# NORTH DAKOTA FOREST SERVICE FUELS FOR SCHOOLS FEASIBILITY STUDIES

Final Report

*(for the period July 1, 2005 – June 30, 2006)*

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2006-EERC-06-07 June 2006

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Final Report

*(for the period July 1, 2005 – June 30, 2006)*

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# NORTH DAKOTA FOREST SERVICE FUELS FOR SCHOOLS FEASIBILITY STUDIES

Final Report

*(for the period July 1, 2005 – June 30, 2006)*

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# NORTH DAKOTA FOREST SERVICE FUELS FOR SCHOOLS FEASIBILITY STUDIES

## EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) provided technical support to the North Dakota Forest Service (NDFS) for a feasibility study under the Fuels for Schools (FFS) program considering utilization of biomass energy in public institutions. The FFS program is a venture between public schools and state and regional foresters of the Northern and Intermountain Regions of the U.S. Department of Agriculture Forest Service. This program helps public schools retrofit their fuel or gas heating systems to biomass heating systems. The dramatic rise in the cost of fossil fuels creates a good opportunity for lower-cost biomass fuels, which benefit both the school and the taxpayer in significant heating savings for these public facilities. The institutions chosen to participate in the feasibility study were the Dakota Adventist Academy (DAA), the United Tribes Technical College (UTTC), and a proposed new public middle school in Mandan, North Dakota. The following summarizes the benefit to each school.

Wood heating systems are a viable option for institutions in the Bismarck–Mandan area. The Bismarck landfill produces sufficient quantities of acceptable-quality wood chips on an annual basis to supply heating fuel to all three schools in the NDFS FFS feasibility study. Wood chips are available for \$3.00/yd$^3$ (\$11.11/ton). Delivery costs differ depending on the transportation method used. Options included delivery by landfill personnel (available only within city limits), hiring a service company, or purchasing a truck and hiring labor to haul the material. These differences are detailed for each institution below.

A wood heating system at the UTTC appears very attractive, with a 6.5-year payback. Installation of four small, automated outdoor (or optional indoor) wood heating systems are recommended for the four buildings studied on the UTTC campus: the Sakakawea (No. 30) and Sitting Bull (No. 33) Residence Halls, and the Education Building (Nos. 31–32). The estimated capital investment of \$278,000 includes four 1.5-MMBtu output Pro-Fab Industries, Inc., wood heating systems to be placed in parallel for distributing heat connected to the UTTC buildings. A separate building for wood chip storage as required by fire code is included in the estimation of capital costs. Wood chips delivered by the Bismarck landfill at \$20.27 per ton (\$1.58/MMBtu) will save UTTC about \$42,900 in annual heating expenses in comparison to the existing natural gas system. These savings take into account the cost of operating labor and ash disposal. Ash produced from wood burning may be applied to fields such as baseball diamonds at local parks, used as fertilizer, or disposed of at the Bismarck landfill.

A wood heating system at the new Mandan middle school (MMS) also appears very attractive, with a 7.2-year payback. Installation of a single indoor, automated wood heating system is recommended for the new public school in place of the currently planned heat pump–natural gas hybrid heating system. Savings of about \$49,200 annually are estimated in comparative heating expenses, accounting for increased labor and ash disposal costs. The option of wood chips at \$27.48 per ton (\$2.15/MMBtu) assumes a purchased used truck and hired labor for delivery.

A capital investment of $352,000 includes a 5-MMBtu/hr Messersmith Manufacturing, Inc., wood heating system.

The NDFS can access financial assistance through the FFS program. Funding at $417,000 is available to approved projects for capital expenses, with a single project limited to 80% federal funding. Given federal assistance, paybacks for UTTC and MMS financial contributions could range from 1–3 years.

A wood heating system can greatly benefit the DAA depending on projected use of the system. Economics were thus compared for primary and backup boiler options. Principal options included the comparison between 1) a primary coal boiler, secondary propane system and 2) a primary wood heating system, secondary coal boiler. Motivation for the study included ease in regulating moderate heating requirements in the spring and fall seasons. Heat used in spring and fall accounts for 11% of the annual energy consumption. Potential boiler down time during winter could account for an additional amount of energy use. The economic outcome of the comparison shows the wood heating system with coal-fired backup to be breakeven with a primary coal boiler and secondary propane system at 18% of the annual heating energy consumed. Therefore, if wood is utilized for heat at greater than 18% of the annual energy use, the wood-fired system appears more economically attractive than a simple propane backup to the existing coal boiler. Wood chips can be delivered to DAA at $25.08–$31.69 per ton ($1.96–$2.48/MMBtu). An estimated capital cost of $352,000 includes a 6.68-MMBtu/hr Messersmith Manufacturing, Inc., wood heating system. Estimated annual heating costs range from $42,300–$45,300.

# NORTH DAKOTA FOREST SERVICE FUELS FOR SCHOOLS FEASIBILITY STUDIES

## INTRODUCTION

The Fuels for Schools (FFS) program is an innovative venture between public schools and state and regional foresters of the Northern and Intermountain Regions of the U.S. Department of Agriculture Forest Service. This program helps public schools retrofit their fuel or gas heating systems to biomass heating systems, significantly reducing heating costs.

The North Dakota Forest Service (NDFS) considered many options within the state of North Dakota for a FFS feasibility study. Efforts began with a statewide study, funded by the National Fire Plan and performed by the Energy & Environmental Research Center (EERC), looking at fire starts, communities at risk, and sources of biomass (Schmidt et al., 2003). The study has been used to prioritize efforts for fire mitigation and biomass utilization in North Dakota. It was followed by a feasibility study of Minot State University (MSU) – Bottineau which met with some difficulties. Although there was an interest in biomass on the campus, a barrier exists in the business industry of the Turtle Mountain region. Efforts are currently under way to build business infrastructure for biomass utilization in the region.

A fire mitigation project with the city of Bismarck was the next attempt to coordinate fire mitigation and biomass utilization in North Dakota. The project identified the heavily wooded area to the south side of Bismarck as a potential fire hazard. A fire trail was constructed as a result of the project, generating trees and logs which were converted to wood chips at the Bismarck Landfill. This material provided an opportunity for a demonstration project by the landfill through the FFS program, using the wood chips generated on-site to heat a new household hazardous waste facility. It also provides an opportunity for an FFS feasibility study of institutions within the Bismarck–Mandan area.

## GOAL AND OBJECTIVES

The FFS program is a three-phase effort. The initial goal is to establish at least one demonstration project in each of the five states – Montana, Idaho, Nevada, Utah, and North Dakota. These demonstrations will gather monitoring data, be the model for future schools, and host tours for interested groups. The next goal is to facilitate the expansion of the program to 50 schools by 2008. Interested schools would be required to compete for federal grant assistance. The final phase would transition the Forest Service out of the primary funding role, where economics, awareness, and demand will begin to drive the program.

The EERC provided technical support to the NDFS to assist in achieving the goals set forth under the FFS program for the demonstration phase. The objective specific to this project was to perform a feasibility study for each school considering utilization of biomass energy.

## APPROACH

The feasibility study covered equipment options, specifications, and economics for each institution to implement the use of biomass energy. A resource assessment was conducted for availability of biomass in the area, and energy profiles of each institution were conducted to size equipment options and to determine potential savings relative to firing biomass. Various quotations were collected to determine capital costs for equipment, and economics were estimated based on the quotations, operational costs, and potential savings.

## INSTITUTIONS STUDIED

The NDFS has identified three institutions within the state that have an opportunity to utilize biomass energy from sources such as fuel mitigation projects, small-diameter forest utilization, and available residues. These schools are the Dakota Adventist Academy (DAA), the United Tribes Technical College (UTTC), and a proposed new public middle school in Mandan, North Dakota.

DAA is accredited with the Association of Seventh-Day Adventist Secondary Schools and Colleges and is approved by the state of North Dakota as a secondary school. The academy is located on approximately 1300 acres, 14 miles northwest of Bismarck, North Dakota. The school building is divided into three sections. The central portion includes classrooms, cafeteria, administrative offices, library, and music areas, and the right and left wings are occupied by dormitories. A 6.68-MMBtu/hr coal boiler is currently used to heat water for radiation heating of all sections. An average of 928 tons coal (12,100 MMBtu) has been consumed annually in the last 3 years for heating of the school. Prices have averaged $24.20 per ton delivered; however, 2006 prices have increased the delivered cost to $27.50/ton ($2.12/MMBtu). The cost of heating expenses for the coming year is, therefore, estimated at $25,500.

DAA would like an economical backup system to the existing coal boiler. This secondary system would provide heat in the winter when the coal boiler is down for repairs or general maintenance. Additional benefits to a secondary system are the potential for expansion to the DAA facilities, such as a greenhouse. A greenhouse would be an opportunity for DAA to provide hands-on experience in plant genetics and biology. DAA would also like a system more easily operable in the first and last months of the winter season. The warm days and cool nights typical to the change in seasons are difficult to moderate with the large coal system. The buildings become too hot for comfort even at minimum capacity, often requiring venting to avoid complete shutdown. DAA is, therefore, interested in a comparison of differing fuel systems: wood, propane, and coal.

UTTC was first founded in 1969 by the United Tribes of North Dakota Development Corporation and offers certified and accredited degree programs. The brick buildings that house UTTC in Bismarck, North Dakota, were initially built from 1900 to 1910 as the second Fort Abraham Lincoln. Four buildings on the campus were considered for the NDFS FSS feasibility study: the Sakakawea (No. 30) and Sitting Bull (No. 33) Residence Halls and the Education Building (Nos. 31 and 32). Because the campus is heated using natural gas and metered as a whole, estimation of annual heating energy was based proportionately on building area. UTTC supplied an estimate of 1.5 MMBtu/hr for each building. With current gas prices at $10.12/MMBtu, $62,500 was given for annual heating costs of all four buildings. UTTC is interested in the comparison of installing a wood heating system for all four buildings or only one building. Although a larger system would offer more savings, a small system would provide the opportunity for direct comparison of operations to the other buildings.

The new public Mandan middle school (MMS) is still in the design stages and construction has yet to begin. The building is expected to cover 115,000 $ft^2$. Current heating designs incorporate a hybrid system of heat pumps and natural gas. The heat pumps are for ground source heating and utilize electricity for operation. Natural gas will be used as a supplemental fuel when the ground source heating is not sufficient to heat the facilities. According to Prairie Engineering, estimated annual natural gas needs are 38,000 Btu/$ft^2$ and electricity needs are 52,000 Btu/$ft^2$ for the school, translating to about 4370 MMBtu/yr natural gas and 1.75 million kWh/yr (5980 MMBtu/yr) electricity (Axvig, 2006). It was assumed that 750,000 kWh/yr of electricity will be from general activities, leaving 1 million kWh (3420 MMBtu) annually from heat pump operations (Oswald, 2006). Expected total energy consumption for heating is thus estimated to be 7790 MMBtu annually. The local utilities provider, Montana–Dakota Utilities Co., supplied the following current rates: $0.043/kWh for electric heat and $7.80/MMBtu for natural gas. Total cost is, therefore, expected to be about $77,100 annually to heat the new facilities at an average $9.89/MMBtu (Oswald, 2006). The economics of a wood heating system were compared to the currently planned hybrid system.

