles to Vira. Go through Vira 3 miles to mill on right side of road.

Tons sawdust available/week: 0 tons

Sawdust cost: $ 2.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: They have a contractor pick up all sawdust, shavings and chips. They generate 100 tons of sawdust per week. They may be willing to talk about changing contracts at some future time.

Note: Talked with Bob Niven.

Brumbaugh Lumber 814-542-8880
RD1 Box 1068
Mapleton Depot, PA 17052

Contact: Chester Brumbaugh

Directions: 57 miles — Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Take 522S out of Mount Union. The mill is 5 miles down the road on the right side (red building). Don t cross the bridge.

Tons sawdust available/week: 30 tons/week

Sawdust cost: $200/load (about $9/ton delivered)

Transportation cost: See above.

What s done with sawdust?: They take the sawdust to Mellot s Wood Preserving Corp., 1398 Sawmill Road, Needmore, PA 17238 (717-573-2516) (a wood creosoting plant about 35 miles from Brumbaugh Lumber). Mellott s has means to lift a box trailer. They use the sawdust for process heat. There is no contract. They take all comers.

Note: Brumbaugh has 8 box trailers. The mill is near Shirleysburg.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

C L Price Sawmill and Planning814-349-4431 and 814-349-5505
319 W Alley St,
Aaronsburg, PA 16820

Contact: C L Price, Dennis and Fred

Directions: 30 miles — Take Route 45 to Millheim. Turn right at redlight then go 3 miles to Counrty store on the right. Turn left and go 1.5 miles then turn right across the bridge to the mill.

Tons sawdust available/week: 40 tons

Sawdust cost: $4.00/ton FOB mill

Transportation cost: Sawdust and woodhog ground slabs $15.00 delivered (slabs ground to 1.5 x 1/4 to 1/2).

What s done with sawdust?: About 30 tons of sawdust per week is sold to farmers. The rest is sold to Jesse Thomas from Thomas Timberlands then to the PSU waste treatment plant.

Note: They have one tri-axle and one dump truck. They have no walking floor vans. the sawdust is stored in a covered bin.

CHJ Lumber 814-345-5271
Box 187
Allport, PA 16821

Contact: Clark Hubler

Directions: 31 miles — Take Route 80W to Snowshoe, then Route 144N to Moshannon. Turn right at blinker light, turn left at next stop sign and take Route 879W to Karthaus. Just out of Karthaus with gas station on left, turn right on first dirt road. Keep to right, sawmill is at the end of the road (before Meeker s Mill).

Tons sawdust available/week: 30 tons

Sawdust cost: $2.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The sawdust is generally sold to farmers in the area.

Note: They have no trucks but have access to a trucking firm. The sawdust is stored outside uncovered.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

*Garner Lumber Co 814-658-3700
PO 462
James Creek, PA 16657

Contact: J. Robert Garner

Directions: 44 miles — Take Route 26S and go to Marklesburg. Turn right onto a mountain road (at Scott Sporting Goods). The mill is one mile up the road.

Tons sawdust available/week: None available at this time. Would be willing to look into the situation and pricing if the project goes forward. They currently generate 80 tons of sawdust per week.

Sawdust cost: No quote at this time.

Transportation cost: See above.

What s done with sawdust?: Most of his sawdust goes to Alexandria Wood Products. Any excess is sold to farmers in the area.

Note: The mill number is 814-658-3401. They have one open top trailer. The walking floor vans are provided by Alexandria Wood Products. They drop them off and pick them up.

Gray s Pallets 717-436-8585
Mifflintown, PA 17059

Contact: Jill Swartz

Directions: 45 miles — Take Route 322E to the Port Royal exit. Turn right off the exit ramp. Go 1/4 mile to a 4-way red blinker light. Turn left and go 2 miles. Turn right onto Wagner Road. Go 1.5 miles. Mill is on the right side of the road.

Tons sawdust available/week: 150 tons (also has 20 tpw chips and 40 tpw slabs)

Sawdust cost: $ 0/ton FOB mill (dust, chips and slabs)

Transportation cost: NA

What s done with sawdust?: They give the sawdust to RB Trucking who resells the dust to farms and horse farms. They also give the chips and slabs to others. There are no contracts for this.

Note: They have no trucks. They are looking into purchasing two tractor trailers (possibly walking floors) in the future to both ship pallets and transport chips. They would still contract out the trucking.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Grubco 814-658-3291
RD1, Box 57A
Hesston, PA 16647

Contact: Mike Grub

Directions: 40 miles — Take Route 26S. Go 8 miles beyond Huntingdon turn right on racetrack road to stop sign turn right then shortly make a left on sawmill road.

Tons sawdust available/week: 50 tons

Sawdust cost: $7.00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: Sawdust is sold to farmers

Note: He has a tractor trailer. But he can contract out for a walking floor. His operation is year round. He stores the dust indoors. He has a front-end loader. The price of his chips is $28/ton (high quality for carbonless paper.

Helsel Lumber Mill, Inc. 814-696-0869
3446 Johnstown Road
Duncansville, PA 16635

Contact: Joel Jackson

Directions: 47 miles — Take Route I-99 to Roaring Spring exit. Turn right at end of ramp (old 220S). Turn right at blinking yellow light (Route 164W). Go 7 miles, the mill is on the left.

Tons sawdust available/week: None available at this time.

Sawdust cost: $ 4.00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: In the winter, they use all their sawdust for heat and to operate 7 kilns. In the summer (March through October) they sell to the farmers.

Note: They are willing to discuss the situation with us as we get closer to having a project. They may have an interest in the future.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

J E Culbertson Co, Inc. 814-643-4519
P.O. Box A
Mill Creek, PA 17060

Contact: Pat Rux

Directions: 40 miles — Take Route 45S or W to Water Street. Turn left onto Route 22E. The mill is on 2E near Mill Creek.

Tons sawdust available/week: 25 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: The sawdust is given to farmers. They also burn their sawdust in winter so there would be none available in wintertime.

Note: They have a small dump truck and a standard box trailer. They manufacture pallets from green wood. The sawdust is blown into a 30 ton silo.

J M Wood Products 717-483-6700
HC 61,
Allensville, PA 17002

Contact: Dave Zook

Directions: 25 miles — Take Route 322E to 655S. Go about 15 miles — turn left off 655 to the mill.

Tons sawdust available/week: 25 tons

Sawdust cost: $75/trailer load or $3.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: A trucker with walking a floor van picks up sawdust and sells it to farmers.

Note: He has no trucks and has one year contracts with the trucker that he would be willing to end.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

J W Kitko and Sons 814-672-3590
Route 53 Rose St
Glen Hope, PA 16645

Contact: Chuck Kitko

Directions: 44 miles — Take Route 322W to Phillipsburg then Route 53S to mill on left side of the road.

Tons sawdust available/week: 20 tons (March thru October)(generates 50 tons/week).

Sawdust cost: $ 0/ton FOB mill

Transportation cost: $6.50 delivered

What s done with sawdust: None available in winter months (used in boilers and kilns).
Note: They don t have walking floor vans or open top trailers.

Kaufman s Mulch 717-667-6317
42 Maple Street
Belleville, PA 17004

Contact: Peter Kaufman

Directions: 26 miles — Take Route 322E to 655/Reedsville exit. Turn right (south) 3 miles to Barrville Road for 2 miles. At stop sign, turn right (3/10 mile into woods)(near Peachey s Wood Products.

Tons sawdust available/week: None available at this time.

Sawdust cost: $11.50/ton delivered

Transportation cost: See above.

What s done with sawdust?: He buys sawdust and then sells it to farmers in southern PA. He also sells as much as he can to Temple Inland which uses chips and sawdust to make fiberboard.
Peter s dad is Paul Kaufman.

Note: He has 7 walking floor vans. He currently sells 250 tons/week of sawdust. He is not willing to reduce the supply to his current customers. He would be willing to consider selling us additional sawdust if it should come available. We will leave him on the list as a possible future supplier.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Kish Lumber 717-667-6157
157 Sawmill Road
Belleville, Pa 17004

Contact: Dave Byler

Directions: 26 miles — Take Route 322E to Route 655S. Go 3 miles and turn right ontoBarrville Road. Go 2 miles to sawmill road and follow signs to mill (on hill).

Tons sawdust available/week: Tentatively 25 tons (out of 75 tons). He also generates 120 tons of chips but he gets $30/ton.

Sawdust cost: $2.15/ton FOB mill

Transportation cost: NA

What s done with sawdust?: Most of the sawdust goes to Paul Kaufman (Kaufman s Mulch). The rest goes to farmers.

Note: He has no trucks and no silo. The sawdust is stored in a shed on concrete. Kish Lumber is listed under L. E. Peachey in the phone book.

Kitko Wood Products 814-672-3606
Route 53 Box 3
Glen Hope, PA 16645

Contact: Ken and Robert

Directions: 44 miles — Take Route 322W to Phillipsburg then Route 53S to mill on left side of the road.

Tons sawdust available/week: 20 tons (March thru October)(generates 80 tons/week).

Sawdust cost: $12:00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: They burn most of their sawdust in their boiler system but not all of it. Some sawdust is sold to Allegheny Particle Board along with their chips.

Note: No sawdust is available in winter months (used in boilers and kilns). They don t have walking floor vans. Sawdust is stored in a concrete bin with a roof. It is loaded with a front end loader.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Kovalick Lumber Co 814-263-4928
RD1, Box 258
Frenchville, PA 16836

Contact: Richard Kovalick

Directions: 45 miles — Take Route 322W to 970N. At the red light in Woodland the road turns into 879E. Go 5 to the top of the third three lane section of road. Turn right at the Girard Township Office sign. Turn right 1/4 down the road to the mill.

Tons sawdust available/week: 60 tons

Sawdust cost: $300/load (22/ton) or $13.60/ton delivered.

Transportation cost: See above.

What s done with sawdust?: They take 20 tons/week to a brick plant that blends the dust into their bricks (no contract). The rest goes to farmers in the area. If there is an excess, they ship it to Temple Inland fiberboard plant in Clarion, PA.

Note: They have 12 box trailers.

McCabe and Sons Lumber 814-832-2046
HC1 Box 26
Alexandria, PA 16611

Contact: Roy McCabe

Directions: 30 miles — Rte. 322E through Water Street (3 miles) on right side (sign at bottom of hill).

Tons sawdust available/week: 20 tons

Sawdust cost: $ 4.50 /ton FOB mill

Transportation cost: Not quoted at this time.

What s done with sawdust?: They sell to farmers year round.

Note: They have open top vans but no walking floor vans..

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Meeker Lumber Company 814-387-6342
HC 21A
Moshannon, PA 16859

Contact: Bruce Meeker

Directions: 30 miles — Rte. 80W to Snowshoe, then 144N to Moshannon. Turn right at blinker light, turn left at next stop sign and take Rte. 879W thru Karthaus. One or two miles out of Karthaus, Rte. 879W goes left, you turn right and go 3 miles past road to Pottersdale (dont turn, go straight). Turn right at next macadam road. Mill is 100 yards down the road.

Tons sawdust available/week: 40 tons sawdust and 40 tons slab wood

Sawdust cost: $2.00 /ton FOB mill (sawdust, $0 FOB mill (slab wood)

Transportation cost: NA

What s done with sawdust?: Tom Capparela from Bellefonte transports his sawdust.

Note: He has no trailers.

Peachey s Wood Products 717-667-9373
209 Sawmill Road,
Reedsville, PA 17084

Contact: John Peachey

Directions: 24 miles — Take Route 322E to Reedsville exit. Turn right of ramp to Route 65S. Turn right at 3 miles onto Barrville Road and go one mile. Then take first right (Green Lane) and then first left (see sign for mill).

Tons sawdust available/week: 70 tons

Sawdust cost: $4.25/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The dust is sold to a broker and to farmers.

Note: They have no trucks. The broker is Paul Kaufman (717-667-6317). He buys sawdust and chips for Oaks Forestry, Temple Inland, Clarion, PA.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Pennsy Lumber Products 814-832-3404
RD1, Box 204A
Williamsburg, PA 16693

Contact: Jerry Lower (as in power)

Directions: 37 miles — Take Route 45S or W to Water Street. Go 22W (right?) to Yellow Spring. Turn left onto Beagle club road. The mill is 2 miles down road on left.

Tons sawdust available/week: 40 tons

Sawdust cost: $12.50/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: They are planning an expansion of their operation. Sawdust will be under roof after the expansion.

Note: They are custom kiln drying at the moment. They plan to start up a pallet manufacturing plant. They have box trailers but no walking floor vans.

Phillip's Wood Products 570-726-3515
RD 2, Box 279
Mill Hall, PA 17751

Contact: Carl and Tina Phillips

Directions: 37 miles — Take Route 150N to Laurel Run Road (2mi before Mill Hall on left). Turn left On Laurel Run Road and go 3 miles to stop sign. Go straight through sign - 3/4 mile on left.

Tons sawdust available/week: 60 tons

Sawdust cost: $ 3.00/ton FOB mill ($0.75/cubic yard)

Transportation cost: NA

What s done with sawdust?: The sawdust is currently bought by farmers in the area.

Note: No delivery vehicle at present but would consider getting one.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Pine Creek Lumber, Inc. 570-726-7795
60 Lizardville Road
RD1, Box 35B,
Mill Hall, PA 17751

Contact: Darrel Reibson

Directions: 37 miles — Take Route 26N to Route 64N toward Mill Hall. Turn right on Route 477 and go 1/4 mile. Turn left on Lizardville Road. The mill is 300 yards down the road.

Tons sawdust available/week: 45 tons (he generates 90 tons/week and he estimates that they could divert half of that for sale to PSU initially). If a long term contract could be in the cards, they would consider weaning the farmers off the dust.

Sawdust cost: $5.50/ton FOB mill

Transportation cost: NA

What s done with sawdust?: All sawdust is sold to farmers at $10/ bucket .

Note: No trucks available. Could contract out for transportation.

(Info from Lou Sycz at mill. He will have Darrel call back if there is a correction.

R H Morgan Lumber Co. 814-447-5662
HCR 60, Box 370
Orbisonia, PA 17243

Contact: Ramon and Linda Morgan and Clyde Cisney Co-owners

Directions: 45miles —Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Take 522S out of Mount Union to Orbisonia. Go through town and make a sharp left before the bridge on a curve. Go 1.5 miles down Blacklog Valley Road on the left hand side.

Tons sawdust available/week: 20 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: $2.00/mile (about $180/load to PSU or $8.00/ton delivered).

What s done with sawdust?: The sawdust is given to farmers.

Note: They have 3 box trailers: two for chips and 1 for sawdust.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Robbins Lumber Co 814-236-3384
RR 1,
Olanta, PA 16863

Contact: Lynn Robbins

Directions: 42 miles — Take Route 322W to Clearfield, then Route 879S or W to Curwensville and Route 453S to mill on right side of the road.

Tons sawdust available/week: 40 tons

Sawdust cost: $3.50/ton FOB mill

Transportation cost: $15.00/ton

What s done with sawdust?: Sawdust is given to neighbors. They also sell to Heaton who sells to State College for blending with treated sewage.