## WOOD CHIP RESOURCES AND TRANSPORTATION OPTIONS

Since all three institutions studied are located in the Bismarck–Mandan area, identification of biomass resources were focused within the region. One of the goals of the FFS is to mitigate the risk of fire by biomass utilization; therefore, wood-based resources were researched. A summary of fuel needs is given in Table 1.

Municipal sources tend to have the most highly concentrated and easily accessible sources of woody biomass for energy use. Mandan Public Works collects wood chips, albeit limited amounts mostly used for residential purposes. Branches are also collected and burned at the Mandan Landfill. The Bismarck Landfill produces about 3900 tons of wood chips annually and sells them for an industrial price of $3.00/$yd^3$ ($11.11/ton) (Hunke, 2005). Up to 1000 tons is currently either sold to local landscapers or used for city projects. The demonstration project at the landfill is estimated to consume about 300 tons of wood chips per year. Should all three institutions utilize wood chips as a primary source of heating energy, an average of 2030 tons/yr would be consumed. Several hundred tons would thus remain available as contingency, which would account for up to a one-third increase in heating needs above the average. Because of the sufficient quantities available, wood chips at the Bismarck Landfill were used for the remaining feasibility study calculations.

**Table 1. Estimated Energy Requirements for Wood Fuel**

| School | Current Energy Source | Current Fuel Price per MMBtu, $ | Current Annual Heating Costs, $ | Average Annual Heating Energy, MMBtu | Wood Equivalent, tons |
|---|---|---|---|---|---|
| Dakota Adventist Academy | Coal | 2.12 | 25,500 | 12,100 | 940 |
| United Tribes Technical College | Natural gas | 10.12 | 62,500 | 6180 | 480 |
| Mandan Middle School | Natural gas–heat pump hybrid | 9.89 | 77,100 | 7790 | 610 |
| Total | – | – | 165,000 | 26,000 | 2030 |

The quality of the wood chips at the Bismarck Landfill was determined as well. The chips are produced from a mixture of municipal trees and wood pallets, mostly hard woods, as shown in Figure 1, using a Duratech 4012 tub grinder with metal extractor (Bren, 2006). Other pictures are available in Appendix A. Tree roots are separated before chipping, and asphalt has also been laid to reduce the presence of dirt.


Figure 1. Bismarck Landfill wood materials.

A source of wood pellets was also researched because of consistency of size and quality. Heartland Wood Pellets in Spearfish, South Dakota, is the closest source of pellets and produces about 26,000 tons per year. Prices are in the range of $130–$150 per ton before transportation (Follette, 2006). Unfortunately, this source is contracted quickly and already sold out for 2007. In addition, production is currently limited by transportation costs for raw materials.

Because transportation costs comprise 75% of the delivered wood chip cost as a fuel, several options were researched for the transportation of wood chips to each institution. The staff of the Bismarck landfill will deliver wood chips within the city limits. Other delivery options include hiring a service company or purchasing a truck and hiring labor to haul the material. Examples of service companies in the region are Pioneer Construction, Inc.; Kuntz & Sons Trucking & Construction; and R&F Dirt & Gravel Hauling.

Costs for transportation depend on labor and duration of delivery, as well as fees for trucks and equipment for hauling, loading, and unloading of the wood chips. The Bismarck Landfill delivers 12 $yd^3$ (3.2 tons) per load of wood chips for $26.34/hr for labor and $33.00/hr for truck and equipment use (Hunke, 2006). Approximately 0.5 hours was estimated by landfill personnel for delivery to UTTC. DAA and MMS are outside Bismarck city limits and may not utilize this option. Costs given by each of the service companies are shown in Table 2. The time estimated for delivery is about 1.3 hr, 1.5 hr, and 2.0 hr for UTTC, DAA, and MMS, respectively. The longer values compared to that estimated by landfill personnel includes the waiting period for an available landfill operator to load an incoming truck.

The institutions may also purchase a used truck and hire labor for transportation of wood chips. A new vehicle is not recommended because of unfavorable economics. Examples found are a 35-$yd^3$ (9.4-ton) forage box for $40,000 and a 48-$yd^3$ (13-ton) tractor trailer for $30,000 (Halstead Trailer Sales, 2006). Observed delivered prices were calculated based on the amortization of capital truck costs for each load over a 4-yr period, $3.00/gal diesel, $27.00/hr wage, and 5 miles to the gallon. The approximate distance of each school from the Bismarck Landfill is 20.3 miles, 10.9 miles, and 6.0 miles for DAA, MMS, and UTTC, respectively. A summary of each delivery method is given in Table 3.

**Table 2. Wood Chip Transportation Costs for Area Service Companies**

| Company | Truck Type | Load Size, $yd^3$, tons | Labor and Equipment Costs |
|---|---|---|---|
| Pioneer Construction, Inc. | Tractor trailer | 28 (7.6) | $90/hr |
| | End-dump railroad truck | 17 (4.6) | $60/hr |
| Kuntz & Sons Trucking & Construction | – | 12 (3.2) | $50/hr |
| R&F Dirt and Gravel Hauling | End-dump truck | 10 (2.7) | $65/load for MMS; $70/load for DAA |
| | Belly-dump truck | 18 (4.9) | $100/load |

**Table 3. Estimated Wood Chip Price per Ton for Various Transportation Methods**

| Company | Truck Type | DAA, $ | Schools<br>UTTC, $ | MMS, $ |
|---|---|---|---|---|
| Bismarck Landfill (within city limits only) | – | – | 20.27 | – |
| Pioneer Construction, Inc. | Tractor trailer | 35.10 | 26.59 | 29.50 |
| | End-dump railroad truck | 37.45 | 28.10 | 31.31 |
| Kuntz & Sons Trucking and Construction | – | 42.21 | 31.17 | 34.95 |
| R&F Dirt & Gravel Hauling | Belly-dump truck | 31.69 | 31.69 | 31.69 |
| | End-dump truck | 37.04 | 35.19 | 35.19 |
| Purchasing Used Equipment and Supplying Labor | Forage box | 30.05 | 36.10 | 33.34 |
| | Tractor trailer | 25.08 | 29.70 | 27.48 |

## FUEL COST COMPARISON

The cost of wood chip delivery was then compared with the current heating source at each of the institutions. The prices of each fuel and delivery option were converted to energy units (e.g., per MMBtu). This allowed the prices of fuel options to be compared directly. The following details the results of the analysis.

Several scenarios were researched for DAA's interest in a fuel comparison between wood, propane, and coal. Figure 2 compares the cost of each of these fuels on an energy basis including transportation. Propane prices have historically averaged $9.45/MMBtu ($0.87/gal) for DAA. DAA-purchased equipment and supply of labor offers the lowest price for delivery of wood

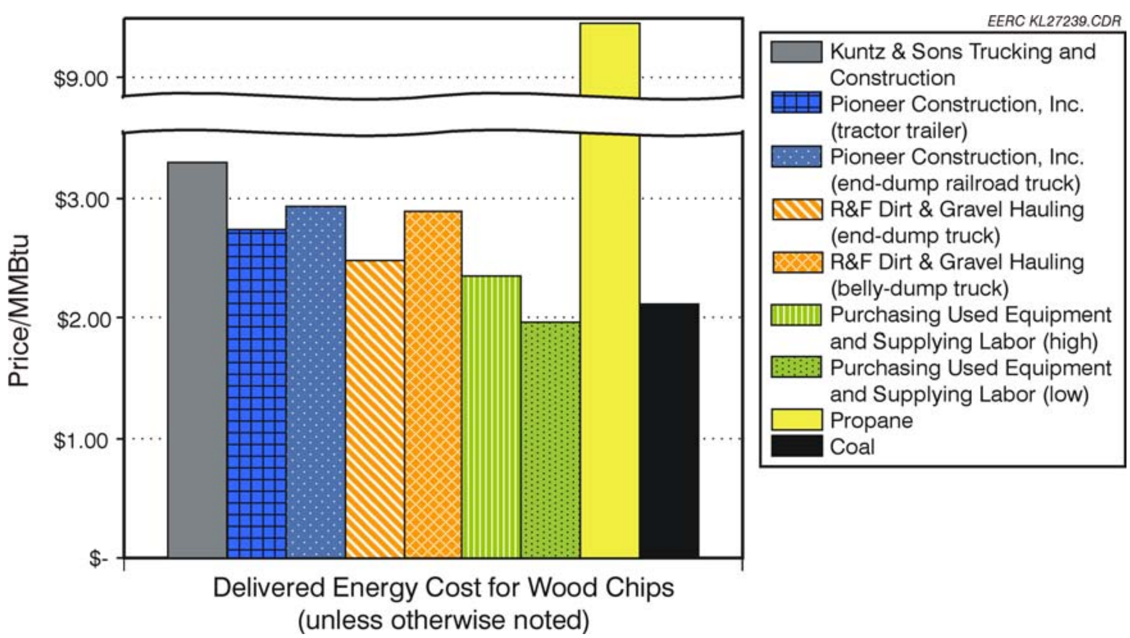


Figure 2. Comparison of fuel options for DAA.

chips at $1.96/MMBtu ($25.08/ton). This observed price is $0.16/MMBtu and $7.49/MMBtu lower than the DAA coal and propane prices, respectively.

However, the observed price of wood chips when delivered by a purchased vehicle and hired labor changes depending on the amount transported. This is a result of the amortization of the truck purchase to provide an estimation of wood chip delivered cost. For example, if wood is used as the primary heating fuel and 940 tons of wood chips are delivered annually to DAA, the observed cost is $25.08/ton. If only half the amount of wood chips (470 tons) is delivered annually, the observed cost is $32.94/ton. For this amount, contracting an end-dump truck with R&F Dirt & Gravel Hauling for the lower cost of $31.69/ton is more economical. The breakeven point would be use of more than 520 tons of wood chips by DAA for heating.

UTTC is interested in the potential savings associated with a lower-cost fuel. Prices are compared in Figure 3. Delivery of wood chips from the Bismarck Landfill by landfill personnel presents the lowest-cost option for UTTC at $1.58/MMBtu ($20.27/ton), an $8.54/MMBtu decrease from the current natural gas price.

Potential savings in heating costs for MMS were based on a comparison to the planned natural gas and heat pump hybrid system. As shown in Figure 4, wood chip costs are significantly lower than energy costs for the hybrid system; however, transportation expenses vary little between wood chip delivery options. The purchasing of equipment and supplying labor were used for calculations at the observed price of $2.15/MMBtu ($27.48/ton), $7.75/MMBtu lower for heating energy compared to the hybrid system.

## EQUIPMENT

Several manufacturers and types of equipment were considered for applicability to each institution's interests. Systems that can burn coal, wood, both wood and coal, or propane were researched for DAA. These included such manufacturers as Messersmith Manufacturing, Inc.; King Coal Furnace Corporation; Hurst Boiler & Welding Co., Inc.; Chiptec Wood Energy Systems; and Parker Boiler Company. Systems of various sizes that accept wood chips as fuel and are capable of supplying heat to either one building or all four buildings of the UTTC study were researched. Manufacturers that fit these criteria are Messersmith Manufacturing, Inc.; King Coal Furnace Corporation; Hurst Boiler & Welding Co., Inc.; Chiptec Wood Energy Systems; Pro-Fab Industries, Inc.; and The Wood Doctor. Because MMS is also interested in larger systems which can utilize wood chips as a fuel, the same manufacturers were studied with the exception of Pro-Fab Industries, Inc., and The Wood Doctor. A description of systems researched from each manufacturer follows and is summarized in Table 4.

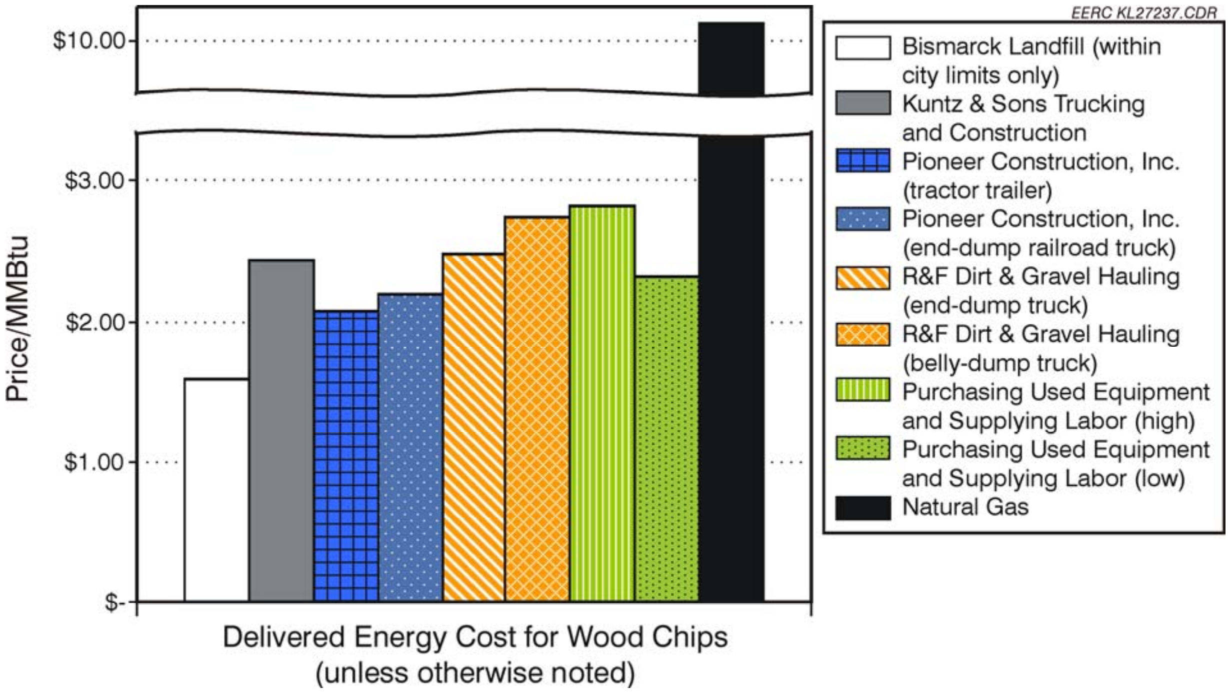


Figure 3. Comparison of fuel options for UTTC.

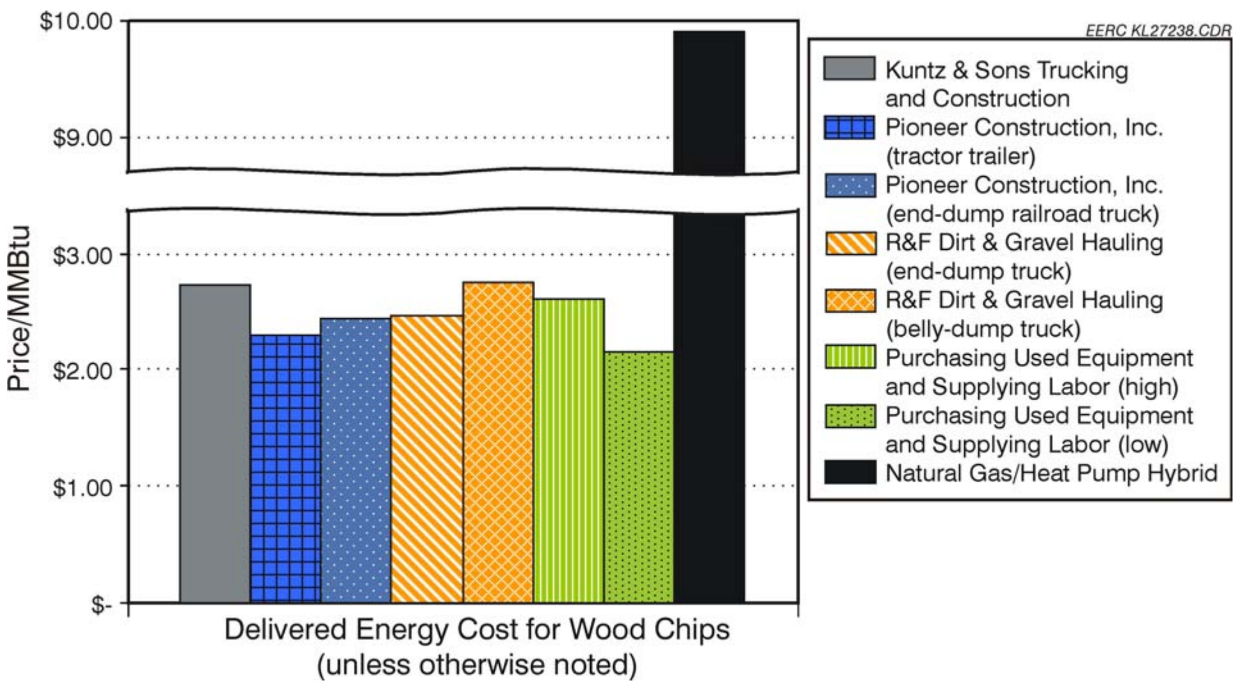


Figure 4. Comparison of fuel options for MMS.

**Table 4. Wood Heating System Manufacturers***

| Company | Range, MMBtu/hr | Materials |
|---|---|---|
| Messersmith Manufacturing, Inc. | 1–20 | Wood chips, saw dust, corn cobs, and wood shavings |
| King Coal Furnace Corporation | 3.4–34 | Coal or wood products (bark, chips, wet or dry sawdust, and shavings) |
| Hurst Boiler & Welding Co., Inc. | 2–60 | Bark, hulls, rubber, sawdust, hog fuel, shavings, agricultural, coal, construction debris, sludge, sander dust, and paper; natural gas, propane, No. 2 oil, heavy oil, or combinations |
| Chiptec Wood Energy Systems | 0.4–50 | Wood chips, sawdust, shavings, clean biofuel, agricultural and food processing residue, pallets, paper pellets, railroad ties, etc. (biomass waste 6%–60% moisture content) |
| Parker Boiler Company | 0.3–6.8 | Natural gas, oil, propane, or combination-fired |
| Pro-Fab Industries, Inc. | 0.75–2.5 | Corn, wood chips, wood pellets, coal, and agricultural residue cubes |
| The Wood Doctor | 0.1–1.3 | Wood chips or logs |

*Contact information given in Appendix B.

Wood heating systems generally consist of three main components: fuel handling, boiler (a.k.a. gasification or combustion), and controls. Figure 5 illustrates a typical system and equipment. The fuel-handling component contains the wood storage bin. If the system is automated, augers and conveyers are included to feed the wood to the boiler. The boiler contains the combustion or gasification chamber for conversion of the wood to energy for heating water in hot-water-heated buildings. Controls within the system will vary depending on degree of automation. They can be limited to burn rate or include motors for augers and conveyors. Ash handling will also depend on automation. Manual systems may require daily ash removal, while automated systems will remove the ash periodically and require weekly cleaning.

Parker Boiler Company and Hurst Boiler & Welding Co., Inc., provide systems capable of utilizing propane for fuel. Parker Boiler Company manufactures direct-fired hot-water boilers (Figure 6) designed from 0.3- to 6.8-MMBtu/hr input available for gas, oil, propane, or combination-fired (Parker Boiler Company, 2006). The boiler is operated with an atmospheric burner system and control system. Hurst Boiler & Welding Co., Inc., is a major supplier of gas-, oil-, and wood-fired boilers ranging from 2.0 to 60 MMBtu/hr (Hurst Boiler & Welding Co., Inc., 2006). Hurst firebox units, shown in Figure 7, are available for firing natural gas, propane, No. 2 oil, heavy oil, or combinations. They are factory packaged with operating controls, relief valves, burner, and fuel train and provide fully automated operation. A separate fuel-handling system is not necessary with this type of boiler.

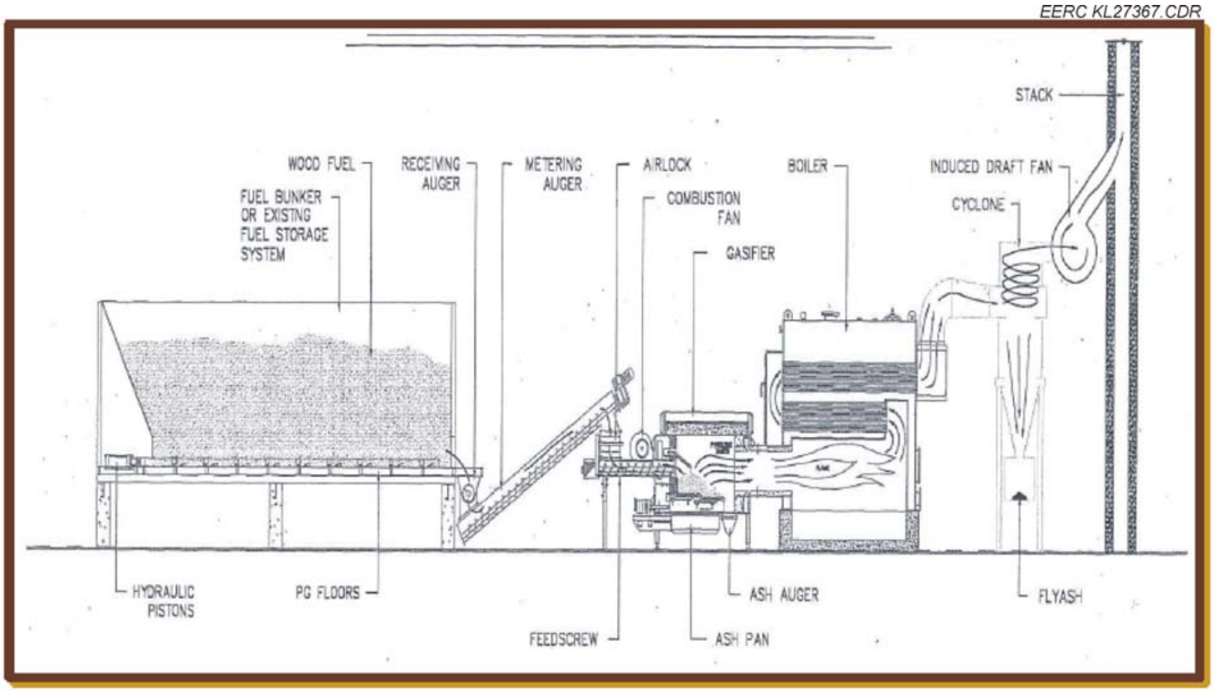


Figure 5. The basic mechanics of a typical wood chip-burning biomass system (Linderman and Scheele, 2006).