Note: Has open top trailers. He told me some mills blend their sawdust with their chips when selling to people that use chips. they would get a larger price for their chips if they could separate the products.

Robinson Lumber Company 814-355-9583
776 Lucas Road
Bellefonte, PA 16823

Contact: Richard N. Robinson

Directions: 10 miles — Take Route 150N between Milesburg and Howard (1 mile north of Curtin village). Turn right at Puff Cigarette Store to lane between house and barn.

Tons sawdust available/week: 20 tons

Sawdust cost: $15.00/ delivered

Transportation cost: See above.

What s done with sawdust?: Sawdust is sold to particle board plant and to farmers for bedding.

Note: They make pallets. They have one walking floor trailer and a 30 ton silo. They would prefer to deliver the wood.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Saw-Rite Sawmill 814-349-1210
74 Airstrip Drive
Millheim, PA 16854

Contact: Sam Stoltzfus

Directions: 24 miles — Take Route 45N to Millheim. Three miles beyond Millheim turn right onto Bower Hollow Road. The mill is on the right.

Tons sawdust available/week: 30 tons sawdust and 60 tons wood chips

Sawdust cost: Sawdust $10.00/ton delivered and Chips $13.00/ton delivered

Transportation cost: See above.

What s done with sawdust?: The dust and chips go to the Viking Energy Power Plant in Northumberland (570-726-7374).

Note: They have two box trailers but no walking floor vans.

Smith Bros. Sawmill 814-542-8320
Highway 522 S.
RR1 Box 168
Mount Union, PA 17066

Contact: Bernard Smith

Directions: 44 miles —Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Then take Route 522S. The mill is 1 1/2 miles down the road ont eh right hand side (about 1/2 mile beyond Fluid Containment.

Tons sawdust available/week: 40 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: NA

What s done with sawdust?: They give the sawdust to farmers in the area.

Note: They have no trucks.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Spigelmyer Lumber 717-248-6555
2316 Hawstone Rd,
Lewistown, PA 17044

Contact: Toby Spigelmyer

Directions: 40 miles — Rte. 322E to Lewistown. Then Rte. 333E to mill on right.

Tons sawdust available/week: 45 tons

Sawdust cost: $4.00/ton FOB mill

Transportation cost: Approximately $6.50/ton to State College ($10.50 delivered)

What s done with sawdust?: Sold to be burned in dry kilns at Cherry Hill Hardwoods (they use about 100 tons/week). The extra sawdust generated by Spigelmeyer Lumber goes to farm bedding or pellet mills. Energex Pellet Mill in Port Royal, PA currently uses 100 tons of sawdust/week and is expanding to 500 tons per week soon.

Note: They contract out transportation with walking floor vans.

Thomas Timberlands Enterprises 814-359-2890
Box 5075, Route 26
Pleasant Gap, PA 16823

Contact: BJ and Richard Thomas

Directions: 10 miles — Take Route 26N to Texaco/Carwash/Gas Station - turn right and take fourth left on gravel road.

Tons sawdust available/week: 40 tons (45-95 generated)(also up to 800 tons/week of chips — avg. 300 tons/week)

Sawdust cost: Sawdust - $10.50 delivered. Chips - $13.33 delivered.

Transportation cost: See above.

What s done with sawdust?: Two loads of sawdust per week (46 tons) is committed to a sewer authority to blend with sludge.

Note: They have one walking bed. They have one 70 ton silo. A load of sawdust weighs 23 tons. A load of chips weighs 24 tons.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Treen Box and Pallet Corp 717-535-5800
Mifflintown, PA 18966

Contact: Vernon Troyer

Directions: 45 miles —Take Route 322E to Port Royal. At stop sign off the ramp turn right. At 4-way blinker light, turn left and go 3.5 miles to Center village. Turn left at the two story farm house with maroon trim. Go 1/4 mile under 322 bridge. The mill is on the right.

Tons sawdust available/week: 100 tons

Sawdust cost: $4.50/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The dust is sold to farmers in the area.

Note: They don t have trucks. They do have a large silo.

Called main office in Ben Salem, PA (Phila.)(215-639-5100) and talked with Keith Geiges. He told me they have two mills in PA: Ken Geromi is the mgr. at Williamsport (570-584-4512) and John Walton is mgr. of the mill in Mifflintown (717-535-5800). I talked with Mary Walton at the Mifflintown mill.

Urbanik Lumber 814-387-4098
Box 195
Clarence, PA 16829

Contact: Sam Urbanik

Directions: 33 miles — Take Route 80W to Snowshoe, then Route 144N toMoshannon blinker light. Turn right and go 2 miles to tee. Turn right onto first road on left.

Tons sawdust available/week: 25 tons sawdust and 75 tons slabs

Sawdust cost: $ 10.00/ton delivered (both)

Transportation cost: See above.

What s done with sawdust?: Sawdust is sold to farmers.

Note: They contract out their shipping. In their area, he believes that most of the mills have twice as much slabs as sawdust and they typically burn it just to get rid of it.

Details of Selected Sawmills for PSU
Phone Survey Short List by alpha - Text

Walker Lumber and Supply Co. 814-857-7642
Route 322 Bigler
Bigler, PA 16825

Contact: Mark Shaw

Directions: 37 miles — Take 322W to Bigler. Mill is on left side of road.

Tons sawdust available/week: 45 tons

Sawdust cost: $16/ton delivered.

Transportation cost: See above.

What s done with sawdust?: They burn their own sawdust but could set aside about two truckloads/week.

Note: The sawdust is kept under roof. They have one 18-wheeler dump trailer. They are owned by Hardwoods of Michigan (their only mill in the area).

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*Not willing to supply sawdust right now but may consider supplying sawdust in the future.

02/28/01

APPENDIX E. POTENTIAL SAWDUST SAWMILLS – PHONE SURVEY SHORT LIST BY DISTANCE (TEXT)

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Robinson Lumber Company 814-355-9583
776 Lucas Road
Bellefonte, PA 16823

Contact: Richard N. Robinson

Directions: 10 miles — Take Route 150N between Milesburg and Howard (1 mile north of Curtin village). Turn right at Puff Cigarette Store to lane between house and barn.

Tons sawdust available/week: 20 tons

Sawdust cost: $15.00/ delivered

Transportation cost: See above.

What s done with sawdust?: Sawdust is sold to particle board plant and to farmers for bedding.

Note: They make pallets. They have one walking floor trailer and a 30 ton silo. They would prefer to deliver the wood.

Thomas Timberlands Enterprises 814-359-2890
Box 5075, Route 26
Pleasant Gap, PA 16823

Contact: BJ and Richard Thomas

Directions: 10 miles — Take Route 26N to Texaco/Carwash/Gas Station - turn right and take fourth left on gravel road.

Tons sawdust available/week: 40 tons (45-95 generated)(also up to 800 tons/week of chips — avg. 300 tons/week)

Sawdust cost: Sawdust - $10.50 delivered. Chips - $13.33 delivered.

Transportation cost: See above.

What s done with sawdust?: Two loads of sawdust per week (46 tons) is committed to a sewer authority to blend with sludge.

Note: They have one walking bed. They have one 70 ton silo. A load of sawdust weighs 23 tons. A load of chips weighs 24 tons.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Peachey s Wood Products 717-667-9373
209 Sawmill Road,
Reedsville, PA 17084

Contact: John Peachey

Directions: 24 miles — Take Route 322E to Reedsville exit. Turn right of ramp to Route 65S. Turn right at 3 miles onto Barrville Road and go one mile. Then take first right (Green Lane) and then first left (see sign for mill).

Tons sawdust available/week: 70 tons

Sawdust cost: $4.25/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The dust is sold to a broker and to farmers.

Note: They have no trucks. The broker is Paul Kaufman (717-667-6317). He buys sawdust and chips for Oaks Forestry, Temple Inland, Clarion, PA.

Saw-Rite Sawmill 814-349-1210
74 Airstrip Drive
Millheim, PA 16854

Contact: Sam Stoltzfus

Directions: 24 miles — Take Route 45N to Millheim. Three miles beyond Millheim turn right onto Bower Hollow Road. The mill is on the right.

Tons sawdust available/week: 30 tons sawdust and 60 tons wood chips

Sawdust cost: Sawdust $10.00/ton delivered and Chips $13.00/ton delivered

Transportation cost: See above.

What s done with sawdust?: The dust and chips go to the Viking Energy Power Plant in Northumberland (570-726-7374).

Note: They have two box trailers but no walking floor vans.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

J M Wood Products 717-483-6700
HC 61,
Allensville, PA 17002

Contact: Dave Zook

Directions: 25 miles — Take Route 322E to 655S. Goabout 15 miles — turn left off 655 to the mill.

Tons sawdust available/week: 25 tons

Sawdust cost: $75/trailer load or $3.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: A trucker with walking a floor van picks up sawdust and sells it to farmers.

Note: He has no trucks and has one year contracts with the trucker that he would be willing to end.

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*Kaufman s Mulch 717-667-6317
42 Maple Street
Belleville, PA 17004

Contact: Peter Kaufman

Directions: 26 miles — Take Route 322E to 655/Reedsville exit. Turn right (south) 3 miles to Barrville Road for 2 miles. At stop sign, turn right (3/10 mile into woods)(near Peachey s Wood Products.

Tons sawdust available/week: None available at this time.

Sawdust cost: $11.50/ton delivered

Transportation cost: See above.

What s done with sawdust?: He buys sawdust and then sells it to farmers in southern PA. He also sells as much as he can to Temple Inland which uses chips and sawdust to make fiberboard. Peter s dad is Paul Kaufman.

Note: He has 7 walking floor vans. He currently sells 250 tons/week of sawdust. He is not willing to reduce the supply to his current customers. He would be willing to consider selling us additional sawdust if it should come available. We will leave him on the list as a possible future supplier.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Kish Lumber 717-667-6157
157 Sawmill Road
Belleville, Pa 17004

Contact: Dave Byler

Directions: 26 miles — Take Route 322E to Route 655S. Go 3 miles and turn right ontoBarrville Road. Go 2 miles to sawmill road and follow signs to mill (on hill).

Tons sawdust available/week: Tentatively 25 tons (out of 75 tons). He also generates 120 tons of chips but he gets $30/ton.

Sawdust cost: $2.15/ton FOB mill

Transportation cost: NA

What s done with sawdust?: Most of the sawdust goes to Paul Kaufman (Kaufman s Mulch). The rest goes to farmers.

Note: He has no trucks and no silo. The sawdust is stored in a shed on concrete. Kish Lumber is listed under L. E. Peachey in the phone book.

C L Price Sawmill and Planning814-349-4431 and 814-349-5505
319 W Alley St,
Aaronsburg, PA 16820

Contact: C L Price, Dennis and Fred

Directions: 30 miles — Take Route 45 to Millheim. Turn right at redlight thengo 3 miles to Counrty store on the right. Turn left and go 1.5 miles then turn right across the bridge to the mill.

Tons sawdust available/week: 40 tons

Sawdust cost: $4.00/ton FOB mill

Transportation cost: Sawdust and woodhog ground slabs $15.00 delivered (slabs ground to 1.5 x 1/4 to 1/2).

What s done with sawdust?: About 30 tons of sawdust per week is sold to farmers. The rest is sold to Jesse Thomas from Thomas Timberlands then to the PSU waste treatment plant.

Note: They have one tri-axle and one dump truck. They have no walking floor vans. the sawdust is stored in a covered bin.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

McCabe and Sons Lumber 814-832-2046
HC1 Box 26
Alexandria, PA 16611

Contact: Roy McCabe

Directions: 30 miles — Rte. 322E through Water Street (3 miles) on right side (sign at bottom of hill).

Tons sawdust available/week: 20 tons

Sawdust cost: $ 4.50 /ton FOB mill

Transportation cost: Not quoted at this time.

What s done with sawdust?: They sell to farmers year round.

Note: They have open top vans but no walking floor vans..

Meeker Lumber Company 814-387-6342
HC 21A
Moshannon, PA 16859

Contact: Bruce Meeker

Directions: 30 miles — Rte. 80W to Snowshoe, then 144N to Moshannon. Turn right at blinker light, turn left at next stop sign and take Rte. 879W thru Karthaus. One or two miles out of Karthaus, Rte. 879W goes left, you turn right and go 3 miles past road to Pottersdale (dont turn, go straight). Turn right at next macadam road. Mill is 100 yards down the road.

Tons sawdust available/week: 40 tons sawdust and 40 tons slab wood

Sawdust cost: $2.00 /ton FOB mill (sawdust, $0 FOB mill (slab wood)

Transportation cost: NA

What s done with sawdust?: Tom Capparela from Bellefonte transports his sawdust.

Note: He has no trailers.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

*American Hickory Corp 717-543-6070
Lewistown, PA 17044

Contact: Mark Colwell

Directions: 31 miles — Take Route 322E to the Burnham exit. Go through Burnham (3 lights) and turn left onto 522 N or E. Go 6 miles to Vira. Go through Vira 3 miles to mill on right side of road.

Tons sawdust available/week: 0 tons

Sawdust cost: $ 2.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: They have a contractor pick up all sawdust, shavings and chips. They generate 100 tons of sawdust per week. They may be willing to talk about changing contracts at some future time.

Note: Talked with Bob Niven.

CHJ Lumber 814-345-5271
Box 187
Allport, PA 16821

Contact: Clark Hubler

Directions: 31 miles — Take Route 80W to Snowshoe, then Route 144N to Moshannon. Turn right at blinker light, turn left at next stop sign and take Route 879W to Karthaus. Just out of Karthaus with gas station on left, turn right on first dirt road. Keep to right, sawmill is at the end of the road (before Meeker s Mill).

Tons sawdust available/week: 30 tons

Sawdust cost: $2.00/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The sawdust is generally sold to farmers in the area.

Note: They have no trucks but have access to a trucking firm. The sawdust is stored outside uncovered.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Urbanik Lumber 814-387-4098
Box 195
Clarence, PA 16829

Contact: Sam Urbanik

Directions: 33 miles — Take Route 80W to Snowshoe, then Route 144N toMoshannon blinker light. Turn right and go 2 miles to tee. Turn right onto first road on left.

Tons sawdust available/week: 25 tons sawdust and 75 tons slabs

Sawdust cost: $ 10.00/ton delivered (both)

Transportation cost: See above.

What s done with sawdust?: Sawdust is sold to farmers.

Note: They contract out their shipping. In their area, he believes that most of the mills have twice as much slabs as sawdust and they typically burn it just to get rid of it.

Phillip's Wood Products 570-726-3515
RD 2, Box 279
Mill Hall, PA 17751

Contact: Carl and Tina Phillips

Directions: 37 miles — Take Route 150N to Laurel Run Road (2mi before Mill Hall on left). Turn left On Laurel Run Road and go 3 miles to stop sign. Go straight through sign - 3/4 mile on left.

Tons sawdust available/week: 60 tons

Sawdust cost: $ 3.00/ton FOB mill ($0.75/cubic yard)

Transportation cost: NA

What s done with sawdust?: The sawdust is currently bought by farmers in the area.