Figure 6. Parker direct-fired hot-water boiler.


Figure 7. Hurst firebox boiler for gas and oil fuels (Hurst Boiler & Welding Co., Inc., 2006).

Hurst, as well as King Coal Furnace Corporation, also manufactures boilers capable of burning wood, coal, or both wood and coal. Hurst solid fuel-fired boilers (Figure 8) are designed for a wide variety of fuels including bark, hulls, rubber, sawdust, hog fuel, shavings, agricultural, coal, construction debris, sludge, sander dust, paper, and/or gas and oil as backup fuels. The following is a list of systems and components available for a solid fuel system:

- Deaerator (makeup water systems)
- Coal bunker storage
- Fuel conveyors
- Forced-draft fans and air systems
- Ash-handling conveyors
- Induced-draft fans and air systems
- Hurst Brand refractories
- Automated control systems
- Fuel-metering systems
- Ash reinjection systems
- Exhaust breeching and stacks
- Emissions control and monitoring
- Fire doors and grates
- Sootblower systems

King Coal Furnace Corporation manufactures stokers designed to burn either coal or wood products (King Coal Furnace Corporation, 2006) for systems ranging from 3.4–34 MMBtu/hr. King Coal wood combustion systems can burn bark, chips, wet or dry sawdust, and shavings no larger than 1 inch in diameter. System options include hydraulic floor scrape fuel storage, conveying equipment, sootblowers, and ash removal for automation. The stoker can be integrated with an existing or new boiler (Figure 9), and wood-burning stokers are designed for gasification of wood products.


Figure 8. Hurst solid fuel-fired boiler (Hurst Boiler & Welding Co., Inc., 2006).


Figure 9. King Coal stoker for combustion of coal or wood (King Coal Furnace Corporation, 2006).

Systems which are primarily designed to use wood include those from Messersmith Manufacturing, Inc., and Chiptec Wood Energy Systems. Messersmith manufactures boilers that burn solid fuels such as wood chips, saw dust, corn cobs, and wood shavings with heating outputs from 1.0 to 20 MMBtu/hr (Messersmith Manufacturing, Inc., 2006). The company also provides a fully automated system for solid fuel combustion (Figure 10), including a storage bin and fuel-handling, combustion, and control systems. The fuel-handling system, shown in Figure 11, includes a traveling auger, storage bin, belt conveyors, and metering bin. The combustion system consists of a boiler, grates, and air blowers. The control system comprises the motors for the augers, conveyors, and blower as well as the control panel containing programmable logic controllers, sensors, switches, and the connecting cables. Chiptec manufactures biomass gasification systems (Figure 12) ranging from 0.4 to 50 MMBtu/hr for fuels such as chips, sawdust, shavings, clean biofuel, agricultural and food-processing residue, pallets, paper pellets, railroad ties and other biomass waste covering a wide range of moisture contents (6%–60%) (Chiptec Wood Energy Systems, 2006). Coal can also be cofired with the biomass fuel. A variety of automation methods are available for material handling including moving-wedge systems, traveling screw unloading systems, silos and silo-unloading systems, and belt and screw conveyors.

Small outdoor wood heating systems can be automated or manual. Several units may also be placed in parallel for distributed heat to create a larger system. Pro-Fab Industries manufactures fully automated multifuel outdoor (or optional indoor) boilers that burn corn, wood chips, wood pellets, coal, and agricultural residue cubes ranging from 0.75 to 2.5 MMBtu/hr (Pro-Fab, 2006). The solid fuel-fired hot-water boiler (Figure 13) is engineered to automatically feed fuel and remove ash. A computerized control system manages all functions of the drive motors. This unit also includes a self-cleaning flue design with automatic spiral flue cleaners. The Wood Doctor manufactures outdoor wood furnaces for use with an existing boiler

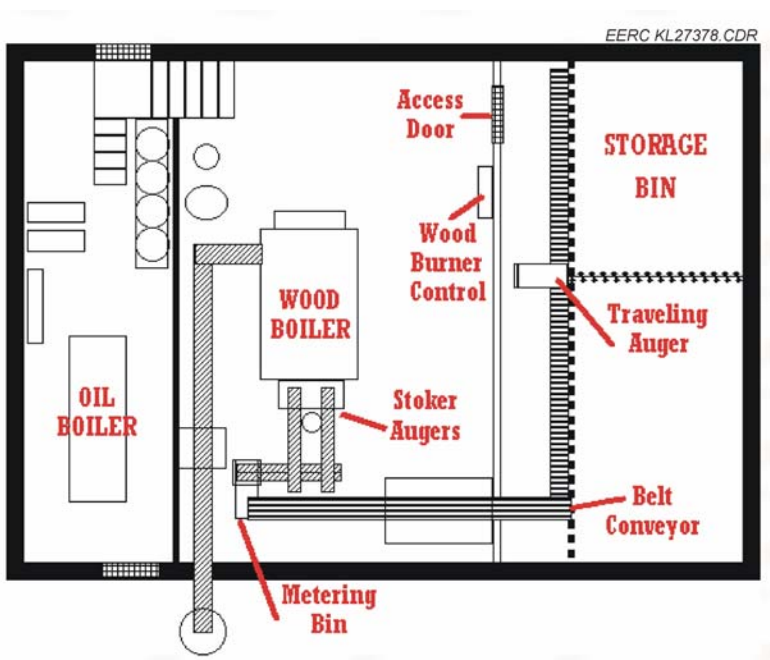


Figure 10. Messersmith solid fuel combustion system designed to burn wood chips (Messersmith Manufacturing, Inc., 2006).

EERC KL27363.CDR

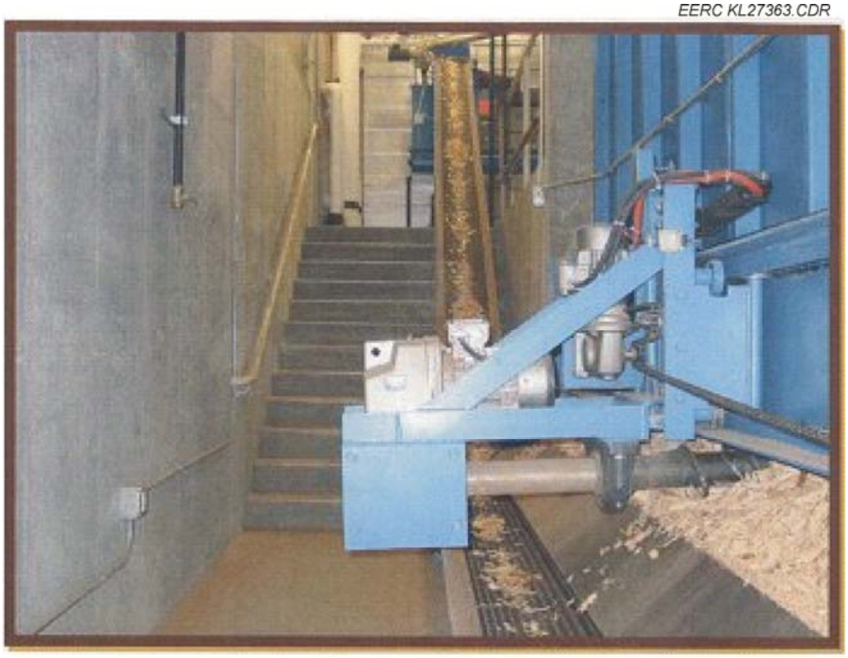

Figure 11. Traveling auger and belt conveyors of the Messersmith system (Messersmith Manufacturing Inc., 2006).

EERC KL27365.CDR

Figure 12. Chiptec gasifiers and boiler system (Chiptec Wood Energy Systems, 2006).


Figure 13. Pro-Fab coal, wood, and pellet hot-water furnace (Pro-Fab Industries, 2006).

system. Furnaces are available from 0.1 to 1.3 MMBtu/hr and may burn wood logs or chips (The Wood Doctor, 2006). Only the furnace, shown in Figure 14, is supplied, and all operations are manual.

## CAPITAL COSTS

Quotes for the equipment of each system type were collected from the manufacturers chosen for this study. The most economical solution for each institution was identified and used


Figure 14. Wood Doctor outdoor wood furnace (The Wood Doctor, 2006).

to determine project capital costs. The cost of any additional structures required for housing equipment or woodchip storage were estimated and included in the capital cost calculation. A contingency factor of 10% was also applied to all capital expenses.

Scenarios researched for the DAA secondary system include propane systems, wood systems, additional coal systems, and systems capable of burning both wood and coal. A comparison of quotes for each of these system types is given in Table 5. The Parker Boiler Company propane system requires the smallest investment, with an installed cost of $47,000. The least expensive wood system (which can also handle coal) is available from Chiptec Wood Energy Systems for $300,000, and a coal-only system is available from Hurst Boiler & Welding Co., Inc., for $374,000. However, the Messersmith quote for $320,000 was used for wood heating system calculations because of its reputation as a more robust system. An example of the Messersmith quote is shown in Appendix C.

Table 6 contains system costs for both UTTC and MMS because of similar energy requirements. The table also includes estimates for a smaller system for direct comparison of operations and savings for one UTTC building. Economies of scale are apparent as system prices

**Table 5. Capital Costs for 6.68-MMBtu/hr Systems for Various Fuels**

| Company | Fuel(s) of Interest | Quote, $ | Comments |
|---|---|---|---|
| Messersmith Manufacturing, Inc. | Wood | 320,000 | 5-MMBtu output, includes combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, one-piece stack for exhaust, control panel, draft fan |
| King Coal Furnace Corporation | Wood | 500,000 | Installed; assumes much of existing coal equipment and storage can be used |
| | Coal | 400,000 | |
| | Wood and Coal | 450,000 | |
| Hurst Boiler & Welding Co., Inc. | Wood, Coal, Wood and Coal | 374,000 | Delivered, installed on existing concrete slab (Hurst provides design); $100,000 addition for wood storage and conveyor system; $80,000 addition for coal auto ash removal |
| | Propane | 110,000 | Delivered, installed on existing concrete slab (Hurst provides design) |
| Chiptec Wood Energy Systems | Wood, Wood and Coal | 300,000 | Fuel-receiving and storage system, metering auger, feed system, gasifier, boiler, fan, cyclone, controls, stack and breeching, installed, start-up, and training |
| Parker Boiler Company | Propane | 47,000 | 6.8-MMBtu boiler only, need contractor to install; assuming $15,000 but can be up to $30,000 |

**Table 6. Capital Costs for 6-MMBtu/hr and 1.5-MMBtu/hr Wood-Only Systems**

| System: School(s) | Company | Quote, $ | Comments |
|---|---|---|---|
| 6 MMBtu/hr: Mandan, UTTC (all buildings) | Messersmith Manufacturing, Inc. | 320,000 | 5-MMBtu output, includes combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, one-piece stack for exhaust, control panel, draft fan |
| | King Coal Furnace Corporation | 375,000 | Installed |
| | Hurst Boiler & Welding Co., Inc. | 374,000 | Estimated |
| | Chiptec Wood Energy Systems | 300,000 | Fuel-receiving and storage system, metering auger, feed system, gasifier, boiler, fan, cyclone, controls, stack and breeching, installed, start-up, and training |
| 1.5 MMBtu/hr: UTTC (one building) | Messersmith Manufacturing, Inc. | 220,000 | 1.5-MMBtu output, includes combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, sectional stack pipe for exhaust, control panel, draft fan |
| | Hurst Boiler & Welding Co., Inc. | 260,000 | Estimated |
| | Chiptec Wood Energy Systems | 150,000 | Fuel-receiving and storage system, metering auger, feed system, gasifier, boiler, fan, cyclone, controls, stack and breeching, installed, start-up, and training |
| | Pro-Fab Industries, Inc. | 45,000 | 1.5-MMBtu output (PC 2520 2.5-MMBtu input), includes feed auger, ash auger, cyclone; would need concrete slab, fuel bin; can be indoor or outdoor w/ or w/o metal shed |
| | The Wood Doctor | 12,000 | 1.3-MMBtu industrial outdoor furnace, wholesale price (i.e., no dealers in area), includes furnace only |

per MMBtu/hr average $57,000 for larger systems and $92,000 for the smaller systems. Again, the Messersmith quote of $320,000 was used for the installed cost of a wood heating system for MMS. Costs for heating one building or all four buildings at UTTC would vary depending on the purchase of an indoor or outdoor system and presence of automation. Prices range from

$375,000 for a large, indoor, automated unit to a $12,000 small, outdoor, manual unit. These differences are described further in the Economic Feasibility section.

Safety and environmental rules are also important to consider when installing a wood-burning system. The North Dakota Department of Health limits particulate emissions to 20% opacity and a 0.6-lb/MMBtu standard for sites with a combined energy output of more than 10 MMBtu/hr (Bachman, 2006). The fire code does not include specifications on outdoor furnaces; however, wood chips are considered a “waste material” according to the fire code, and they are not prohibited to accumulate in any occupied building (Hoium, 2006). Building codes simply require manufacturer specifications to be followed and the proper permits to be acquired before any construction takes place (Ziegler, 2006).

Separate buildings were, therefore, considered for a wood heating system at each institution. Although DAA does not have a separate boiler building, the fire walls containing the boiler system and the lack of upper floor occupation above the boiler room satisfies safety codes without the need for an additional building for woodchip storage. Separate building costs were not considered for MMS either, because of the insignificant difference, if any, from costs for the planned construction. Because the UTTC buildings studied are occupied by students and faculty, separate buildings will be required for the wood heating systems. The Messersmith quote gives a building requirement of 40' W × 50' L × 20' H. A 2000-$ft^2$ building was thus assumed for large systems and 500 $ft^2$ was used for small system calculations. Price estimations are $30–50/$ft^2$ for a steel building and $100–$125/$ft^2$ for brick (Fitterer, 2006).

## SYSTEM LAYOUT

Features to consider for the layout of a wood heating system are sufficient land, additional buildings, if required, and access for delivery trucks. Accessibility for operating personnel should also be taken into account. It is assumed that the existing natural gas system for UTTC and the planned natural gas system for MMS will remain as backup systems.

The location of a wood heating system will, therefore, vary for each institution. The secondary DAA heating system could easily be located next to the existing boiler room, as shown in Figure 15. There is already sufficient accessibility for woodchip delivery and available space for woodchip storage and a wood heating system. The propane tank owned by DAA is adjacent to the building, making it a convenient location for a propane system as well. Options for UTTC depend on the size of system installed and are shown in Figure 16. A large system requires more land and could be located between the Education Building and the Sakakawea Residence Hall. A small system for one building could be located next to the Sitting Bull Residence Hall. Both locations have street access for woodchip delivery through Ft. Berthold Avenue. Drawings for the Mandan school heating system are not yet available. Current plans are for the main mechanical system to be located on the second floor level, with a cooling tower on the ground (Fitterer, 2006). A wood heating system would require ground-level access.

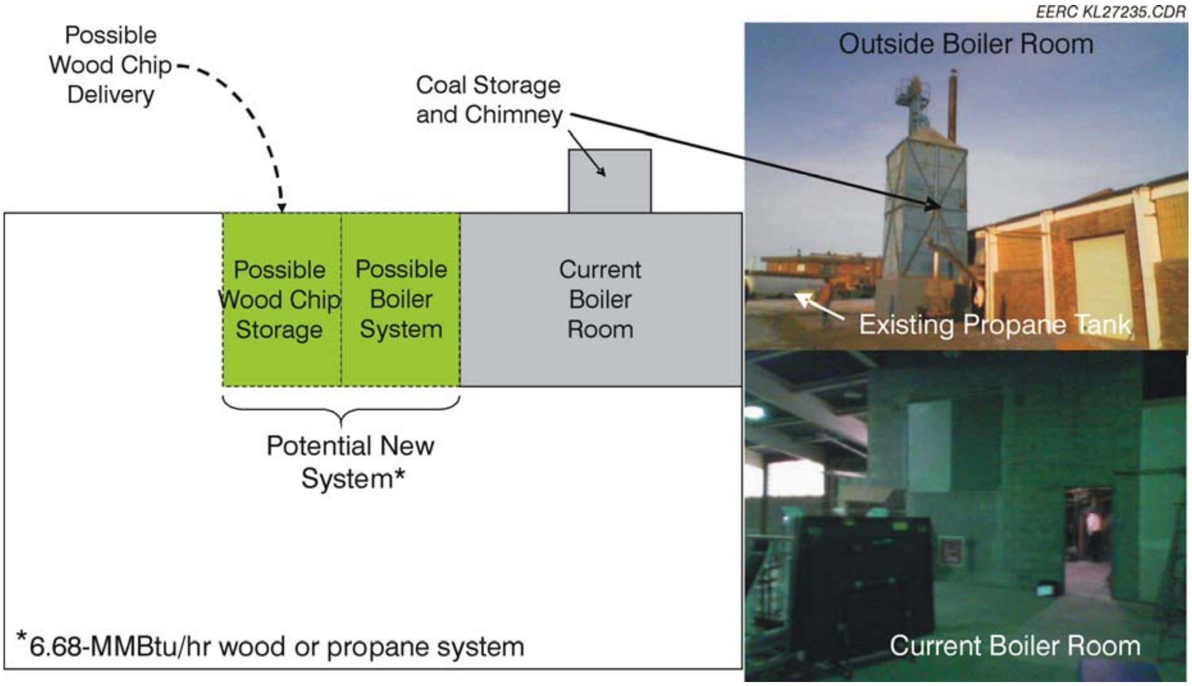


Figure 15. DAA secondary heating system location.

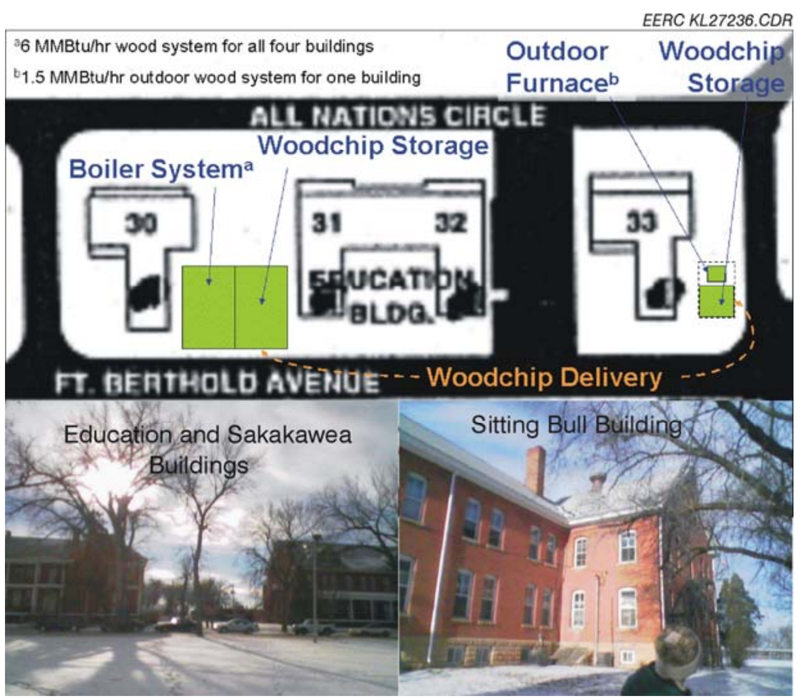


Figure 16. UTTC heating system options and locations.

## OPERATING COSTS

Costs for system operation in addition to fuel price include the additional labor required to operate the system in comparison to each institution's existing heating system. Other costs to consider are ash disposal and escalation of operating costs.

Additional labor required for a solid fuel heating system in comparison to a natural gas system was estimated for the UTTC and MMS sites; a savings in labor is credited to the DAA propane scenario. A rate of $27/hr is used, with an estimated 10 hours per week for an automated wood heating system, which equates to about 360 hours per year. About 230 extra labor hours would be required for a manual wood system, based on manufacturer estimates of two loadings per day at full capacity with a 20-minute loading time.

Ash production is about 3% of the amount of wood burned and requires proper disposal (Food and Agriculture Organization of the United Nations, 1986). Because DAA currently burns coal, ash produced through burning wood instead of coal would not significantly change disposal costs. Approximately 4 tons, or 14 tons per year, of ash would be produced at UTTC for a small wood system or a large system, respectively, and about 18 tons per year is estimated from a MMS system. Ash can be disposed of either at a landfill or applied to fields as fertilizer. Wood ash could supply 25–70 lb of potash ($K_2O$) and 30–32 lb of phosphate ($P_2O_5$) and may be applied at rates of 5–20 tons per acre (Kopecky et al., 2006). The ash may require testing to prove viability as a fertilizer and to determine optimal application rates. Baseball diamonds and football fields are good examples for application. Ball diamonds are typically 2 acres and can easily be located at city parks. Football fields are usually about 1 acre; unfortunately, many are covered with artificial turf. Bismarck has 13 parks with baseball diamonds, which equates to at least 26 acres available (Bismarck Parks and Recreation District, 2006); Mandan has at least four ball diamonds, giving 8 acres (Mandan Parks & Recreation, 2006). Disposal costs would, therefore, be the price of transportation: $10.34/ton for MMS, and $8.70/ton for UTTC. UTTC also has the option of disposal at the Bismarck Landfill for $10/ton (Hunke, 2006).

Escalation was taken into account in the analysis for all systems. Natural gas rates have increased by an average of 16% per year over the last 10 years (Energy Information Administration, 2006a), yet futures projections estimate a change of -1.1% over the next ten years (Energy Information Administration, 2006b). A similar effect was noted for diesel fuel and, thus, transportation costs of wood chips, with an 11% observed increase per year over the last decade (Energy Information Administration, 2006c) and a projected change of 1% per year for the next decade (Energy Information Administration, 2006b). Therefore, the standard escalation rate of 4% was used for fuel calculations. Labor and ash disposal escalation rates were set at 2.7%.