Note: No delivery vehicle at present but would consider getting one.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Pennsy Lumber Products 814-832-3404
RD1, Box 204A
Williamsburg, PA 16693

Contact: Jerry Lower (as in power)

Directions: 37 miles — Take Route 45S or W to Water Street. Go 22W (right?) to Yellow Spring. Turn left onto Beagle club road. The mill is 2 miles down road on left.

Tons sawdust available/week: 40 tons

Sawdust cost: $12.50/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: They are planning an expansion of their operation. Sawdust will be under roof after the expansion.

Note: They are custom kiln drying at the moment. They plan to start up a pallet manufacturing plant. They have box trailers but no walking floor vans.

Pine Creek Lumber, Inc. 570-726-7795
60 Lizardville Road
RD1, Box 35B,
Mill Hall, PA 17751

Contact: Darrel Reibson

Directions: 37 miles — Take Route 26N to Route 64N toward Mill Hall. Turn right on Route 477 and go 1/4 mile. Turn left on Lizardville Road. The mill is 300 yards down the road.

Tons sawdust available/week: 45 tons (he generates 90 tons/week and he estimates that they could divert half of that for sale to PSU initially). If a long term contract could be in the cards, they would consider weaning the farmers off the dust.

Sawdust cost: $5.50/ton FOB mill

Transportation cost: NA

What s done with sawdust?: All sawdust is sold to farmers at $10/ bucket .

Note: No trucks available. Could contract out for transportation.

(Info from Lou Sycz at mill. He will have Darrel call back if there is a correction.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Walker Lumber and Supply Co. 814-857-7642
Route 322 Bigler
Bigler, PA 16825

Contact: Mark Shaw

Directions: 37 miles — Take 322W to Bigler. Mill is on left side of road.

Tons sawdust available/week: 45 tons

Sawdust cost: $16/ton delivered.

Transportation cost: See above.

What s done with sawdust?: They burn their own sawdust but could set aside about two truckloads/week.

Note: The sawdust is kept under roof. They have one 18-wheeler dump trailer. They are owned by Hardwoods of Michigan (their only mill in the area).

J E Culbertson Co, Inc. 814-643-4519
P.O. Box A
Mill Creek, PA 17060

Contact: Pat Rux

Directions: 40 miles — Take Route 45S or W to Water Street. Turn left onto Route 22E. The mill is on 2E near Mill Creek.

Tons sawdust available/week: 25 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: The sawdust is given to farmers. They also burn their sawdust in winter so there would be none available in wintertime.

Note: They have a small dump truck and a standard box trailer. They manufacture pallets from green wood. The sawdust is blown into a 30 ton silo.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Grubco 814-658-3291
RD1, Box 57A
Hesston, PA 16647

Contact: Mike Grub

Directions: 40 miles — Take Route 26S. Go 8 miles beyond Huntingdon turn right on racetrack road to stop sign turn right then shortly make a left on sawmill road.

Tons sawdust available/week: 50 tons

Sawdust cost: $7.00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: Sawdust is sold to farmers

Note: He has a tractor trailer. But he can contract out for a walking floor. His operation is year round. He stores the dust indoors. He has a front-end loader. The price of his chips is $28/ton (high quality for carbonless paper.

Spigelmyer Lumber 717-248-6555
2316 Hawstone Rd,
Lewistown, PA 17044

Contact: Toby Spigelmyer

Directions: 40 miles — Rte. 322E to Lewistown. Then Rte. 333E to mill on right.

Tons sawdust available/week: 45 tons

Sawdust cost: $4.00/ton FOB mill

Transportation cost: Approximately $6.50/ton to State College ($10.50 delivered)

What s done with sawdust?: Sold to be burned in dry kilns at Cherry Hill Hardwoods (they use about 100 tons/week). The extra sawdust generated by Spigelmeyer Lumber goes to farm bedding or pellet mills. Energex Pellet Mill in Port Royal, PA currently uses 100 tons of sawdust/week and is expanding to 500 tons per week soon.

Note: They contract out transportation with walking floor vans.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Robbins Lumber Co 814-236-3384
RR 1,
Olanta, PA 16863

Contact: Lynn Robbins

Directions: 42 miles — Take Route 322W to Clearfield, then Route 879S or W to Curwensville and Route 453S to mill on right side of the road.

Tons sawdust available/week: 40 tons

Sawdust cost: $3.50/ton FOB mill

Transportation cost: $15.00/ton

What s done with sawdust?: Sawdust is given to neighbors. They also sell to Heaton who sells to State College for blending with treated sewage.

Note: Has open top trailers. He told me some mills blend their sawdust with their chips when selling to people that use chips. they would get a larger price for their chips if they could separate the products.

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*Garner Lumber Co 814-658-3700
PO 462
James Creek, PA 16657

Contact: J. Robert Garner

Directions: 44 miles — Take Route 26S and go to Marklesburg. Turn right onto a mountain road (at Scott Sporting Goods). The mill is one mile up the road.

Tons sawdust available/week: None available at this time. Would be willing to look into the situation and pricing if the project goes forward. They currently generate 80 tons of sawdust per week.

Sawdust cost: No quote at this time.

Transportation cost: See above.

What s done with sawdust?: Most of his sawdust goes to Alexandria Wood Products. Any excess is sold to farmers in the area.

Note: The mill number is 814-658-3401. They have one open top trailer. The walking floor vans are provided by Alexandria Wood Products. They drop them off and pick them up.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Kitko Wood Products 814-672-3606
Route 53 Box 3
Glen Hope, PA 16645

Contact: Ken and Robert

Directions: 44 miles — Take Route 322W to Phillipsburg then Route 53S to mill on left side of the road.

Tons sawdust available/week: 20 tons (March thru October)(generates 80 tons/week).

Sawdust cost: $12:00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: They burn most of their sawdust in their boiler system but not all of it. Some sawdust is sold to Allegheny Particle Board along with their chips.

Note: No sawdust is available in winter months (used in boilers and kilns). They don t have walking floor vans. Sawdust is stored in a concrete bin with a roof. It is loaded with a front end loader.

J W Kitko and Sons 814-672-3590
Route 53 Rose St
Glen Hope, PA 16645

Contact: Chuck Kitko

Directions: 44 miles — Take Route 322W to Phillipsburg then Route 53S to mill on left side of the road.

Tons sawdust available/week: 20 tons (March thru October)(generates 50 tons/week).

Sawdust cost: $ 0/ton FOB mill

Transportation cost: $6.50 delivered

What s done with sawdust: None available in winter months (used in boilers and kilns).
Note: They don t have walking floor vans or open top trailers.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Smith Bros. Sawmill 814-542-8320
Highway 522 S.
RR1 Box 168
Mount Union, PA 17066

Contact: Bernard Smith

Directions: 44 miles —Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Then take Route 522S. The mill is 1 1/2 miles down the road ont eh right hand side (about 1/2 mile beyond Fluid Containment.

Tons sawdust available/week: 40 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: NA

What s done with sawdust?: They give the sawdust to farmers in the area.

Note: They have no trucks.

Gray s Pallets 717-436-8585
Mifflintown, PA 17059

Contact: Jill Swartz

Directions: 45 miles — Take Route 322E to the Port Royal exit. Turn right off the exit ramp. Go 1/4 mile to a 4-way red blinker light. Turn left and go 2 miles. Turn right onto Wagner Road. Go 1.5 miles. Mill is on the right side of the road.

Tons sawdust available/week: 150 tons (also has 20 tpw chips and 40 tpw slabs)

Sawdust cost: $ 0/ton FOB mill (dust, chips and slabs)

Transportation cost: NA

What s done with sawdust?: They give the sawdust to RB Trucking who resells the dust to farms and horse farms. They also give the chips and slabs to others. There are no contracts for this.

Note: They have no trucks. They are looking into purchasing two tractor trailers (possibly walking floors) in the future to both ship pallets and transport chips. They would still contract out the trucking.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Kovalick Lumber Co 814-263-4928
RD1, Box 258
Frenchville, PA 16836

Contact: Richard Kovalick

Directions: 45 miles — Take Route 322W to 970N. At the red light in Woodland the road turns into 879E. Go 5 to the top of the third three lane section of road. Turn right at the Girard Township Office sign. Turn right 1/4 down the road to the mill.

Tons sawdust available/week: 60 tons

Sawdust cost: $300/load (22/ton) or $13.60/ton delivered.

Transportation cost: See above.

What s done with sawdust?: They take 20 tons/week to a brick plant that blends the dust into their bricks (no contract). The rest goes to farmers in the area. If there is an excess, they ship it to Temple Inland fiberboard plant in Clarion, PA.

Note: They have 12 box trailers.

R. H. Morgan Lumber Co. 814-447-5662
HCR 60, Box 370
Orbisonia, PA 17243

Contact: Ramon and Linda Morgan and Clyde Cisney Co-owners

Directions: 45miles —Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Take 522S out of Mount Union to Orbisonia. Go through town and make a sharp left before the bridge on a curve. Go 1.5 miles down Blacklog Valley Road on the left hand side.

Tons sawdust available/week: 20 tons

Sawdust cost: $ 0/ton FOB mill

Transportation cost: $2.00/mile (about $180/load to PSU or $8.00/ton delivered).

What s done with sawdust?: The sawdust is given to farmers.

Note: They have 3 box trailers: two for chips and 1 for sawdust.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Treen Box and Pallet Corp 717-535-5800
Mifflintown, PA 18966

Contact: Vernon Troyer

Directions: 45 miles —Take Route 322E to Port Royal. At stop sign off the ramp turn right. At 4-way blinker light, turn left and go 3.5 miles to Center village. Turn left at the two story farm house with maroon trim. Go 1/4 mile under 322 bridge. The mill is on the right.

Tons sawdust available/week: 100 tons

Sawdust cost: $4.50/ton FOB mill

Transportation cost: NA

What s done with sawdust?: The dust is sold to farmers in the area.

Note: They don t have trucks. They do have a large silo.

Called main office in Ben Salem, PA (Phila.)(215-639-5100) and talked with Keith Geiges. He told me they have two mills in PA: Ken Geromi is the mgr. at Williamsport (570-584-4512) and John Walton is mgr. of the mill in Mifflintown (717-535-5800). I talked with Mary Walton at the Mifflintown mill.

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*Helsel Lumber Mill, Inc. 814-696-0869
3446 Johnstown Road
Duncansville, PA 16635

Contact: Joel Jackson

Directions: 47 miles — Take Route I-99 to Roaring Spring exit. Turn right at end of ramp (old 220S). Turn right at blinking yellow light (Route 164W). Go 7 miles, the mill is on the left.

Tons sawdust available/week: None available at this time.

Sawdust cost: $ 4.00/ton FOB mill

Transportation cost: No quote at this time.

What s done with sawdust?: In the winter, they use all their sawdust for heat and to operate 7 kilns. In the summer (March through October) they sell to the farmers.

Note: They are willing to discuss the situation with us as we get closer to having a project. They may have an interest in the future.

Details of Selected Sawmills for PSU
Phone Survey Short List by distance - Text

Brumbaugh Lumber 814-542-8880
RD1 Box 1068
Mapleton Depot, PA 17052

Contact: Chester Brumbaugh

Directions: 57 miles — Take Route 26 to Huntingdon. Take Route 22E to Mount Union. Take 522S out of Mount Union. The mill is 5 miles down the road on the right side (red building). Don t cross the bridge.

Tons sawdust available/week: 30 tons/week

Sawdust cost: $200/load (about $9/ton delivered)

Transportation cost: See above.

What s done with sawdust?: They take the sawdust to Mellot s Wood Preserving Corp., 1398 Sawmill Road, Needmore, PA 17238 (717-573-2516) (a wood creosoting plant about 35 miles from Brumbaugh Lumber). Mellott s has means to lift a box trailer. They use the sawdust for process heat. There is no contract. They take all comers.

Note: Brumbaugh has 8 box trailers. The mill is near Shirleysburg.

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*Not willing to supply sawdust right now but may consider supplying sawdust in the future.

02/28/01

APPENDIX F. OTHER POTENTIAL BIOMASS RESIDUES

POTENTIAL BIOMASS RESIDUES FOR PENN STATE COMBUSTOR

Bakers:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Delectable Delights by Heather Holland		Centre Hall, PA 16828			814-364-2995	
Pacifico Angelo & Sons					800-934-2867	

Biological Products:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Vespa Labs		RD1 Spring Mills, PA 16875	814-422-8165			

Boxes – Corrugated, Fiber & Wooden:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Beacon Container Corp. of PA		Montoursville, PA 17754			800-332-8562 570-368-2688	
C & E Containers, Inc.		Jersey Shore, PA 17740			570-398-4464	
Mail Boxes Etc.		State College, PA 16801			814-237-2552	
Packaging Service Group		Jersey Shore, PA 17740			570-398-4792	
Parcel Plus		State College, PA 16801			814-231-8030	
Sullivan’s Moving & Storage		Bellefonte, PA 16823			814-234-7090	
U-Haul Company		State College, PA 16801			814-234-8719	
Zeigler’s Packing and Crating		State College, PA 16801			814-238-4021	

Building Materials:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Black Bear Truss		State College, PA 16801			800-326-9689	
Centre Concrete Co.		State College, PA 16801			814-238-0558	
Crain Lumber Co.		Port Matilda, PA 16870			814-692-5020	
84 Lumber Co.		Milesburg, PA 16853			814-355-1584	
GOSCO Hardwood Products		Lewistown, PA 17044			717-543-6470	
Heather-Lite Co (polyurethane)		Centre Hall, PA 16828			814-364-1947	
Houts O W & Son Inc.		State College, PA 16801			814-238-6701	
Penns Valley Building Supply		Spring Mills, PA 16875			814-422-7827	
Jones & Brown		Johnstown, PA 15901			800-452-0227	
Lezzer Lumber Co.		State College, PA 16801			814-237-3511	
Miller Builder’s Supply		State College, PA 16801			814-237-2886	
Oak Hall Fabricators		Centre Hall, PA 16828			814-364-1616	
Quehanna Millwork		Frenchville, PA 16836			814-263-4145	
Triangle Building Supplies		Bellefonte, PA 16823			814-355-5885	
Your Building Centers, Inc.		State College, PA 16801			800-585-3377 814-238-4971	

Butchering:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
A J Peachey & Sons		State College, PA 16801			814-237-0288	

Cabinet Makers:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Associated Woodcrafts		Centre Hall, PA 16828			814-364-9190	
Biddle's Jeff Woodworking		Boalsburg, PA 16827			814-466-7720	
Cabinet Solutions		State College, PA 16801			814-861-3253	
Creekside Custom Millwork		Bellefonte, PA 16823			814-357-8102	
Interior Motives		Duncansville, PA 16635			814-693-9100	
McClellan Millwork		Centre Hall, PA 16828			814-364-9858	
New Cabinet Fashions		State College, PA 16801			814-238-7611	
Price Hardwood & Cabinetry		State College, PA 16801			814-231-0260	
R A F Woodworking		Centre Hall, PA 16828			814-364-9235	
Rogers Terry L Custom Wood Shop		Bellefonte, PA 16823			814-355-8788	
Traditional Touch		Altoona, PA 16601			814-942-2737	

Candy – Wholesale:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Gardner's Candies		Tyrone, PA 16686			814-684-3925	

Feed Wholesale & Manufacturers:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Tyrone Milling		Tyrone, PA 16686			800-439-6455	

Food, Brokers, Consultants, Products:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Colyer Escargot Farm		Millheim, PA 16854			814-349-9809	
Fellinger Mike Co		State College, PA 16801			814-867-0701	
Food Safety Consultants		Hollidaysburg, PA 16648			814-696-5943	
Hanover Foods Corp		Centre Hall, PA 16828			814-364-1482	
Herloicher Foods		State College, PA 16801			814-237-0134	
Suzie Wong's Eggroll & More		Ferguson, PA			814-237-5005	
SYSCO Food Service of Central PA					800-733-7420	
Village Eating House		Harris, PA			814-466-6865	

Furniture Designers & Custom Builders:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Butterfield, Robert		Julian, PA 16844			814-355-9054	
Happy Valley Wooden Treasures		Port Matilda, PA 16870			814-692-8811	

Home Improvements (possible source of construction/demolition wood):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Affordable Roofing		State College, PA 16801			814-237-2866	
Appalacian Building & Construction		Bellefonte, PA 16823			814-355-0973	

Ark Construction		State College, PA 16801			814-234-8943	
Bald Knob Builders		Boalsburg, PA 16827			814-466-7658	
Bonchack Maintenance		State College, PA 16801			814-238-1123	
Brothers in Christ Construction		Penns Valley, PA			814-364-9202	
C. L. Greenland		State College, PA 16801			814-237-2363	
Casamento & Sons Construction		Port Matilda, PA 16870			814-234-3748	
Discount Remodelers, Inc.		Bellefonte, PA 16823			814-355-0680	
E-B Enterprises		Boggs, PA			814-355-2098	
Frey Builders		Spring Mills, PA 16875			814-364-9955	
Gilmore Construction		Bellefonte, PA 16823			814-355-0911	
Handyworks		Bellefonte, PA 16823			814-355-8060	
Hartswick Construction, Inc.		State College, PA 16801			814-238-9537	
Homan Construction, Inc.		State College, PA 16801			814-237-4051	
Homescapers		Bellefonte, PA 16823			814-353-0507	
Hoy & Reede		Pleasant Gap, PA 16823			814-359-3032	
J. B. Roofing		State College, PA 16801			814-231-2824	
Johnson Construction, Inc.		Spring Mills, PA 16875			814-364-1436	
Jovinelli Services		State College, PA 16801			814-238-6671	
Kitchen Klassics		Bellefonte, PA 16823			814-353-8110	
Knisely Built		State College, PA 16801			814-237-5515	
Kunes General Contracting, Inc.		State College, PA 16801			814-234-5828	
Lindsay Construction		Boalsburg, PA 16827			814-466-7775	

MPM Builders		Boalsburg, PA 16827			814-466-0555	
Master Renovators & Builders, Inc.		State College, PA 16801			814-234-3066	
Mountainside Electric		State College, PA 16801			814-234-8447	
RJL Construction		Potter, PA			814-364-1020	
Reits Construction		Spring, PA			814-357-8122	
Remodeler's Workshop		Pleasant Gap, PA 16823			814-359-3207	
Sampsel Construction		Spring Mills, PA 16875			814-422-8919	
Shuey Construction		Pleasant Gap, PA 16823			814-359-2862	
Smith's Custom Builders		Spring Mills, PA 16875			814-422-8407	
Solartherm Remodelers Company, Inc.		State College, PA 16801			814-231-8855	
Veronesi Building & Remodeling, Inc.		State College, PA 16801			814-237-4514	
Witmer Construction, Inc.		State College, PA 16801			814-238-6062	

Logging Companies:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Carl Emery Logging		Woodeard, PA			814-349-5737	
Fye Logging & Veneer, Inc.		Moshannon, PA 16859			814-387-6503	
Hoover Wood Products		Snow Shoe, PA 16874			814-387-0244	
Pine Creek Lumber, Inc.		Mill Hall, PA 17751			570-726-7795	
Superior Lumber		State College, PA 16801			814-234-1133	
Sustainable Forestry Initiative		State College, PA 16801			814-867-9299	
Thomas Timberland Enterprises,Inc.		Pleasant Gap, PA 16823			814-359-2890	

Wheeland Lumber Co., Inc.		State College, PA 16801			814-867-6475	
Doc’s Dry Kilns		Rebersburg, PA 16872			814-349-5762	
Wetzel Palmer, Jr.		Jersey Shore, PA 17740			570-398-7771	

Lumber – Retail:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Alexandria Wood Products, Inc.		Alexandria, PA 16611			888-748-3952 814-669-4469	
Biddle’s Jeff Woodworking		Boalsburg, PA 16827			814-466-7720	
Crain Lumber Company		Port Matilda, PA 16870			814-692-5020	
Eastern Wood Products		Williamsport, PA			800-445-5428	
84 Lumber Co.		Milesburg, PA 16853			814-355-1584	
Keystone Hardwoods		Julian, PA 16844			814-355-0953	
Lezzer Lumber Co		State College, PA 16801			814-237-3511	
Peachey’s Wood Products		Reedsville, PA 17084			717-667-9373	
Penns Valley Building Supply		Spring Mills, PA 16875			814-422-7827	
Price C L Sawmill & Planing Mill		Cobum, PA 16832			814-349-4431	Office: Aaronsburg, PA 814-349-5505
Price Hardwood & Cabinetry, State College, PA 16801					814-231-0260	
Quehanna Millwork		Frenchville, PA 16836			814-263-4145	
Triangle Building Supplies & Services		Bellefonte, PA 16823			814-355-5885	
Wood Powell		Huntingdon, PA 16652			814-643-0691	
Woodcrafter’s Supply		Altoona, PA 16601			814-943-2833	
Your Building Centers, Inc.		State College, PA 16801			800-585-3377 814-238-4971	

Lumber – Wholesale:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Kovalick Lumber		Snow Shoe, PA 16874			814-387-4230	
Lezzer Wholesale Supply		State College, PA 16801			814-237-5977	
Price Hardwood & Cabinetry		State College, PA 16801			814-231-0260	
Thomas Timberland Enterprises,Inc.		Pleasant Gap, PA 16823			814-359-2890	

Newswpapers (waste newsprint):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Associated Press		State College, PA 16801			814-238-3649	
Blue White Illustrated		State College, PA 16801			814-234-1177	
Centre Daily Times		State College, PA 16801			814-238-5000	
Construction Data Corp.		State College, PA 16801			814-234-5120	
Pennsylvania Business Central		State College, PA 16801			814-867-2222	
Pittsburgh Post Gazette		Pittsburgh, PA			412-263-1100	
Voices of Central PA		State College, PA 16801			814-234-1699	

Nurseries – Plants – Trees etc. (possible source of wood from prunings, dead stock etc):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Andreozzi's Posies		Port Matilda, PA 16870			814-692-4076	

Aquatic Jewells		Bellefonte, PA 16823			814-355-1271	
Black Bear Nursery		Winburne, PA 16879			814-345-6953	
Blackhawk Homestead Service		Centre Hall, PA 16828			814-364-9668	
College Gardens Nursery		State College, PA 16801			814-237-6801	
College Gardens Nursery		Port Matilda, PA 16870			814-234-3600	
Countryside Nursery		Warriors Mark, PA 16877			814-692-5288	
D & H Tree Farm		Kylertown, PA 16847			814-345-5055	
Fox Hill Gardens		State College, PA 16801			814-237-9087	
Garden Shed		State College, PA 16801			814-238-5090	
Holliis Garden Center & Greenhouse Nursery		Osceola Mills, PA 16666			814-339-6289	
Horseshoe Lane Nursery		Bellefonte, PA 16823			814-353-1644	
J. L. Farm		State College, PA 16801			814-237-9045	
K & K Flowers		Snow Shoe, PA 16874			814-387-0100	
KLR Landscaping		Milesburg, PA 16853			814-355-8211	
Narber's Landscaping & Nursery		Boalsburg, PA 16827			814-466-7905	
Nardozzo's Landscaping & Nursery		Potters Mills, PA			814-364-2770	
Nittany Enhancements Nursery & Landscaping		Boalsburg, PA 16827			814-466-6128	
Norse Paddle Company		Spring Mills, PA 16875			814-422-8844	
Sammis Greenhouse		Centre Hall, PA 16828			814-364-2881	
Tait Farm Trees		Boalsburg, PA 16827			814-466-6910	

Potato Chips – Wholesale:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Herr's Foods, Inc.		Hollidaysburg, PA 16648			800-328-4313	
Luse Distributing		Centre Hall, PA 16828			814-364-1216	
Utz Quality Foods, Inc.		Hanover, PA 17331			800-367-7629	

Recycling Centers:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Centre County Recycling Program		Bellefonte, PA 16823			814-238-6649	
Centre County Solid Waste Authority		Bellefonte, PA 16823			814-238-7005	
John Glenn Sanitation Service, Inc.		371 Struble Rd State College, PA 16801			814-234-0141	
Krentzman, Joe & Son, Inc.		Lewistown, PA 17044			717-543-5635	
P G Recycling, Inc. (paper)		Altoona, PA 16601			814-944-1210	
Sterda Recycling Systems (paper)		Bellwood, PA			814-742-8453	

Rubbish & Garbage Removal:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Carson Fred Sanitary Disposal Service		State College, PA 16801			814-238-6895	
Chambers of PA		State College, PA 16801			814-235-1901	
John Glenn Sanitation Service		State College, PA 16801			814-234-0141	
Kline A M		Bellefonte, PA 16823			814-237-7468	

Love Aubrey Disposal Service		Lock Haven, PA 17745			570-748-2760	
Newman, B E, Inc.		Milesburg, PA 16853			814-355-4626	
Superior Waste Services		25 Decibel Rd State College, PA 16801	4		814-237-3713	
USA Waste Services of PA		2901 Stewart Dr State College, PA 16801			814-235-1901	

Septic Tanks - Cleaning & Repairing (possible source of biowastes):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Buckrun Farms		State College, PA 16801			814-234-8850	
Center Penn Service		Bellefonte, PA 16823			800-252-3846 814-355-2185	
Carson Sanitary Disposal Service		State College, PA 16801			814-238-6895	
McKee Excavation		Runville, PA			814-355-5574	
Robinson Septic Service, Inc.		Milesburg, PA 16853			814-355-4474	
Shawley Septic Tank Service		Boalsburg, PA 16827			814-466-6325	
Wilts Septic Service		Altoona, PA 16601			814-943-8232 814-742-8743	
Zooks Liquid Hauling		Millmont, PA 17845			570-922-1466	

Sewage Disposal Systems (possible source of biowastes):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
College Harris Joint Authority		State College, PA 16801			814-238-8370	
Ferguson Township Authority		Pine Grove Mills, PA 16868			814-238-0927	
Mid Centre County Authority		Milesburg, PA 16853			814-355-8435	

Mountaintop Area Municipal Authority		Snow Shoe, PA 16874			814-387-4321	
Patton-Ferguson Joint Authority		State College, PA 16801			814-238-9662	
Spring Creek Pollution Control Facility		State College, PA 16801			814-238-2259	
University Area Joint Authority		State College, PA 16801			814-238-5361	

Stables (possible source of manure & bedding):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Carousel Farm		State College, PA 16801			814-364-2512	
Centre Stables		Penna Furnace, PA			814-692-5530	
Eastwood Farms		Bellefonte, PA 16823			814-355-4523	
Graystone Stables		Port Matilda, PA 16870			814-692-4400	
Hillhaven Farm		State College, PA 16801			814-237-6003	
Jodon’s Slab Cabin Farm & Tack		State College, PA 16801			814-237-8769	
Jodon’s Stables		Port Matilda, PA 16870			814-692-7404	
Kocher Farms Stable & Tack Shop		Penna Furnace, PA			814-238-4124	
Lazy B Stables		State College, PA 16801			814-234-3610	
Nittany Mountain Trail Rides		Woodward, PA 16882			814-349-8300	
Nittany Mountain Trail Rides		Haines, PA			814-349-8300	
Perlick Queens Three Farm		Bellefonte, PA 16823			814-383-4781	

Tire Dealers (possible source of waste tires):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Bastion Tire Sales, Inc.		State College, PA 16801			814-238-4955	
Bierlein Automotive		Potter's Mills, PA			814-364-1904	
Charlie's Tire & Service		Morrisdale, PA 16858			814-342-0819	
Cooper Tires		Pleasant Gap, PA 16823			814-359-4290	
Eddie's Tire		Lewistown, PA 17044			717-248-7510	
Firestone Tire & Service Center		State College, PA 16801			814-238-5505	
Forklifts, Inc.		State College, PA 16801			814-238-0508	
Fred's Tire Company		Bellefonte, PA 16823			814-353-0396	
General Automotive Service		State College, PA 16801			814-238-4427	
LMR Tires		Lamar, PA 16848			570-726-7981	
Lohr's Garage		State College, PA 16801			814-234-7888	
Lohr's Garage		Bellefonte, PA 16823			814-355-2323	
Long's Tire Service		Martinsburg, PA 16662			814-793-2083	
McCarthy Tire Service		Milesburg, PA 16853			814-355-2102	
Monro Muffler Brake		State College, PA 16801			814-234-2911	
Pep Boys Automotive Supercenters		State College, PA 16801			814-861-1680	
Raymond's Tire Distribution, Inc.		Pleasant Gap, PA 16823			814-359-4290	
Sears Auto Center		State College, PA 16801			814-231-5682	
Stewart's Auto Parts		State College, PA 16801			814-231-8125	
Tire Town, Inc.		State College, PA 16801			814-238-2190	

Walmart		State College, PA 16801			814-235-9407	

Tire Retreading & Repairings (possible source of waste tires):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Wagner, Inc.		Yeagertown, PA 17099			717-248-6210	
Valley Truck & Trailer Sales & Service, Inc.		State College, PA 16801			814-237-2464	

Tree Service:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Aikey’s Tree Service		State College, PA 16801			814-238-0665	
Aikey’s Tree Service		Bellefonte, PA 16823			814-353-0360	
Allegheny Professional Tree Care					800-835-4541	
B & H Tree Service		Bellefonte, PA 16823			814-355-5441	
Centre Tree Care, Inc.		Centre Hall, PA 16828			814-364-2815	
Dave’s Total Tree Service		Bellefonte, PA 16823			814-357-8333	
Dincher & Cincher Tree Surgeons					800-286-3090	
E-B Enterprises		Boggs, PA			814-355-2098	
Eco-Lawn		Pine Grove Mills, PA 16868			814-364-7336	
Evergreen Tree Care		State College, PA 16801			814-466-8733	
McDonough’s Tree Service					800-585-9060	
Meek Tree Service & Landscape Maintenance		Julian, PA 16844			814-355-0538	