## ECONOMIC FEASIBILITY

The economic feasibility of the systems considered for each institution was calculated based on the capital costs, operating costs, and estimated savings compared to the current heating costs. A simple payback was determined for each system for UTTC and MMS by dividing the capital expenses by the potential annual savings. The simple paybacks estimated could then be compared to identify the systems with the quickest rate of return. Because DAA will retain use of its existing coal boiler, a comparison of annual costs for each secondary system was performed. Capital costs were amortized over an assumed 20-yr service life and added to the calculated operating costs for an estimated annual heating cost. This cost was then used to directly compare the differing fuel systems.

A wood heating system can greatly benefit DAA depending on projected use of the system. Economics were thus compared for several primary and backup boiler options. Options included the comparison between 1) a primary coal boiler, secondary propane system; 2) a primary coal boiler, secondary wood heating system; 3) primary and secondary coal boilers; and 4) a primary wood system, secondary coal boiler. Motivation for the study included ease in regulating moderate heating requirements in the spring and fall seasons. Heat used in spring and fall accounts for 11% of the annual energy consumption. DAA is also considering possible expansion of the facilities to accommodate a greenhouse. Assuming a greenhouse with a volume of 15,000 $ft^2$, an increase of about 4% could be expected in the annual energy consumption for the expansion. Potential boiler down time during winter could account for an additional amount of energy use.

The economic outcome of the comparison is shown in Figure 17. The higher price of propane eventually overcomes the low capital cost with increased use as a secondary system. The breaking point occurs when propane is used for 18% of the annual energy consumption. Estimated annual heating costs, given in Table 7, range from $36,800 for spring and fall use to $42,300 at the breakeven point. If wood is utilized at greater than 18% of the annual energy use for heating during season changes, estimated downtime of the existing coal system, and/or supplying heat for a greenhouse, the wood-fired system appears more economically attractive than a simple propane backup to the existing coal boiler. Estimated annual heating costs range from $42,300–$45,300. A more detailed analysis is provided in Appendix D.

The feasibility of a wood system at UTTC or MMS is dependent on potential energy savings by heating with a lower-cost fuel. Three types of systems were considered for both large and small application to the UTTC site due to varying capital and operating costs: indoor automated, outdoor (or optional indoor) automated, and outdoor manual. Analyses were also performed on a 5-MMBtu/hr Messersmith indoor automated wood heating system for MMS. The results are summarized in Table 8. The economics for the outdoor automated system (i.e., Pro-Fab Industries) are the most favorable for UTTC, with an estimated capital cost of $278,000. The larger system assumes four small systems placed in parallel for distributing heat connected to the four UTTC buildings studied. This would generate an estimated annual savings of $42,900, and a simple payback period of 6.5 years. Capital expenses for MSS are estimated to be $352,000, generating $49,200 in annual savings and a 7.2-year simple payback period over the currently planned hybrid system. Full economic analyses for each scenario are given in Appendix D.

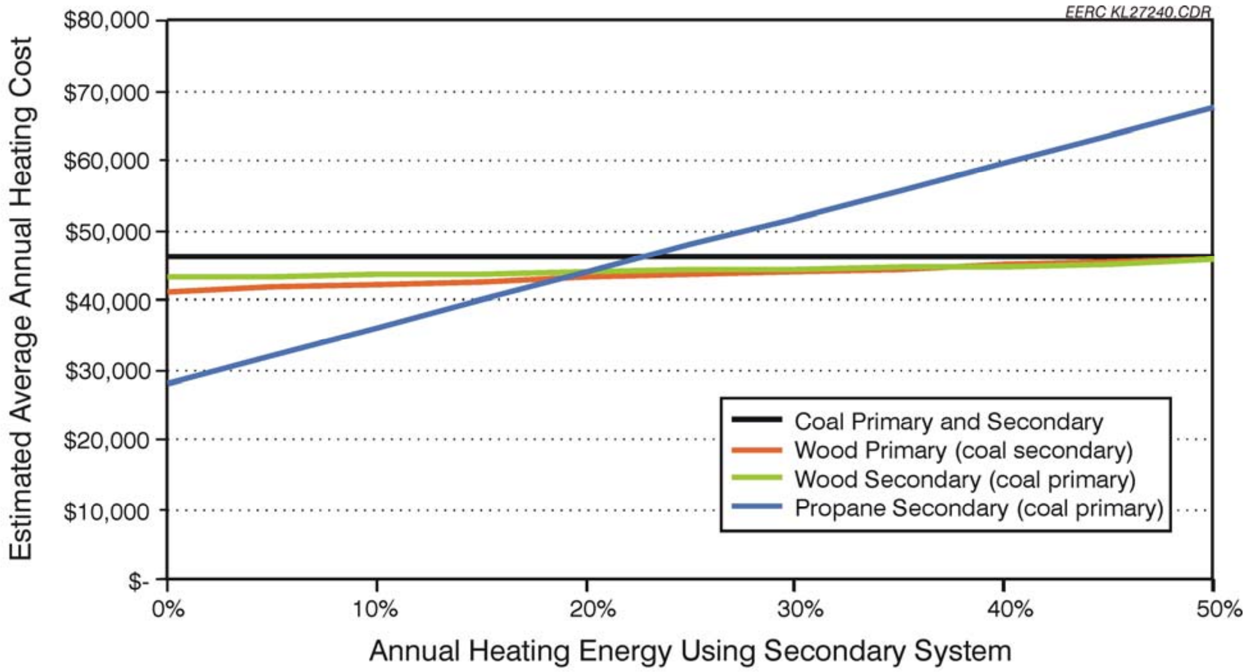


Figure 17. Comparison of DAA primary and secondary system options.

**Table 7. Estimated DAA Annual Energy Costs for Various Heating Systems and Annual Energy Consumption**

| System Type | Coal–Coal System Energy Costs | Coal–Propane System Energy Costs (Low[b]) | Coal–Propane System Energy Costs (High[c]) | Wood–Coal System Energy Costs (Low[d]) | Wood–Coal System Energy Costs (High[e]) |
|---|---|---|---|---|---|
| Capital Cost | $411,000 | $51,700 | | $352,000 | |
| Operating Expenses | $25,500 | $34,200 | $39,700 | $24,700 | $27,700 |
| Annual Cost Equivalent[a] | $46,100 | $36,800 | $42,300 | $42,300 | $45,300 |

[a]Capital costs amortized over assumed 20-year service life; [b]assumes propane use as secondary system for 11% of the annual energy consumption; [c]assumes propane use as secondary system for 18% of the annual energy consumption; [d] assumes a primary wood system and coal use as secondary system for 18% of the annual energy consumption; [e]assumes 50% of the annual energy consumption by each system.

The NDFS can access financial assistance through the FFS program. Funding at $417,000 is available to approved projects for capital expenses, with a single project limited to 80% federal funding. DAA does not qualify for this portion of the program since it is a private institution. Given federal assistance, paybacks for UTTC and MMS cost share could range from 1–3 years. Examples are shown in Appendix D. A payback of 8–10 years is considered economical by the NDFS.

**Table 8. Economic Results of Wood Heating Systems for UTTC and MMS**

| Institution | UTTC | | | | | | MMS |
|---|---|---|---|---|---|---|---|
| | Large | | | Small | | | |
| System | Indoor Automated | Outdoor Automated | Outdoor Manual | Indoor Automated | Outdoor Automated | Outdoor Manual | Indoor Automated |
| Capital Costs | $432,000 | $278,000 | $133,000 | $185,000 | $ 69,500 | $ 33,200 | $ 352,000 |
| Current Annual Operating Costs Using Natural Gas | $62,500 | | | $16,000 | | | $ 77,100 |
| Estimated Operating Costs Using Wood Chips | $ 19,600 | $ 19,600 | $ 44,500 | $ 5,000 | $ 5,000 | $ 11,200 | $ 27,900 |
| Estimated Annual Savings | $ 42,900 | $ 42,900 | $ 18,000 | $ 11,000 | $ 11,000 | $ 4,800 | $ 49,200 |
| **Project Simple Payback** | **10** | **6.5** | **7.4** | **17** | **6.3** | **6.9** | **7.2** |

## LESSONS LEARNED FROM MONTANA FFS PROGRAM

The Montana FFS program has been installing wood heating systems since 2003. Four schools are currently using wood heating systems, with five institutions to have wood systems operating within the coming year and three schools funded for installation within the next two years. Many lessons may be learned from their practical experiences and are summarized below. Appendix E contains the full comments from each institution, a summary of Montana FFS projects, and an example of a wood fuel contract outlining fuel quality details.

Similarities in experiences from the institutions using wood heating systems under the Montana FFS program include system manufactures, fuel source and quality, operational training, buildings, and backup systems. Every new installation requires a "shakedown" period for adjustments, such as smoke. Chiptec and Messersmith systems have primarily been installed thus far. Maintenance personnel are trained at start-up, and both Messersmith and Chiptec monitor the systems through electronic links. Operational labor duties, estimated at about 10 hours per week, include loading of the wood chip storage bin and weekly cleanup such as scraping the ash grates and occasionally breaking bridges in the storage bin. The institutions currently use wood chips as a fuel source and have stated fuel quality as the one item of utmost concern. Either diesel fuel or natural gas was used prior to the installation of a wood heating system and currently operates as a backup system. Most of the schools have required a separate building, designed by an architect, for the wood heating system.

Some unique experiences have occurred as well. Smaller systems are cheaper, but more problems have been observed. For example, a rock found its way into one of the Chiptec systems; it became lodged and bent the auger, breaking a shaft. Additional difficulties have been observed with compacting from wet material. Contract details are also essential as one school initially had a 3-day wood chip storage bin designed and the contract simply stated "day-bin." This created confusion during construction, and a 1-day storage bin was built. Different issues occur with different manufacturers as well. Messersmith has a fuse which shuts down the system before damage occurs. Chiptec has auto ash removal which requires emptying once a week, whereas Messersmith requires manual ash removal.

## CONCLUSIONS

Wood heating systems are an economically viable option for institutions in the Bismarck–Mandan area. The Bismarck Landfill produces sufficient quantities of acceptable-quality wood chips on an annual basis to supply heating fuel to all three institutions in the NDFS FFS demonstration feasibility study. The institutions studied were DAA, UTTC, and MMS.

A wood heating system can greatly benefit DAA depending on projected use of the system. Motivation for the study included an economic comparison of secondary system options for ease of heating during season changes, estimated downtime of the existing coal system, and/or supplying heat for a potential greenhouse. Secondary wood, propane, and coal systems as well as a wood system for primary use were considered. A wood heating system with coal-fired backup is more economically attractive than propane backup system if used for more than 18% of the annual energy consumed. Wood chips can be delivered to DAA for $25.08–$31.69 per ton ($1.96–$2.48/MMBtu) using a purchased truck and supplied labor or a belly-dump truck by R&F Dirt & Gravel Hauling if less than 520 tons wood chips are delivered annually. An estimated capital cost of $352,000 includes a 6.68-MMBtu/hr Messersmith Manufacturing, Inc., wood heating system. Estimated annual heating costs range from $42,300–$45,300.