Moore Andrew Tree Surgeon		State College, PA 16801			814-234-0186	
Plant-Life		Centre Hall, PA 16828			814-364-9456	
Prescott's Tree Service		State College, PA 16801			814-867-1118	
Smith Tree Service		Boalsburg, PA 16827			814-466-2357	
Stout Tree Professionals		Philipsburg, PA 16866			814-342-7297	
Total Tree Service		Boalsburg, PA 16827			814-466-6650	
Warner Clarke Landscape Maintenance		State College, PA 16801			814-231-3253	

Waste Reduction, Disposal & Recycling Service – Industrial:

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
Centre County Solid Waste Authority		253 Transfer Rd Bellefonte, PA 16823	12		814-238-7005	
Superior Waste Services, Inc.		25 Decibel Rd State College, PA 16801	4		814-237-3713	

Windows (possible source of waste wood):

Company Name	Tons/week available	Location	Miles to State College	FOB$/ ton	Phone	Contact
84 Lumber Company		Milesburg, PA 16853			814-355-1584	
Appleby Systems, Inc.					800-767-0200	
Bob Showers Windows Sunroom Enclosures					800-948-4262	
Cisney & O'Donnell, Inc.		State College, PA 16801			814-235-9277	
Conklin Scott Builders, Inc.		Philipsburg, PA 16866			800-723-8753	
DJS Building & Remodeling		State College, PA 16801			814-231-0530	

Discount Remodelers, Inc.		Bellefonte, PA 16823			814-355-0680	
Haupt Home Improvement		Spring Mills, PA 16875			814-422-8138	
Johnson Construction, Inc.		Spring Mills, PA 16875			814-364-1436	
Mike's Window Service		Williamsport, PA			570-323-1848	
PA Door & Window Gallery					888-572-3667	
Pella Window & Door Company		State College, PA 16801			800-933-3694	
Penns Valley Windows		Centre Hall, PA 16828			814-364-2177	
Smith's Custom Builders, Inc.		Spring Mills, PA 16875			814-422-8407	
Solarshield, Inc.		Altoona, PA 16601			800-862-2000	
Solartherm Remodelers Company, Inc.		State College, PA 16801			814-231-8855	
Spring Lake Vinyl		Miles, PA			814-349-4405	
Triangle Building Supply & Service		Bellefonte, PA 16823			814-355-7073	
Triangles Home Showcase		State College, PA 16801			814-867-2400	
Veronesi Building & Remodeling, Inc.		State College, PA 16801			814-237-4514	
Wineland & Son, Inc.		Martinsburg, PA			800-870-7992	
Witherite Home Improvement & Siding		Boalsburg, PA 16827			814-466-7465	

APPENDIX G. FOSTER WHEELER/PARSONS SCOPE OF SUPPLY

APPENDIX #7

SCOPE OF SUPPLY

The following is a general listing of the scope work that Foster Wheeler (FW) and Parsons performed for this feasibility study for a state-of-the-art Compact ACFB steam generator:

WORK DESCRIPTION	FW	PARSONS	COMMENTS
GENERAL ARRANGEMENT			
Boiler House	X		
Feed and Gas Cleanup	X		
Site Plan		X	
Auxiliary Support System		X	
STEAM GENERATOR			
Furnace	X		Natural Circulation
Component Separators	X		Water Cooled
Convection Pass Enclosure	X		
Steam Drum w/Internals	X		Ship Installed
Internal Boiler Piping, including Headers, Downcomers, Feeders, Risers and Transfer Pipes	X		
Air Distribution Grid and Plenum	X		
Fluidization Nozzles	X		Shop Installed – Arrowhead Type
Superheater Coils	X		
Economizer Coils	X		Bare Tube
Spray Attemperators	X		
Access/Observation Doors	X		
Wall Openings/Penetrations/Seals	X		
Penthouse/Header Enclosures	X		
BOILER APPURTENANCES & VALVES			
Feed Stop & Check Valves	X		Manual Valve
Feedwater Regulating	X		
Main Steam Stop	X		
Attemperator Regulating, Isolation Valves	X		Actuated Regulating Valves
Drain and Vent Valves	X		
Blowdown/Blowoff Valves	X		
Safety Valves for Drum, Superheater	X		
Safety Valve Silencers	X		
ERV with Controller	X		
ERV Silencer	X		
Steam & Water Sample Shutoff Valves	X		
Chemical Feed Shutoff Valve	X		

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Chemical Cleaning Valves	X		
Nitrogen Blanket Valves	X		
Instrument Shutoff/Drain Valves	X		
Blowdown Tank	X		
Auxiliary Steam Shutoff Valves	X		If required
Sootblower Steam Shutoff Valves	X		
Steam Coil Valving	X		If required
SOOTBLOWER SYSTEM			
Steam Retract/Type Blowers	X		Superheater, Economizer
Electric Motor Drives	X		
Pressure Reducing Station	X		
Main and Branch Piping	X		
Valves, Steam Traps, Fittings	X		
Supports	X		
Control Logic	X		
Control Hardware	X		
AIR HEATERS			
Air Preheat Steam Coils	X		If required
Tubular Airheater	X		
MAJOR FANS			
Forced Draft (FD)	X		
Electric Motor Drives	X		
Inlet Vanes & Pneumatic Actuator	X		
Outlet Dampers	X		
Inlet Silencers	X		
Shaft Couplings w/Guard	X		
Bearing Metal TCs	X		
Motor RTDs	X		
Sole Plates	X		
Vibration Transducer Pads	X		
Vibration Monitor	X		
Vibration Transducer	X		
Ring Oiled Bearings	X		As required
Water/Oil Heat Exchanger	X		As required
Tests Dynamic Balancing	X		
Induced Draft (ID) Fan, including:	X		
Electric Motor Drives	X		
Inlet Vanes & Pneumatic Actuator	X		
Outlet Dampers	X		
Shaft Couplings w/Guard	X		
Bearing Metal TCs	X		
Motor RTDs	X		

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Sole Plates	X		
Vibration Transducer Pads	X		
Vibration Monitor	X		
Vibration Transducer	X		
Ring Oiled Bearings	X		As required
Water/Oil Heat Exchanger	X		As required
Tests Dynamic Balancing	X		
Motors	X		
Silencers	X		
Wall Seal Blowers	X		
Motors	X		
Silencers	X		
FLUES, DUCTS, HOPPERS, STACK			
Fan Inlet Ducts	X		If required
Fans to Airheater	X		
Airheater to Boiler	X		
Secondary Air Ducts	X		
Air Flow Elements	X		
Economizer to Airheater Outlet	X		
Airheater Outlet to Baghouse	X		
Baghouse to ID Fan	X		
ID Fan to Breeching	X		
Stack Breeching	X		
Stack		X	
Access Doors	X		Within Scope
Expansion Joints	X		Within Scope
Economizer/Airheater Hoppers	X		
Hopper Level Detectors	X		Within Scope
PARTICULATE REMOVAL			
Baghouse	X		
BURNER SYSTEMS			
Above Bed Start-up Burners, including:	X		
Burner Valve Train	X		
BMS Logic	X		
Burner Controls	X		Integrated w/DCS
Local Panel	X		
Flame Scanners	X		
COAL AND BIOFUEL FEED SYSTEMS			
Coal Receiving/Unloading		X	
Coal Handling/Reclaiming/Conveying		X	
Long Term Coal Storage		X	

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Coal Sizing		X	
Biomass Receiving/Unloading	X		Site arrangement by Parsons
Biomass Handling/Reclaiming/Conveying	X		
Wood Sizing	X		Balance of biomass sizing by Penn State
Prepared Fuel Bunkers/Silos	X		
Bunker/Silo Discharge Valves	X		
Flow Monitors	X		
Gravimetric & Volumetric Belt Feeders	X		
Feed Point Isolation Valves	X		Actuated
Downspouts, Chutes, Air Piping, Expansion Joints	X		
LIMESTONE FEED SYSTEM			
Limestone Sizing/Drying		X	Delivered pre-sized
Limestone Receiving/Unloading	X		By truck
Prepared Limestone Silo	X		One per boiler
Silo Discharge Valves	X		
Rotary Flow Control Feeders/Motors	X		
Diverter Valves	X		
Rotary Feeder-Airlocks/Motors	X		
Air Purge and Venting Systems	X		
Pneumatic Conveying System	X		
Blower Packages/Motors	X		
Instruments	X		
Sand System	X		
SOLIDS RECYCLE SYSTEM			
Wall Seal	X		
Solids Return Legs	X		
Air Piping/Dampers	X		
Instrumentation	X		
SPENT BED MATERIAL SYSTEM			
Furnace Transfer Pipes	X		
Stripper Coolers	X		
Knife Gate Shutoff Valves	X		
Rotary Flow Control Valves/Motors	X		
Ash Conveying to Silo	X		Combined BA/FA
Ash Storage Silo	X		
Silo Unloading	X		
FLYASH HANDLING SYSTEM			
Pick-Up from Hoppers	X		Economizer/Airheater
Conveying System	X		

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Blowers/Motors	X		
Storage Silo	X		Combined BA/FA
BED ASH HYDRATION/REINJECTION			
Pick-Ups from Retention Vessel	X		
Pneumatic Conveying System, including: Mixers, Surge Silos, Blowers/Motors, Piping, Splitters and Injection Nozzles	X		
Control System Design and Instrumentation	X		Integrated w/DCS
PIPING SYSTEMS			
Safety Valve Exhaust & Drain	X		
Drains	X	X	Parsons BOP to interface w/FW
Vents	X	X	Parsons BOP to interface w/FW
Steam outside Boiler House Limits		X	Parsons BOP to interface w/FW
Feedwater System		X	Parsons BOP to interface w/FW
Condensate		X	Parsons BOP to interface w/FW
Feedwater Pumps & Piping		X	Parsons BOP to interface w/FW
Pressure Gage	X		
Blowdown and Blow-off Water	X		
Seal Air	X		
Plant/Service Air		X	
Instrument Air		X	
Spraywater	X		
Water Gages Remote Level Ind.	X		
Sootblower	X		
Interconnecting Tubing		X	
Cooling Water		X	Closed Loop System and Heat Exchanger Pumps
Chemical Feed		X	
Fuel Oil	X	X	Parsons BOP to interface w/FW
Auxiliary Steam		X	
Condensate		X	
Water Treatment/Supply		X	
Waste Water		X	
Fire Protection		X	

WORK DESCRIPTION	FW	PARSONS	COMMENTS
INSTRUMENTATION AND CONTROLS			
DCS	X	X	Wiring by Parsons, Hardware & design by FW
Combustion Controls	X		
Fuel Safety System	X		
Safety Interlocks	X		
Limestone Controls	X		
Fuel Feeder Controls	X		
Sootblower Controls	X		
Panels		X	
Bed Thermocouples	X		
Metal Thermocouples	X		
Hopper Thermocouples	X		
Process Thermocouples	X		
Thermowells	X		
Thermocouple Junction Box	X		
Water columns & Gage Assembly	X		
Remote Level Indicator	X		
Pressure Taps	X		
Drum Pressure Gage	X		
Combustion Air Flow Elements	X		With Transmitters
Field Transmitters/Switches		X	
Control Wiring/Cables		X	
Instrument Wiring/Cables		X	
Interconnecting Wiring/Tubing		X	
O_2 Analyzers	X		
NO_x Analyzer	X		
Stack Analyzers/CEMs	X		
Water/Steam Sampling System		X	
Damper Actuators	X		Within Scope
STRUCTURAL			
Foundations		X	Loads by FW
Base Plates	X	X	FW for Boiler
Anchor Bolts	X	X	FW for Boiler
Structural Steel Design	X	X	FW for Boiler
Structural and Support Steel Supply:			
BOP Area	X		Except coal receiving building by Parsons
Boiler Area w/Baghouse	X		
Fuel Silo Bay	X		
Airheater Supports	X		
Flue and Duct Supports	X		
Ash Silo	X		Site arrangement by Parsons

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Platform/Stair Supports	X		
Elevator Framing	X		
All Piping Support Steel	X		
Conduit/Cable Tray Support Steel	X		
Misc. Support for Lighting, Cabinets, Panels, etc.	X		
Boiler Integral Steel	X		
Buckstays	X		
Hangers/Lugs	X		
Boiler Guide Steel	X		
Piping Hangers	X		
Platforms	X		
Checker Plate	X		
Handrail/Toeplate	X		
Stairtreads	X		
Caged Ladder	X		
Roof Framing	X		
Out Buildings			
- Biomass Receiving/Handling	X		
- Coal Receiving/Handling/Crushing		X	
- Water Treatment/Control Room, etc	X		Building by FW, Equip by P
- Turbine Generator	X		Building by FW, Equip by P
- Chilled Water			By Penn State
ELECTRICAL			
Electrical Motors	X	X	Within Scope
Motor Control Center/Switchgear		X	
Power Wiring/Cables		X	
Conduit & Cable Trays		X	
Lighting/HVAC		X	
Grounding Systems		X	
Communications System		X	
Electric Motor Starters (Integral)	X	X	
BOILER MISCELLANEOUS			
Insulation/lagging Specifications			
Insulation	X	X	FW for Boiler Parsons for Piping
Lagging	X	X	FW for Boiler Parsons for Piping
Refractory Specifications	X		
Refractory	X		
Pressure Parts	X		Field Installed
Separator Hood	X		Field Installed
Stripper/Cooler	X		Field Installed
Loopseal	X		Field Installed

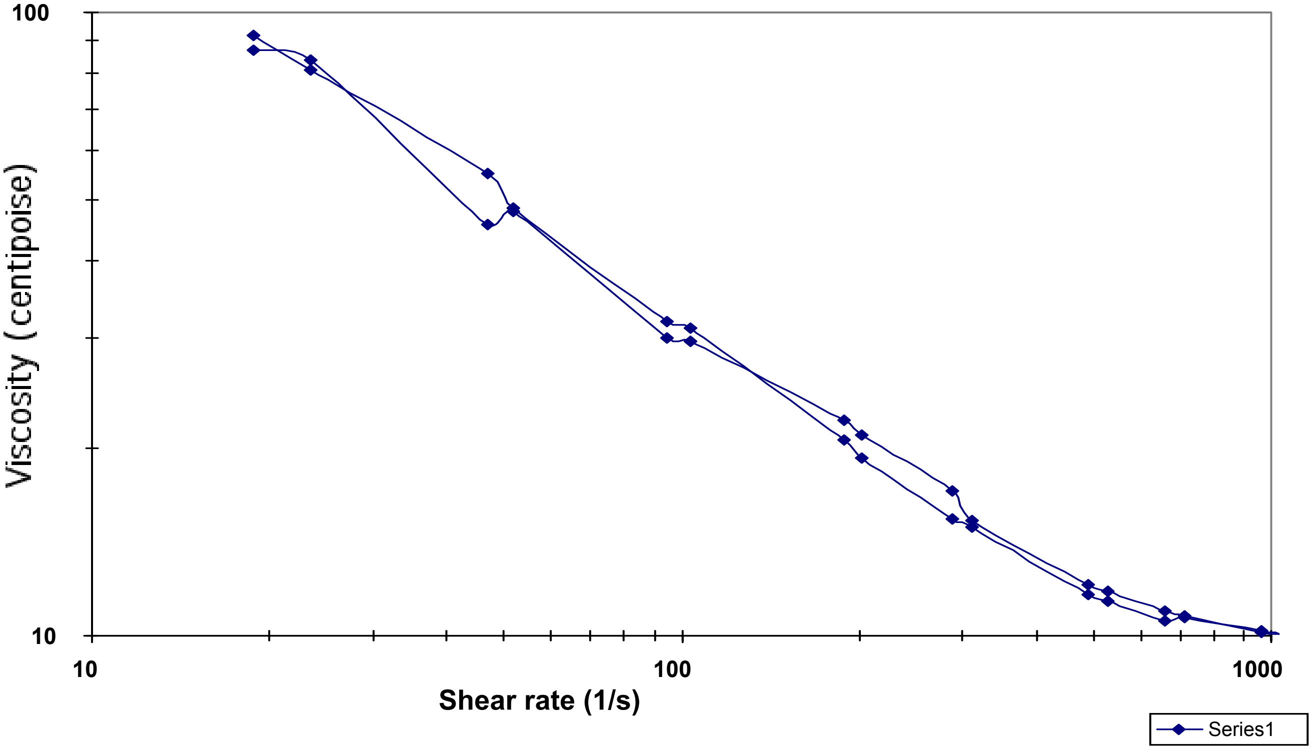
WORK DESCRIPTION	FW	PARSONS	COMMENTS
Monorails	X		As required
Maintenance Hoists	X		As required
Elevator	X		
Building Enclosures			Wind loads on FW Steel, brick siding/roofing design, supply & installation by Penn State
Building Roofs			
Chemical Feed System		X	
Service Air System		X	
Instrument Air System		X	
Feedwater Treatment		X	
Blowdown System	X	X	FW Scope to and including BD Tank
Prime Painting	X		Within Scope
Field Touch-up Painting	X		
Finish Painting	X		
PLANT MISCELLANEOUS			
Site Grading and Preparation		X	
Architectural			By Penn State
Underground Ducts and Piping		X	As required
Foundations and Concrete Work		X	
Heat Tracing		X	If required
Critical Piping		X	
Main Steam		X	
Feedwater		X	
Plant Communication/Paging System		X	
SHIPPING AND RECEIVING			
Ship Material and Equipment	X	X	Each his own
Unload Material and Equipment	X	X	Each his own
Storage and Protection	X	X	Each his own
Duties	X	X	Each his own
Taxes, Tariffs, Bonds, Insurance			Excluded
SITE REQUIREMENTS DURING CONSTRUCTION			
Permits	X	X	Support to PSU
Construction Services			
Security		X	Support to PSU
Laydown Area		X	
Roads		X	
Warehouse		X	
First Aid		X	
Dust Control		X	
Sanitary Facilities		X	

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Utilities			By Penn State
Electric			By Penn State
Compressed Air			By Penn State
Potable Water			By Penn State
Construction Water			By Penn State
Heat			By Penn State
Light			By Penn State
Clean-Up/Disposal		X	
Start-up Spare Parts	X	X	
Operational Spare Parts			Later
ERECTION – Follows Material/Equipment Supply			
Construction Management	Support	X	
COMMISSIONING			
Equipment Alignment	X	Support	
Equipment Checkout	X	Support	
Initial Lubrication	X	Support	
Equipment & Piping Flush-Out	X	Support	
Boiler Hydrotest	X	Support	
Supply Heat and Disposal of Hydrowater	X	Support	
Air Test Boiler	X	Support	
Air Test Flues & Ducts	X	Support	
Chemical Clean Boiler	X	Support	
Supply & Disposal of Chemicals	X	Support	
Steam Blows – SHTR, & Pipe	X	Support	
Controls Checkout and Tuning	X	Support	
Field Calibration of Instruments and DCS	X	Support	
Turbine Check-out, Run-in and Tuning	X	Support	
First Coal Fires	X	Support	
Boiler Check-out and Tuning	X	Support	
O&M Manuals	X	X	
Operation Training	X	X	
START-UP AND TESTING			
Operating Personnel			Penn State
Fuel, Sorbent, Chemicals			Penn State
Site Engineers	X	X	Each his own
Vendor Representatives	X	X	Each his own
Craft Labor	X	X	Each his own
Standby Labor	X	X	Each his own
Test Personnel	Support	Support	
Test Criteria and Format	Support	Support	
Test Equipment	X	X	Each his own
Emissions Testing	Support	Support	

WORK DESCRIPTION	FW	PARSONS	COMMENTS
Laboratory Testing	X	X	As required
Report Preparation	X	X	Each his own

APPENDIX H. ANALYSIS AND PHOTOGRAPHS OF POTENTIAL FEEDSTOCKS

Digester Effluent



28-31 cp at 100/s

WWTP Sludge

2,708 tons/yr @ 11.6% solids = 314 dry tons/yr

	Rep 1	Rep 2	Rep 3	Rep 4
Moisture	77.2	76.9	84.4	76.2
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	49.6	48.3	N.D.[c]	N.D.
Ash	46.9	48.2	N.D.	N.D.
Fixed Carbon	3.5	3.5	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)				
Carbon	30.3	N.D.	N.D.	N.D.
Hydrogen	4.3	N.D.	N.D.	N.D.
Nitrogen	4.1	N.D.	N.D.	N.D.
Sulfur	1.1	N.D.	N.D.	N.D.
Oxygen	13.3	N.D.	N.D.	N.D.
HHV (Btu/lb)	4,325	5,268	4,678	N.D.
Bulk Density[b] (g/cc)	1.0			
(lb/ft^3)	62.4			

[a] Dry Basis

[b] Determined from Entire Sample

[c] Not Determined

Pine Chips

Composition assumed same as pine shavings
Bulk density = 0.10 g/cc

Pine Shavings

	Rep 1	Rep 2	Rep 3	Rep 4
Moisture	45.0	46.3	46.2	N.D.[c]
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	84.7	83.0	82.1	81.9
Ash	0.1	0.0	0.2	0.0
Fixed Carbon	15.2	17.0	17.8	18.1
Ultimate Analysis (wt. %, d.b.)				
Carbon	49.1	N.D.	N.D.	N.D.
Hydrogen	6.4	N.D.	N.D.	N.D.
Nitrogen	0.2	N.D.	N.D.	N.D.
Sulfur	0.2	N.D.	N.D.	N.D.
Oxygen	44.0	N.D.	N.D.	N.D.
HHV (Btu/lb)	8,502	8,422	8,197	N.D.
Bulk Density[b] (g/cc)	0.19			
(lb/ft^3)	11.9			

[a] Dry Basis

[b] Determined from Entire Sample

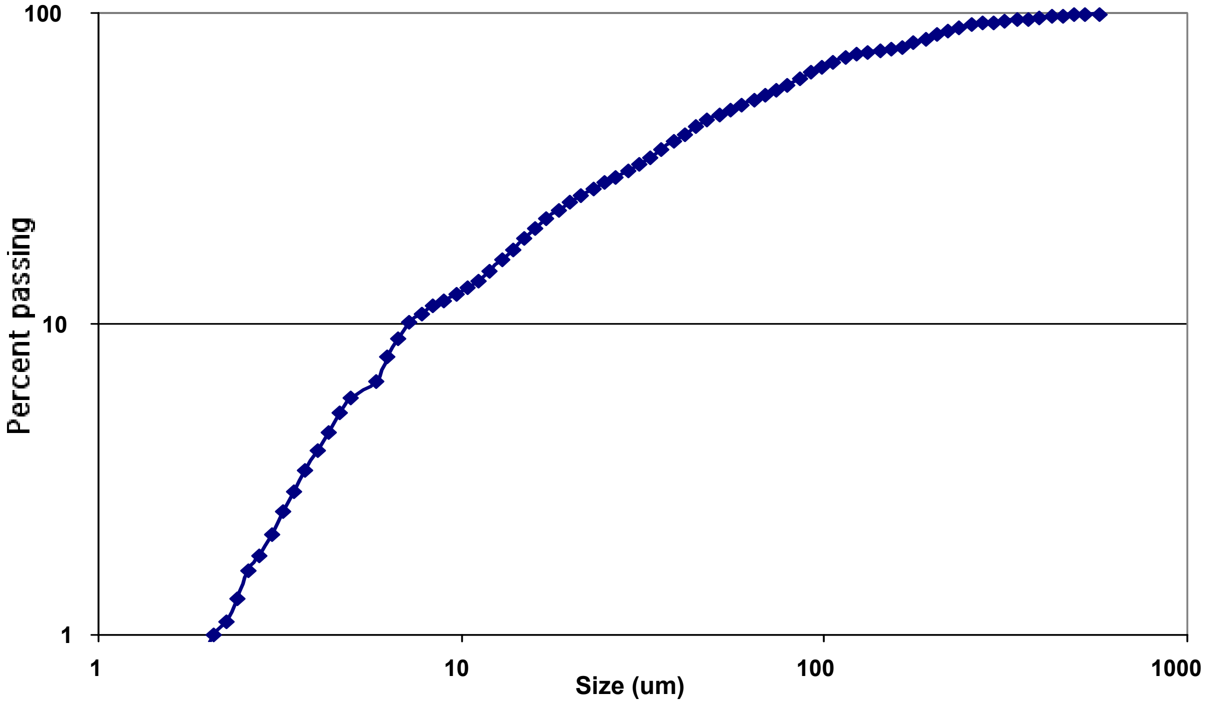
[c] Not Determined

Fly Ash

1,445 tons/yr

	Rep 1	Rep 2	Rep 3	Rep 4
Moisture	22.8	24.5	23.8	N.D.[c]
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	8.5	7.2	8.0	8.2
Ash	73.8	74.1	72.2	73.4
Fixed Carbon	17.7	18.7	18.1	17.5
Ultimate Analysis (wt. %, d.b.)				
Carbon	22.0	23.5	22.7	21.0
Hydrogen	0.3	0.1	0.1	0.1
Nitrogen	0.3	0.2	0.3	0.2
Sulfur	1.2	0.9	0.7	0.6
Oxygen	2.4	1.2	4.0	4.6
HHV (Btu/lb)	1,737	1,700	1,520	1,436
Bulk Density[b] (g/cc)	0.72			
(lb/ft^3)	11.9			

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

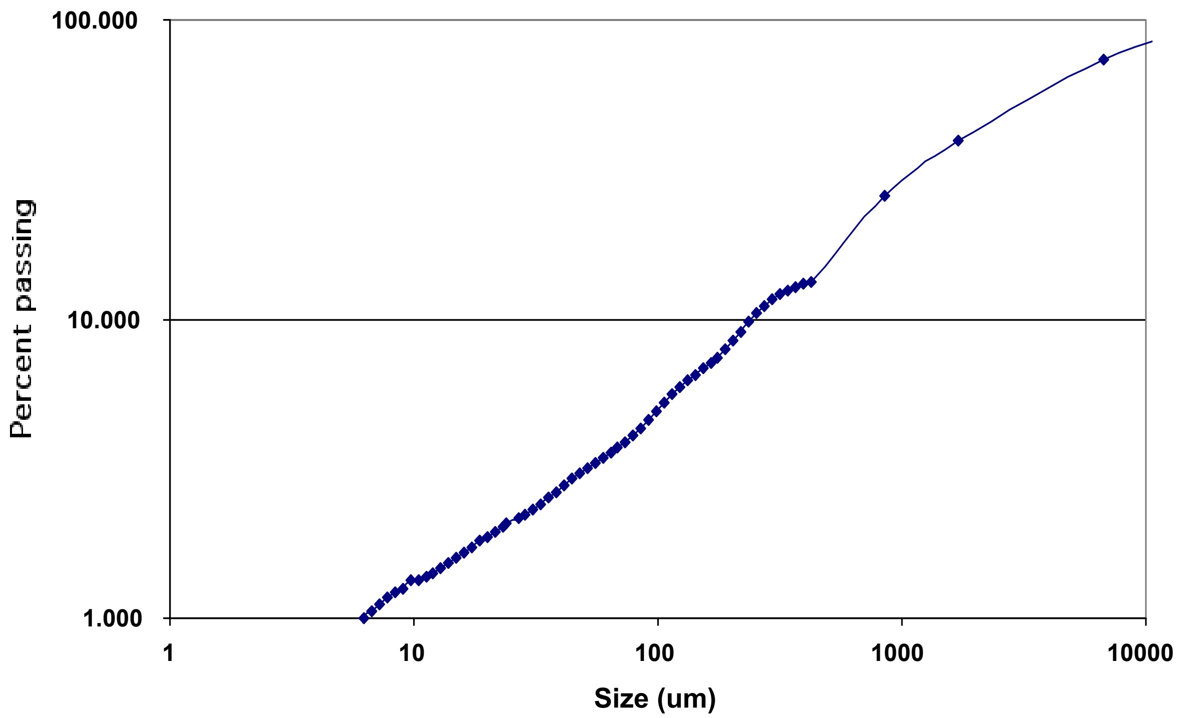

100
10
1
Percent passing
1
10
100
1000
Size (um)

Bottom Ash

6,990 tons/yr

	Rep 1	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Moisture	4.9	4.8	4.9	N.D.[c]	N.D.
Proximate Analysis (wt. %, d.b.[a])					
Volatile Matter	1.9	1.8	0.8	1.4	N.D.
Ash	73.4	73.1	72.4	72.1	N.D.
Fixed Carbon	24.7	25.1	26.8	26.5	N.D.
Ultimate Analysis (wt. %, d.b.)					
Carbon	31.5	31.3	28.0	26.7	26.9
Hydrogen	0.0	0.1	0.1	0.0	0.0
Nitrogen	0.6	0.5	0.6	0.4	0.3
Sulfur	0.2	0.2	0.2	0.2	0.2
Oxygen	-5.7	-5.2	-1.3	0.6	N.D.
HHV (Btu/lb)	2,341	2,076	1,863	1,798	N.D.
Bulk Density[b] (g/cc)	0.84				
(lb/ft^3)	52.4				

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined


100.000
10.000
1.000
Percent passing
1
10
100
1000
10000
Size (um)

Hard Plastic (from horticulture dept.)

400 lb/yr

	Rep 1	Rep 2	Rep 3	Rep 4
Moisture	0.2	N.D.[b]	N.D.	N.D.
<u>Proximate Analysis (wt. %, d.b.[a])</u>				
Volatile Matter	96.1	96.6	N.D.	N.D.
Ash	3.8	3.4	N.D.	N.D.
Fixed Carbon	0.1	0.0	N.D.	N.D.
<u>Ultimate Analysis (wt. %, d.b.)</u>				
Carbon	86.2	87.4	80.6	86.1
Hydrogen	10.9	10.9	14.0	11.8
Nitrogen	0.2	0.2	0.1	0.1
Sulfur	0.1	0.1	0.1	0.1
Oxygen	-1.2	-2.0		
HHV (Btu/lb)	18,240	18,549	18,500	N.D.
Chlorine Content (ppm)	216	N.D.	N.D.	N.D.