Wood heating systems are an attractive option for the United Tribes Technical College and the new public Mandan Middle School. Installation of four small, automated, outdoor (or optional indoor) wood heating systems are recommended for the four buildings studied on the UTTC campus. The $278,000 capital investment for four 1.5-MMBtu output Pro-Fab Industries, Inc., wood heating systems to be placed in parallel for distributing heat connected to the UTTC buildings, could generate $42,900 in annual savings compared to the existing natural gas system. Wood chips would be delivered by Bismarck Landfill personnel at $20.27 per ton ($1.58/MMBtu). The simple payback period for the project is an estimated 6.5 years. MMS may also benefit from a wood heating system in place of a ground source heat pump–natural gas hybrid heating system, saving about $49,200 annually in comparative heating expenses. A purchased truck and supplied labor could deliver wood chips for an observed price of $27.48 per ton ($2.15/MMBtu). A capital investment of $352,000 for a 5-MMBtu/hr Messersmith Manufacturing, Inc., wood heating system generates a payback period of 7.2 years for the project. In addition, the NDFS may access financial assistance for capital expenses through the FFS program; paybacks for UTTC and MMS cost share would range from 1–3 years.

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# APPENDIX A

# BISMARCK LANDFILL WOOD CHIPS


DURATECH

# APPENDIX B

# MANUFACTURER CONTACT INFORMATION

**Appendix B. Manufacturer Contact Information**

| Company | Range, MMBtu/hr | Range, hp | Materials | Website | Contact | Phone | Toll-free | Fax | E-mail | Location | Mailing Address (if different) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Messersmith Manufacturing, Inc. | 1-20 | 30-600 | Wood | www.burnchips.com | Gerry Guard | (906) 466-9010 | | (906) 466-2843 | sales@burnchips.com | 2612 F Road Bark River, MI 49807 | |
| King Coal Furnace Corporation | 3.4-34 | 100-1000 | Coal, wood, both | www.kingcoal.com | Mike (owner) | (701) 255-6406 | | (701) 255-6916 | kingcoal@btinet.net | 1270 Beech Street Igoe Industrial Park #5 Bismarck, ND 58504 | P.O. Box 2161 Bismarck ND 58502 |
| Hurst Boiler & Welding Co., Inc. | 2-60 | 60-1800 | Coal, wood, both; gas (natural & propane), oil, heavy oil, and combination gas/oil | www.hurstboiler.com | Gene (sales) | (229) 346-3545 | (877) 944-8778 | (229) 346-3874 | solid-fuel-sales@hurstboiler.com | Highway 319 N. Coolidge, GA 31739 | P.O. Box Drawer 350 Coolidge, GA 31738 |
| Chiptec Wood Energy Systems | 0.4-50 | 12-1500 | Wood, both | www.chiptec.com | Bob Bender (President) | (802) 658-0956 | (800) 244-4146 | (802) 660-8904 | BobBender@Chiptec.com | 48 Helen Avenue South Burlington, VT 05403 | |
| Parker Boiler Company | 0.3-6.8 | 9-203 | Propane, natural gas, diesel, combination gas/diesel | www.parkerboiler.com | Mike Leeming | (323) 727-9800 | | (323) 722-2848 | sales@parkerboiler.com | 5930 Bandini Blvd. Los Angeles, CA 90040 | |
| Local Representative: Northwest Iron Fireman, Inc. | | | | www.northwestironfireman.com | Gregg | (701) 237-4096 | | (701) 237-4097 | Ironman1@aol.com | 1508 5th Ave. N. Fargo, ND 58102 | |
| Pro-Fab Industries, Inc. | 0.75-2.5 | 22-75 | Wood | www.profab.org | Lorne Beaucha | (204) 364-2211 | (888) 933-4440 | | info@profab.org | | PO Box 112 Arborg, MB Canada R0C 0A0 |
| The Wood Doctor | 0.1-1.3 | 3-39 | Wood | www.wooddoctorfurnace.com | Dave McCaula | (239) 247-2079 | | (902) 639-1232 | info@wooddoctorfurnace.com | | |

# APPENDIX C

# QUOTE FOR MESSERSMITH MANUFACTURING, INC.

May 22, 2006

VIA FACSIMILE AND U.S. MAIL

Ms. Kerryanne Leroux
Research Engineer
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202-9018

Dear Ms. Leroux:

We are pleased to quote a biomass boiler system for Bismark, North Dakota. Wood from a tub grinder will work as a fuel if it is sized small enough. As we previously discussed, it is important to keep the fuel free of dirt, stones, snow and rain. The boiler will be a new Hurst boiler Model FB-1000 rated for 30 psi hot water and have an output of 5,000,000 BTU per hour. It will be equipped with an automatic tube cleaner and dedicated 5 HP air compressor with 120 gal. receiver. The combustor base will be refractory lined, contain cast iron grates and stand 5 feet tall.

The system will include one steel wall for the chip storage bin that is 50' long and 10' high. The bin is 16' wide. Note that the floor of the chip bin should be 3' higher than the floor of the boiler room. The fuel handling system will automatically deliver the proper amount of fuel to the combustor.

A 10 HP induced draft fan is also included. As the heat load changes, the Messersmith Control Panel will control the amount of fuel used and the combustion air to efficiently provide the correct amount of heat. A cyclone, Model HE - 1, will help to remove particulates (and meet your goal of 0.6 lbs./MMBTU) from the flue gases before they exit the pre-fabricated, un-guyed stack.

The system cost, including installation, start-up and operator training, is $314,227 F.O.B. Bismark, ND. Terms are: 35% down, 55% at delivery, and 10% 30 days after start-up.

The customer shall provide: applicable permits, taxes, and engineering fees; a building to house the system; power to the control panel; and piping and waterside appliances.

**MESSERSMITH MANUFACTURING, INC.**
2612 F Road • Bark River, MI 49807 • (906) 466-9010 • FAX (906) 466-2843
www.burnchips.com • email: sales@burnchips.com

If you have any questions, please do not hesitate to contact us.

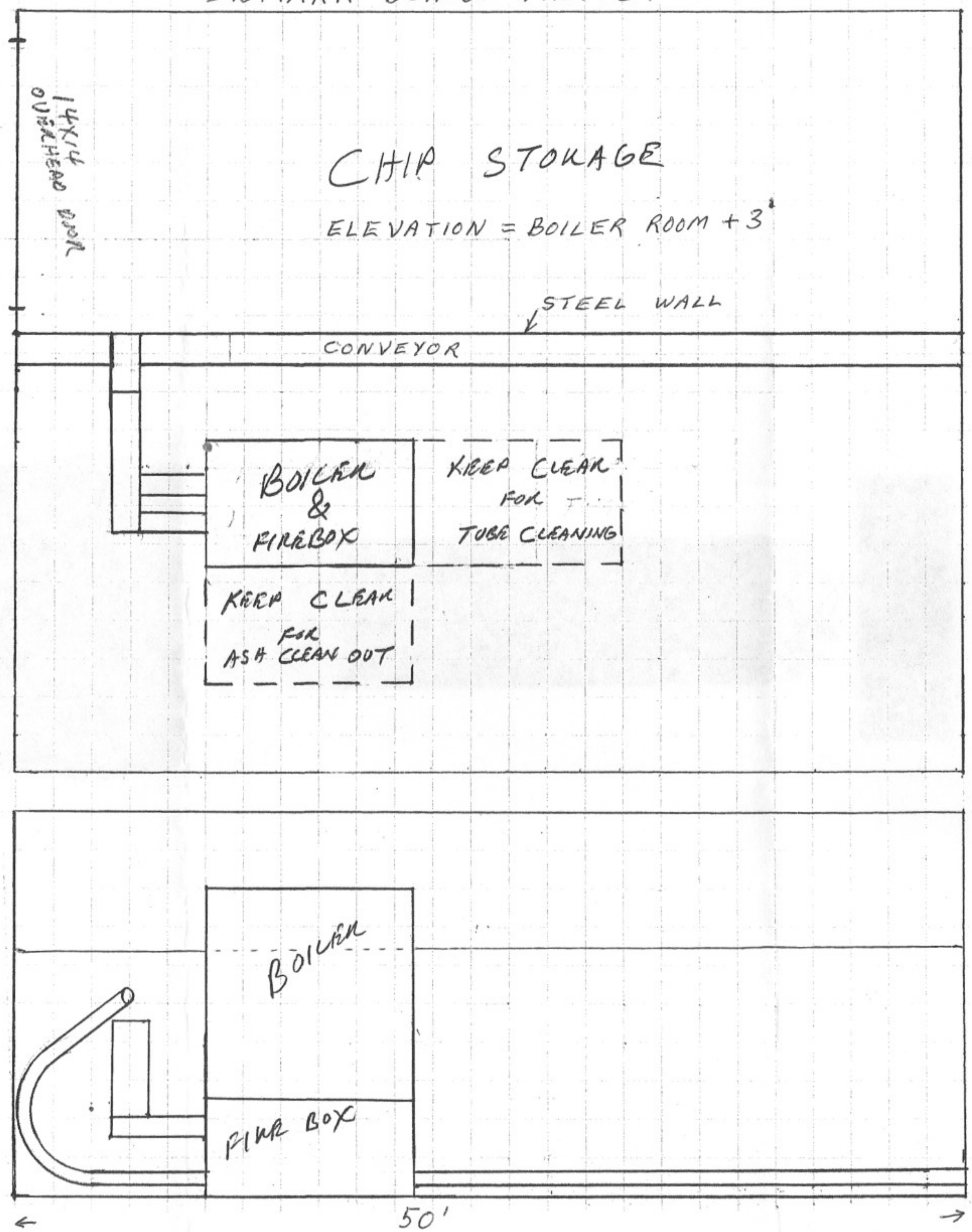
Sincerely,

Gerry Guard

Gerry Guard

GG/tv

BISMARK SCHOOL PROJECT




5-6 MMBTU INSTALLATION
MESSERSMITH MFG.