[a] Dry Basis
[b] Not Determined

Plastic Bags (from horticulture dept.)

2,000 lb/yr

	Rep 1	**Rep 2**	**Rep 3**	**Rep 4**
Moisture	0.1	N.D.[b]	N.D.	N.D.
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	96.9	96.5	N.D.	N.D.
Ash	2.7	3.3	N.D.	N.D.
Fixed Carbon	0.4	0.2	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)				
Carbon	86.1	81.4	74.8	78.9
Hydrogen	14.0	13.3	14.1	13.0
Nitrogen	0.3	0.3	0.2	0.1
Sulfur	0.0	0.0	0.0	0.0
Oxygen	-3.1	1.7	N.D.	N.D.
HHV (Btu/lb)	19,474	19,170	19,230	N.D.
Chlorine Content (ppm)	334	N.D.	N.D.	N.D.

[a] Dry Basis
[b] Not Determined

Dairy Tie-Stall Manure

13,200 tons/yr along with Dairy free-stall manure and mulch hay and mulch leaves

	Rep 1	Rep 2	Rep 3
Moisture	64.7	64.4	66.1
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	76.0	74.6	N.D.[c]
Ash	6.0	5.7	N.D.
Fixed Carbon	18.1	19.7	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	48.6	48.1	N.D.
Hydrogen	5.8	5.8	N.D.
Nitrogen	1.4	1.1	N.D.
Sulfur	0.1	0.1	N.D.
Oxygen	38.1	39.2	N.D.
HHV (Btu/lb)	8,203	7,850	N.D.
Bulk Density[b] (g/cc)	0.40		
(lb/ft^3)	25.0		

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Dairy Free-Stall Manure

13,200 tons/yr along with Dairy tie-stall manure and mulch hay and mulch leaves

	Rep 1	Rep 2	Rep 3
Moisture	69.8	69.6	71.5
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	30.1	31.1	N.D.[c]
Ash	62.5	62.2	N.D.
Fixed Carbon	7.4	6.7	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	22.6	21.7	N.D.
Hydrogen	2.9	2.8	N.D.
Nitrogen	1.1	1.1	N.D.
Sulfur	0.1	0.1	N.D.
Oxygen	10.8	12.1	N.D.
HHV (Btu/lb)	3,644	3,953	
Bulk Density[b] (g/cc)	0.81		
(lb/ft^3)	50.5		

[a] Dry Basis

[b] Determined from Entire Sample

[c] Not Determined

Mulch Hay

Mixed into Dairy tie-stall and Dairy free-stall manure

	Rep 1	Rep 2	Rep 3
Moisture	19.5	19.3	18.3
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	77.6	77.5	N.D.[c]
Ash	5.3	5.0	N.D.
Fixed Carbon	17.1	17.5	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	46.5	46.3	N.D.
Hydrogen	5.7	5.8	N.D.
Nitrogen	1.7	1.6	N.D.
Sulfur	0.2	0.2	N.D.
Oxygen	40.6	41.1	N.D.
HHV (Btu/lb)	8,058	8,221	N.D.
Bulk Density[b] (g/cc)	0.041		
(lb/ft^3)	2.6		

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Mulch Leaves

Mixed into Dairy tie-stall and Dairy free-stall manure

	Rep 1	Rep 2	Rep 3
Moisture	19.5	26.8	20.7
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	71.1	70.3	N.D.[c]
Ash	9.7	10.0	N.D.
Fixed Carbon	19.2	19.7	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	48.4	48.8	N.D.
Hydrogen	5.6	5.6	N.D.
Nitrogen	1.4	1.2	N.D.
Sulfur	0.1	0.1	N.D.
Oxygen	34.8	34.3	N.D.
HHV (Btu/lb)	8,000	7,975	N.D.
Bulk Density[b] (g/cc)	0.082		
(lb/ft^3)	5.1		

[a] Dry Basis

[b] Determined from Entire Sample

[c] Not Determined

Bale Tarp

800-1,000 lb/yr

	Rep 1	Rep 2	Rep 3	Rep 4
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	92.4	92.5	N.D.[b]	N.D.
Ash	7.4	7.3	N.D.	N.D.
Fixed Carbon	0.2	0.2	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)				
Carbon	66.4	71.8	73.0	71.5
Hydrogen	11.5	12.7	11.8	13.6
Nitrogen	0.3	0.4	0.4	0.3
Sulfur	0.0	0.0	0.0	0.0
Oxygen	14.4	7.8	N.D.	N.D.
HHV (Btu/lb)	18,085	20,181	N.D.	N.D.

[a] Dry Basis
[b] Not Determined

Silo Bunker Cover

800 lb/yr

	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Proximate Analysis (wt. %, d.b.[a])					
Volatile Matter	97.3	96.8	N.D.[b]	N.D.	N.D.
Ash	2.6	3.1	N.D.	N.D.	N.D.
Fixed Carbon	0.0	0.1	N.D.	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)					
Carbon	75.5	78.8	76.5	79.9	77.7
Hydrogen	12.8	13.7	14.1	11.8	13.1
Nitrogen	0.2	0.2	0.2	0.2	0.2
Sulfur	0.2	0.1	0.0	0.1	0.1
Oxygen	8.7	4.1	N.D.	N.D.	N.D.
HHV (Btu/lb)	19,202	19,223	N.D.	N.D.	N.D.

[a] Dry Basis
[b] Not Determined

Miscellaneous Manure (from covered manure barn)

	Rep 1	Rep 2	Rep 3
Moisture	46.1	55.9	49.6
<u>Proximate Analysis (wt. %, d.b.[a])</u>			
Volatile Matter	21.2	22.3	N.D.[c]
Ash	74.0	73.1	N.D.
Fixed Carbon	4.9	4.6	N.D.
<u>Ultimate Analysis (wt. %, d.b.)</u>			
Carbon	19.1	20.1	N.D.
Hydrogen	2.4	2.5	N.D.
Nitrogen	1.0	1.0	N.D.
Sulfur	0.1	0.1	0.1
Oxygen	3.4	3.2	N.D.
HHV (Btu/lb)	3,144	2,974	N.D.
Bulk Density[b] (g/cc)	0.70		
(lb/ft^3)	43.7		

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Sheep Manure

265 tons/yr

	Rep 1	Rep 2	Rep 3	Rep 4
Moisture	47.8	45.8	35.0	42.8
Proximate Analysis (wt. %, d.b.[a])				
Volatile Matter	65.2	65.1	N.D.[c]	N.D.
Ash	20.9	20.4	N.D.	N.D.
Fixed Carbon	14.0	14.6	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)				
Carbon	40.6	40.1	N.D.	N.D.
Hydrogen	5.1	5.1	N.D.	N.D.
Nitrogen	2.1	2.2	N.D.	N.D.
Sulfur	0.6	0.6	N.D.	N.D.
Oxygen	30.7	31.6	N.D.	N.D.
HHV (Btu/lb)	6,895	6,610	N.D.	N.D.
Bulk Density[b] (g/cc)	0.37			
(lb/ft^3)	23.1			

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Red Oak Shavings

	Rep 1	Rep 2	Rep 3
Moisture	25.4	28.8	29.0
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	79.4	79.5	N.D.[c]
Ash	1.6	1.5	N.D.
Fixed Carbon	19.0	19.0	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	52.4	51.6	N.D.
Hydrogen	5.7	5.8	N.D.
Nitrogen	0.8	0.5	N.D.
Sulfur	0.0	0.0	N.D.
Oxygen	39.5	40.6	N.D.
HHV (Btu/lb)	8,199	8,069	N.D.
Bulk Density[b] (g/cc)	0.18		
(lb/ft^3)	11.2		

[a] Dry Basis

[b] Determined from Entire Sample

[c] Not Determined

Beef Barn Manure

1,033 tons/yr

	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Moisture					
Proximate Analysis (wt. %, d.b.[a])					
Volatile Matter					
Ash					
Fixed Carbon					
Ultimate Analysis (wt. %, d.b.)					
Carbon					
Hydrogen					
Nitrogen					
Sulfur					
Oxygen					
HHV (Btu/lb)					
Bulk Density[b] (g/cc)					
(lb/ft^3)					
Chlorine Content (ppm)					

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Swine Waste

2,505 tons/yr @ 2.2% solids

Analysis Report for Manure and Composts

October 30, 1998

RESULTS

Rep	pH	Solids	P	K	NH_4N	Org-N	Tot-N	Volatile	Tot-C	C/N*
		%	% (dry weight basis)							
1	NR	2.22	2.66	5.25	NR	NR	13.64	70.51	40.90	3.00
2	NR	2.20	2.38	5.16	NR	NR	9.77	70.41	40.84	4.18
Average	NR	2.21	2.52	5.20	NR	NR	11.71	70.46	40.87	3.59

NR - Not requested

One dry ton of this material is equivalent to 10,852 gallons of wet material or 45.3 tons of wet material.

1.99 dry tons of this biosolid to supply 100 lbs of phosphorus.

0.43 dry tons of this biosolid will supply 100 lbs of total N.

**Estimated carbon/nitrogen ratio. Carbon estimated as 58% of volatile solids.*

PRIMARY NUTRIENT CONTENT

% on Dry Weight Basis

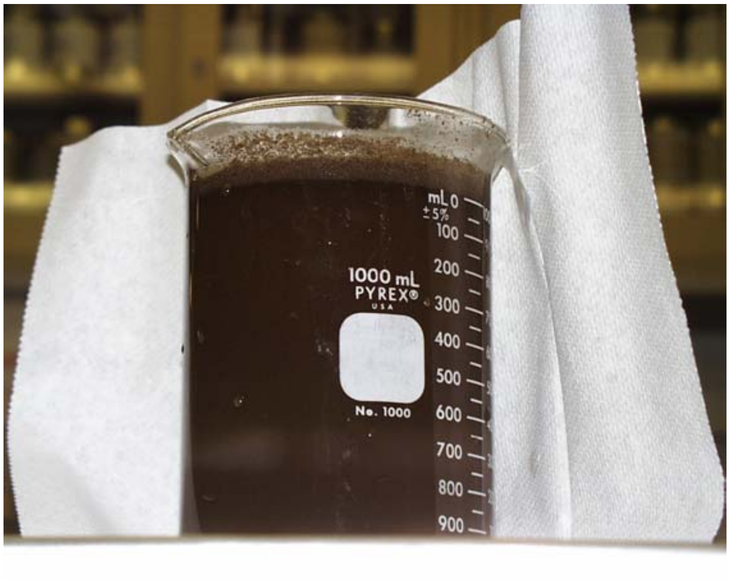
	Level	0- - - - - - - - -2- - - - - - - - -4- - - - - - - - -6- - - - - - - - -
Total N	11.71	***************************************
P_2O_5	5.77	*****************************
K_2O	6.24	***************************

On As Is Basis

Tot-N	P_2O_5	K_2O	Tot-N	P_2O_5	K_2O	NH_4N	
lbs/ton			lbs/100gal			lbs/ton	lbs/100gal
5.18	2.55	2.76	2.17	1.07	1.16	0.00	0.00

COMMENTS

Swine Waste



	Rep 1	Rep 2	Rep 3
Moisture	97.8	97.8	97.8
Moisture (after drying)	1.0	N.D.	N.D.
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	59.6	N.D.	N.D.
Ash	33.1	N.D.	N.D.
Fixed Carbon	7.3	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	38.0	N.D.	N.D.
Hydrogen	5.5	N.D.	N.D.
Nitrogen	3.2	N.D.	N.D.
Sulfur	0.6	N.D.	N.D.
Oxygen	19.6	N.D.	N.D.
HHV (Btu/lb)	7,328	7,521	7,465
Bulk Density[b] (g/cc)	1.0	N.D.	N.D.
(lb/ft^3)	62.4	N.D.	N.D.
Chlorine Content (ppm)	N.D.	N.D.	N.D.

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

Reed Canary Grass

600 tons/yr

	Rep 1	Rep 2	Rep 3
Moisture	65.2	74.9	70.1
Moisture (after drying)	1.3	N.D.	N.D.
Proximate Analysis (wt. %, d.b.[a])			
Volatile Matter	76.1	N.D.	N.D.
Ash	4.1	N.D.	N.D.
Fixed Carbon	19.8	N.D.	N.D.
Ultimate Analysis (wt. %, d.b.)			
Carbon	45.8	N.D.	N.D.
Hydrogen	6.1	N.D.	N.D.
Nitrogen	1.0	N.D.	N.D.
Sulfur	0.1	N.D.	N.D.
Oxygen	42.9	N.D.	N.D.
HHV (Btu/lb)	7,103	7,290	7,325
Bulk Density[b] (g/cc)	0.05	N.D.	N.D.
(lb/ft^3)	3.12	N.D.	N.D.
Chlorine Content (ppm)	N.D.	N.D.	N.D.

[a] Dry Basis
[b] Determined from Entire Sample
[c] Not Determined

APPENDIX I. COAL AND LIMESTONE ANALYSIS

G and C Coal Analysis Lab., Inc.
R.D. 1, Box 324
Summerville, PA 15864
814-849-2559

FAX Number: (814)-849-8878

Date: ______________

TO: Penn State

RE: The Residual Moisture was
used in the calculation not the
total - please call if you have
any questions!
Thank You

ATTN: Bruce Miller

Number of Pages Including Cover Page: 4

G & C
L A B

G and C COAL ANALYSIS LAB., INC.

R.D. 1, BOX 324
SUMMERVILLE, PA 15864
(814) 849-2559
FAX: (814) 849-8878

RECEIVED FROM:

Penn State University
Attn: Bruce Miller
C214 Coal Utilization Lab
University Park , PA 16802

LAB NO. 430592
SAMPLED 01-22-01
RECEIVED 01-26-01
REPORTED 02-01-01

SAMPLE MARKED:
Reliant Bradford Train
PAP-58

ANALYSIS REPORT

	AS RECEIVED	DRY BASIS
% Moisture...(Residual Moisture)...........	0.39	
% Ash................................	14.64	14.70
% Sulfur.............................	2.26	2.27
B.T.U................................	13,067	13,118
B.T.U.(Moisture-Ash Free)................	15,379	
% Volatile Matter......................	24.07	24.16
% Fixed Carbon........................	60.90	61.14
Fusing Temperature....................	ID: 2518	ST: 2566
	HT: 2601	FT: 2632

1.73 Lbs. Sul./mil. BTU
11.20 Lbs. Ash /mil. BTU

THE ABOVE ANALYTICAL RESULTS WERE OBTAINED FOLLOWING ASTM PROCEDURES.

G&C COAL ANALYSIS LAB., INC.

APPROVED BY

G and C Coal Analysis Lab., Inc.
RD 1, Box 324
Summerville, PA 15864
814-849-2559
Fax: 814-849-8878

RECIEVED FROM:

Penn State Univ.
Attn: Bruce Miller
C214 Coal Utilization Lab
University Park, PA 16802

Lab # : 430592
Date Sampled: 01-22-01
Date Received: 01-26-01
Date Reported: 02-01-01

SAMPLE MARKED:

Reliant Bradford Train
PAP-58

ULTIMATE ANALYSIS

	As Received	Dry Basis
% CARBON	72.47	72.75
% HYDROGEN	3.89	3.91
% NITROGEN	1.49	1.50
% OXYGEN (by difference)	4.85	4.87
% ASH	14.64	14.70
% SULFUR	2.26	2.27
% MOISTURE	0.39	

The above analytical results were obtained following ASTM procedures.

G & C COAL ANALYSIS LAB., INC.

APPROVED BY

G and C Coal Analysis Lab., Inc.
RD 1, Box 324
Summerville, PA 15864
814-849-2559
Fax: 814-849-8878

Received From:

Penn State Univ.
Attn: Bruce Miller
C214 Coal Utilization Lab
University Pard, PA 16802

Date Received: 01-22-01

Date Reported: 02-01-01

Lab Number : 430592

Sample Marked: Reliant Bradford Train
PAP-58

Mineral Analysis of Ash

SiO2............	48.20
Al2O2...........	25.34
TiO2............	1.23
Fe2O3...........	18.34
CaO.............	2.28
MgO.............	0.82
Na2O............	0.25
K2O.............	2.22
P2O3............	0.40
SO3.............	0.67
Und.............	0,25

The above analytical results were obtained following ASTM procedures.

G & C COAL ANALYSIS LAB., INC.

APPROVED BY

MECKLEY'S
Limestone Products, Inc.

R.D. #1 Box1682, Herndon, PA 17830
Phone: 570/758-3001 Fax: 570/758-2400

Date: 1/28/01 / 1/29/01

Facsimile Cover Sheet

Message For:

Name: Bruce Miller
Company: PSU
Fax No.: 814.863.7432 / 814-863-8892
From: Jim Meckley

Number of Pages Including This Cover Letter: 3

MEMO/REMARKS:

Bruce:

Following are two analysis reports that would give you the appropriate range of variation that could be expected from the material that we would propose to supply to your project.
Barring any unforseen adverse change in fuel oil prices, we feel quite confident that the material can be delivered to your silos in the range of $28.00 per ton (this price should be fine for at least two more years). If you need any additional information, please don't hesitate to contact me.

Regards,

If you are not the intended receiver of this message, or if this message is unreadable, please contact 570/758-3001 immediately. Thank you.

Phone 717-648-2216
Fax 717-648-6606

WILSON TESTING LABORATORIES, INC.
401 West Chestnut Street SHAMOKIN, PA. 17872

HARRY WILSON
President

ANNETTE WITCOSKIE, B.S.
Biology — Lab Supervisor

TOM BARWICK, B.S.
Chemistry

TIM BARWICK, B.S.
Chemistry

November 13, 1998

Client: MECKLEY'S LIMESTONE PRODUCTS INC.
Address: R. D. # 1 BOX 950
HERNDON, PA, 17830
D. MARQUETTE

CHEMICAL ANALYSIS REPORT
PA D.E.R. CERTIFIED #49-303

Date collected: 10/03/98 Hour: 00:00AM
~~[illegible]~~ ~~[illegible]~~
Type of sample: Limestone
Location sample collected: 75% MATERIAL BIN 6
Name of sampler: FM
Remarks: Ep Toxicity

Laboratory Number: 137917

Parameter	Result	Units	Comments	Date	Time	Method	Analyst
$MgCO_3$	4.2						
$CaCO_3$	82.28						
Calcium Oxide CaO	46.1	%		11/11/98	02:00PM	EPA 200.7	TLB
Magnesium Oxide MgO	2.00	%		11/11/98	02:00PM	EPA 200.7	TLB
Arsenic, Total	<0.005	MG/L	TCLP	11/12/98	09:45AM	SM #3113B	TLB
Barium, Total	0.3	MG/L	TCLP	11/11/98	01:00PM	SM #3111D	TLB
Cadmium, Total	<0.01	MG/L	TCLP	11/11/98	10:30AM	SM #3113B	TLB
Chromium, Total	<0.04	MG/L	TCLP	11/11/98	10:50AM	SM #3113B	TLB
Lead, Total	<0.1	MG/L	TCLP	11/11/98	03:30PM	SM #3111B	TLB
Mercury, Total	<0.002	MG/L	TCLP	[illegible]	[illegible]	EPA 245.2	TLB
Selenium, Total	<0.005	MG/L	TCLP	11/12/98	10:15AM	SM #3113B	TLB
Silver, Total	<0.05	MG/L	TCLP	11/12/98	08:00AM	SM #3111B	TLB

Wilson Testing Laboratories

Harry Wilson

Harry Wilson, President
Annette Witcoskie, Director
HW/aw/rb

Phone 717-[illegible]-221[illegible]
Fax 717-[illegible]

WILSON TESTING LABORATORIES, INC.

401 West Chestnut Street SHAMOKIN, PA. 17872

HARRY WILSON
President

NANETTE WITCOSKIE, B.S.
Biology – Lab Supervisor

TOM BARWICK, B.S.
Chemistry

TIM BARWICK, B.S.
Chemistry

November 13, 1998

Client: MECKLEY'S LIMESTONE PRODUCTS INC.
Address: R. D. # 1 BOX 950
HERNDON, PA, 17830
D. MARQUETTE

CHEMICAL ANALYSIS REPORT
PA D.E.R. CERTIFIED #49-303

Date collected: 10/03/98 Hour: 00:00AM
Date received: 11/06/98 Hour: 11:00AM
Type of sample: Limestone
Location sample collected: 85% MATERIAL BIN 7
Name of sampler: FM
[illegible]: Ep Toxicity

Laboratory Number: 137918

$MgCO_3$ 3.29

Parameter	Result	Units	Comments	Date	Time	Method	Analyst
$CaCO_3$	85.85						
Calcium Oxide CaO	48.1	%		11/11/98	02:00PM	EPA 200.7	TLB
Magnesium Oxide MgO	1.57	%		11/11/98	02:00PM	EPA 200.7	TLB
Arsenic, Total	<0.005	MG/L	TCLP	11/12/98	09:45AM	SM #3113B	TLB
Barium, Total	0.3	MG/L	TCLP	11/11/98	01:00PM	SM #3111D	TLB
Cadmium, Total	<0.01	MG/L	TCLP	11/11/98	10:30AM	SM #3113B	TLB
Chromium, Total	<0.04	MG/L	TCLP	11/11/98	10:50AM	SM #3113B	TLB
Lead, Total	<0.1	MG/L	TCLP	11/11/98	03:30PM	SM #3111B	TLB
Mercury, Total	<0.002	MG/L	TCLP	11/12/98	01:00PM	EPA 245.2	TLB
Selenium, Total	<0.005	MG/L	TCLP	11/12/98	10:15AM	SM #3113B	TLB
Silver, Total	<0.05	MG/L	TCLP	11/12/98	08:00AM	SM #3111B	TLB

Sincerely,
Wilson Testing Laboratories

Harry Wilson

Harry Wilson, President

ew/rb

APPENDIX J. DESCRIPTION OF THE CHEMICAL FRACTIONATION PROCEDURE

Appendix A details the chemical fractionation procedure to determine the mode of occurrence of the mineral components of the biomass feedstocks, coal ashes, and sewage sludge.

Purpose: To determine the occurrence (free, organic, mineral) of the inorganic components in the fuels.

Method: Ground fuel is successively washed with water, ammonium acetate, and hydrochloric acid.

Results: Determined by analyzing both solid and liquid samples taken after each washing step. Mass balance is done to determine the amount of inorganic components lost during each step.

Steps:

1) Dry Fuel

- Fuel are completely dried at 60°C in the large Dispatch oven
- Pyrex pie plates are used for drying (metal tools/containers should be avoided so that contamination will be minimal)

2) Grind Fuel

- Dried fuel is ground to –60 mesh (<250 μm)
- Clean the crusher and pulverizer with compressed air, followed with acetone before every new fuel to be ground
- Cut up fuel if necessary (example: hay)
- Slowly feed to disc crusher
- Feed output from disc crusher to pulverizer
- If necessary, recut and refeed fuel particles that are too large to be fed until they enter the pulverizer
- Remove pulverized fuel from output bin and store in a labeled container in the Dispatch oven until fractionated

3) Clean Glassware

- All glassware and stirrers must be thoroughly cleaned before use as follows:
  clean with scrubber and water
  rinse with deionized water
  rinse with 1M HNO_3 made with deionized water
  rinse with deionized water
  dry on rack

4) Water Wash

- Weigh 120 grams of ground fuel into clean beaker (600 ml for coals, up to 2,000 ml for fluffy biomass)
- Place beaker on stir/heat plate
- Add cleaned stir bar
- Slowly add deionized water and stir with clean glass rod
- Stop adding water when all fuel is wetted and stirring well and heat to 70°C.
- Stir overnight

5) Solid/ Liquid Separation

- Quickly remove beaker from plate and pour mixture into cleaned centrifuge tubes (if the mixture is not stirring as you pour it you will get separation by density and size)
- Centrifuge
- Set up a vacuum filter with Whatman coarse paper (402) and large (1,000 ml) vacuum flask
- Pour supernatant from centrifuge tubes through vacuum filter
- Scrape out solid from centrifuge tubes into a cleaned and labeled Pyrex plate with a clean Teflon coated spatula
- Repeat until beaker is empty
- Scrape solid from Pyrex plate into vacuum filter
- Rinse centrifuge tubes and beaker into vacuum filter
- Rinse solids in vacuum filter with approximately 500 ml of deionized water
- Scrape solids from vacuum funnel back into the Pyrex plate and rinse vacuum funnel with deionized water into plate
- Stir solids thoroughly to mix fractions of different density/size
- Place a small (~15 g) sample of the solids into a sample container, being careful to take a REPRESENTATIVE sample to be submitted for analysis
- Shake up liquid in vacuum flask and put a small sample (~120 ml) in a Nalgene bottle and label to be submitted for analysis
- Measure volume of liquid remaining using a 1,000 ml graduated cylinder and discard this liquid after recording the volume

6) Dry Washed Solids

- Dry solids in Pyrex plate and sample container in Dispatch oven overnight (longer if moisture remains)
- Weigh both bulk solids and sample and record weights

7) Ammonium Acetate Wash

- Repeat water wash procedure using the dried filtrate from the water wash, this time using 1M ammonium acetate made with deionized water
- Heat liquid to 70°C during the stirring phase, checking temperature with a clean thermometer clamped into place on the beaker
- Excess water must be added before you leave for the night to ensure that all the water does not evaporate

- Ammonium acetate wash must be done three times
- Keep the liquid from each washing/centrifuging/filtering step in a labeled container, and take a sample from the combined liquid after the third washing to be submitted for analysis
- Dry the solid after the third washing and remove ~15g to be submitted for analysis
- The remaining solid goes on to the hydrochloric acid step

8) Hydrochloric Acid Wash

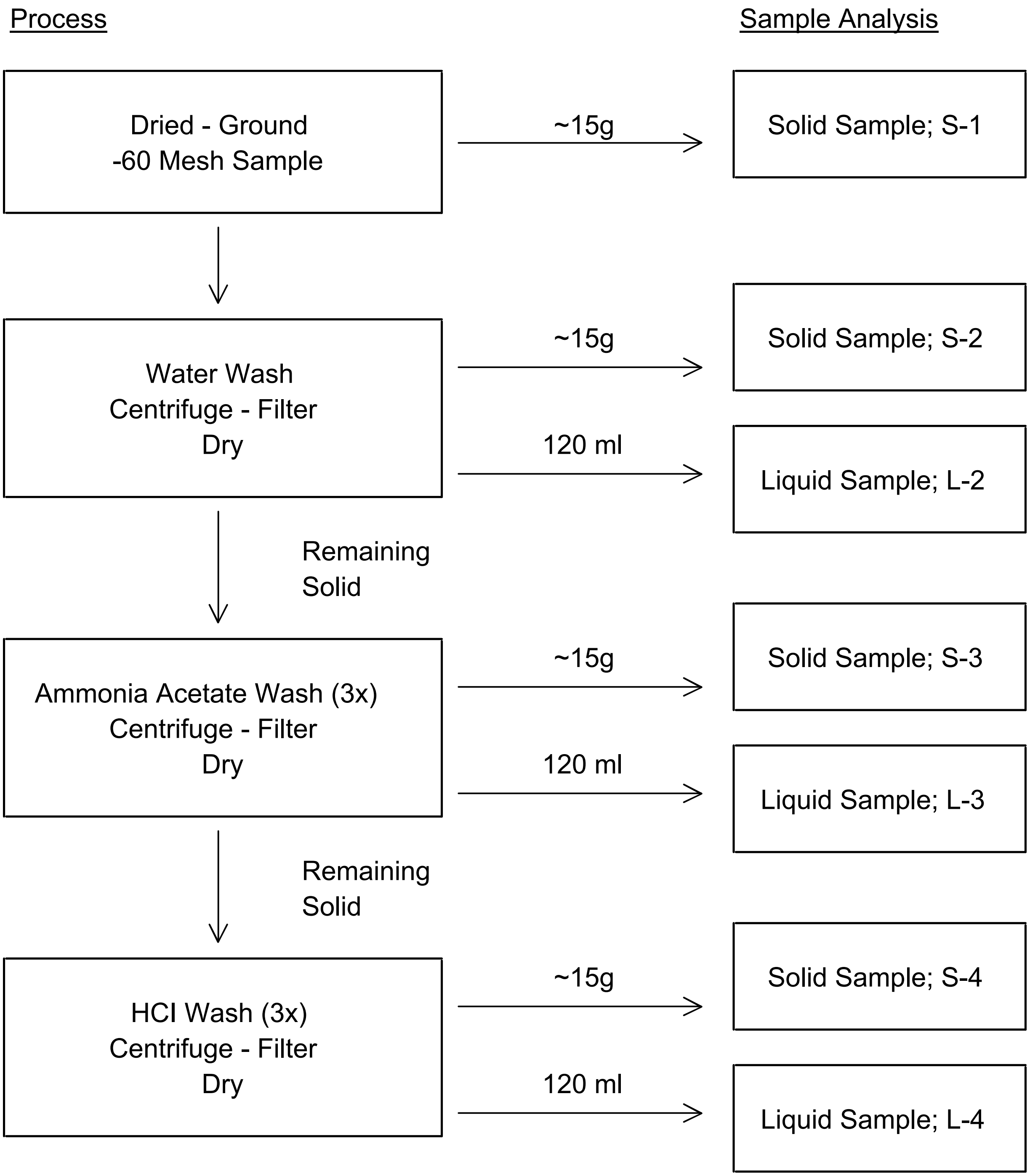
- Repeat the ammonium acetate procedure using 1M HCl rather than ammonium acetate
- Submit ~15g dried solid and 120 ml liquid for analysis

9) Refilter Liquid Samples (if necessary)

- If particulate matter can be seen settled at the bottom of your liquid sample containers, they must be refiltered
- Pass the liquid through a clean vacuum filter set up with a fine Whatman paper and pour back into sample bottle

10) Analyze Samples

- Perform Inductively Coupled Plasma (ICP) spectrometric analysis on all solid and liquid samples



Liquid Samples - add 3% nitric acid.