SCALE
1/8" = 1'

W 40' X L 50' X H 20

20' CEILING

# APPENDIX D

# ECONOMIC ANALYSES SPREADSHEETS

# APPENDIX D1

# DAKOTA ADVENTIST ACADEMY ECONOMIC ANALYSIS FOR VARIOUS HEATING SYSTEMS

## Appendix D1. Dakota Adventist Academy Economic Analysis for Various Heating Systems

| Capital Costs[a] | System | Contingencies (10%) | Total |
|---|---|---|---|
| Hurst Coal System[b] | $ 374,000 | $ 37,400 | $ 411,400 |
| Parker Propane System[c] | $ 47,000 | $ 4,700 | $ 51,700 |
| Messersmith Wood Burning System[d] | $ 320,000 | $ 32,000 | $ 352,000 |

| Escalation Rates | |
|---|---|
| Coal | 4% |
| Propane | 4% |
| Woodchips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | **Year** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **Coal-Coal System Energy Costs** | | | | | | | | | | | | |
| Coal Consumption | 12,070 | MMBtu/yr | | | | | | | | | | |
| Coal Price | $ 2.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | $ 25,534 | $ 26,555 | $ 27,617 | $ 28,722 | $ 29,871 | $ 31,065 | $ 32,308 | $ 33,600 | $ 34,944 | $ 36,342 |
| **Annual Cost Equivalent** | **$ 46,104** | | | | | | | | | | | |
| **Coal-Propane System Energy Costs (Low[f])** | | | | | | | | | | | | |
| Propane Consumption | 14432 | gal/yr | | | | | | | | | | |
| Propane Price | $ 0.87 | per gal | $ 12,546 | $ 13,048 | $ 13,570 | $ 14,113 | $ 14,677 | $ 15,264 | $ 15,875 | $ 16,510 | $ 17,170 | $ 17,857 |
| Labor Saved | -39.6 | hrs/yr | | | | | | | | | | |
| Labor Rate | $ 27.00 | per hour | $ (1,069) | $ (1,112) | $ (1,156) | $ (1,203) | $ (1,251) | $ (1,301) | $ (1,353) | $ (1,407) | $ (1,463) | $ (1,522) |
| Coal Consumption | 10,743 | MMBtu/yr | | | | | | | | | | |
| Coal Price | $ 2.12 | per MMBtu | $ 22,725 | $ 23,634 | $ 24,579 | $ 25,562 | $ 26,585 | $ 27,648 | $ 28,754 | $ 29,904 | $ 31,101 | $ 32,345 |
| Subtotal B | | | $ 34,202 | $ 35,570 | $ 36,993 | $ 38,472 | $ 40,011 | $ 41,612 | $ 43,276 | $ 45,007 | $ 46,808 | $ 48,680 |
| **Annual Cost Equivalent** | **$ 36,787** | | | | | | | | | | | |
| **Coal-Propane System Energy Costs (High[g])** | | | | | | | | | | | | |
| Propane Consumption | 23616 | gal/yr | | | | | | | | | | |
| Propane Price | $ 0.87 | per gal | $ 20,530 | $ 21,351 | $ 22,205 | $ 23,094 | $ 24,017 | $ 24,978 | $ 25,977 | $ 27,016 | $ 28,097 | $ 29,221 |
| Labor Saved | -65 | hrs/yr | | | | | | | | | | |
| Labor Rate | $ 27.00 | per hour | $ (1,750) | $ (1,820) | $ (1,892) | $ (1,968) | $ (2,047) | $ (2,129) | $ (2,214) | $ (2,302) | $ (2,394) | $ (2,490) |
| Coal Consumption | 9,898 | MMBtu/yr | | | | | | | | | | |
| Coal Price | $ 2.12 | per MMBtu | $ 20,938 | $ 21,775 | $ 22,646 | $ 23,552 | $ 24,494 | $ 25,474 | $ 26,493 | $ 27,552 | $ 28,654 | $ 29,801 |
| Subtotal C | | | $ 39,718 | $ 41,307 | $ 42,959 | $ 44,677 | $ 46,465 | $ 48,323 | $ 50,256 | $ 52,266 | $ 54,357 | $ 56,531 |
| **Annual Cost Equivalent** | **$ 42,303** | | | | | | | | | | | |
| **Wood-Coal System Energy Costs (Low[h])** | | | | | | | | | | | | |
| Woodchip Consumption | 773 | tons/yr | | | | | | | | | | |
| Woodchip Price, including transporation[i] | $ 26.04 | per ton | $ 20,132 | $ 20,938 | $ 21,775 | $ 22,646 | $ 23,552 | $ 24,494 | $ 25,474 | $ 26,493 | $ 27,552 | $ 28,655 |
| Coal Consumption | 2,173 | MMBtu/yr | | | | | | | | | | |
| Coal Price | $ 2.12 | per MMBtu | $ 4,596 | $ 4,780 | $ 4,971 | $ 5,170 | $ 5,377 | $ 5,592 | $ 5,815 | $ 6,048 | $ 6,290 | $ 6,542 |
| Subtotal D | | | $ 24,728 | $ 25,717 | $ 26,746 | $ 27,816 | $ 28,929 | $ 30,086 | $ 31,289 | $ 32,541 | $ 33,842 | $ 35,196 |
| **Annual Cost Equivalent** | **$ 42,328** | | | | | | | | | | | |
| **Wood-Coal System Energy Costs (High[j])** | | | | | | | | | | | | |
| Woodchip Consumption | 472 | tons/yr | | | | | | | | | | |
| Woodchip Price, including transporation[i] | $ 31.69 | per ton | $ 14,941 | $ 15,538 | $ 16,160 | $ 16,806 | $ 17,478 | $ 18,177 | $ 18,905 | $ 19,661 | $ 20,447 | $ 21,265 |
| Coal Consumption | 6,035 | MMBtu/yr | | | | | | | | | | |
| Coal Price | $ 2.12 | per MMBtu | $ 12,767 | $ 13,277 | $ 13,809 | $ 14,361 | $ 14,935 | $ 15,533 | $ 16,154 | $ 16,800 | $ 17,472 | $ 18,171 |
| Subtotal E | | | $ 27,707 | $ 28,816 | $ 29,968 | $ 31,167 | $ 32,414 | $ 33,710 | $ 35,059 | $ 36,461 | $ 37,919 | $ 39,436 |
| **Annual Cost Equivalent** | **$ 45,307** | | | | | | | | | | | |

[a]Assuming no additional building costs due to existing structure, labor and ash are not compared for wood systems due to similarity to coal system operations; [b]Delivered, installed on existing concrete slab (Hurst provides design), $100,000 addition for wood storage and conveyor system, $80,000 addition for coal auto ash removal; [c]6.8 MMBtu, boiler only, need contractor for installation, assuming $15,000 but can be up to $30,000; [d]5 MMBtu output system including combuster, boiler, storage bin, chip handling systems (conveying), cyclone (for particulates), training & start-up, one-piece stack for exhaust, control panel, draft fan; [e]Amortized capital costs over assumed 20-year service life; [f]Assumes propane use as secondary system with 11% annual energy consumption; [g]Assumes propane use as secondary system with18% annual energy consumption; [h]Assumes a primary wood system and coal use as secondary system with 18% annual energy consumption; [i]R&F Dirt & Gravel Hauling (belly-dump truck); [j]Assumes 50% annual energy consumption by each system.

# APPENDIX D2a

# UNITED TRIBES TECHNICAL COLLEGE
# ECONOMIC ANALYSIS FOR LARGE INDOOR
# AUTOMATED WOOD HEATING SYSTEM

## Appendix D2a. United Tribes Technical College Economic Analysis for Large Indoor Automated Wood Heating System

| Capital Costs | | |
|---|---|---|
| Messersmith Wood-Burning System[a] | $ | 320,000 |
| System Building[b] | $ | 80,000 |
| Contingencies (10%) | $ | 32,000 |
| **Total** | **$** | **432,000** |
| NDFS FFS @ 80% | $ | 345,600 |
| UTTC Responsibility | $ | 86,400 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 6,176 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 62,500 | $ 65,000 | $ 67,600 | $ 70,304 | $ 73,116 | $ 76,041 | $ 79,082 | $ 82,246 | $ 85,536 | $ 88,957 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 482 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation | $ | 20.27 | per ton | $ 9,779 | $ 10,171 | $ 10,577 | $ 11,000 | $ 11,440 | $ 11,898 | $ 12,374 | $ 12,869 | $ 13,384 | $ 13,919 |
| Additional Labor | | 360 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 9,720 | $ 9,982 | $ 10,252 | $ 10,529 | $ 10,813 | $ 11,105 | $ 11,405 | $ 11,713 | $ 12,029 | $ 12,354 |
| Ash Production | | 14 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 126 | $ 129 | $ 133 | $ 136 | $ 140 | $ 144 | $ 148 | $ 152 | $ 156 | $ 160 |
| Subtotal B | | | | $ 19,625 | $ 20,282 | $ 20,962 | $ 21,666 | $ 22,394 | $ 23,147 | $ 23,927 | $ 24,733 | $ 25,569 | $ 26,433 |
| **Savings (A-B)** | | | | **$ 42,875** | **$ 44,718** | **$ 46,638** | **$ 48,638** | **$ 50,723** | **$ 52,894** | **$ 55,156** | **$ 57,512** | **$ 59,967** | **$ 62,524** |
| Project Simple Payback | | 10 | | | | | | | | | | | |
| Payback for UTTC | | 2.0 | | | | | | | | | | | |

a5-MMBtu output system including combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, one-piece stack for exhaust, control panel, draft fan; assuming 40'W x 50'L x 20'H at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); cBismarck Landfill transportation services; transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose in Bismarck Landfill).

# APPENDIX D2b

# UNITED TRIBES TECHNICAL COLLEGE ECONOMIC ANALYSIS FOR SMALL INDOOR AUTOMATED WOOD HEATING SYSTEM

## Appendix D2b. United Tribes Technical College Economic Analysis for Small Indoor Automated Wood Heating System

| Capital Costs | | |
|---|---|---|
| Chiptech Wood-Burning System[a] | $ | 150,000 |
| System Building[b] | $ | 20,000 |
| Contingencies (10%) | $ | 15,000 |
| **Total** | **$** | **185,000** |
| NDFS FFS @ 80% | $ | 148,000 |
| UTTC Responsibility | $ | 37,000 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006**<br>**1** | **2007**<br>**2** | **2008**<br>**3** | **2009**<br>**4** | **2010**<br>**5** | **2011**<br>**6** | **2012**<br>**7** | **2013**<br>**8** | **2014**<br>**9** | **2015**<br>**10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 1,581 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 16,000 | $ 16,640 | $ 17,306 | $ 17,998 | $ 18,718 | $ 19,466 | $ 20,245 | $ 21,055 | $ 21,897 | $ 22,773 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 124 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation | $ | 20.27 | per ton | $ 2,504 | $ 2,604 | $ 2,708 | $ 2,816 | $ 2,929 | $ 3,046 | $ 3,168 | $ 3,294 | $ 3,426 | $ 3,563 |
| Additional Labor | | 90 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 2,430 | $ 2,496 | $ 2,563 | $ 2,632 | $ 2,703 | $ 2,776 | $ 2,851 | $ 2,928 | $ 3,007 | $ 3,088 |
| Ash Production | | 4 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 32 | $ 33 | $ 34 | $ 35 | $ 36 | $ 37 | $ 38 | $ 39 | $ 40 | $ 41 |
| Subtotal B | | | | $ 4,966 | $ 5,132 | $ 5,305 | $ 5,483 | $ 5,668 | $ 5,859 | $ 6,057 | $ 6,261 | $ 6,473 | $ 6,693 |
| **Savings (A-B)** | | | | **$ 11,034** | **$ 11,508** | **$ 12,001** | **$ 12,515** | **$ 13,050** | **$ 13,607** | **$ 14,188** | **$ 14,793** | **$ 15,424** | **$ 16,080** |
| Project Simple Payback | | 17 | | | | | | | | | | | |
| Payback for UTTC | | 3.4 | | | | | | | | | | | |

[a]5-MMBtu output system including combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, one-piece stack for exhaust, control panel, draft fan; [b]assuming 500 sq ft at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services; [d]transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX D2c

# UNITED TRIBES TECHNICAL COLLEGE ECONOMIC ANALYSIS FOR SMALL OUTDOOR MANUAL WOOD HEATING SYSTEM

## Appendix D2c. United Tribes Technical College Economic Analysis for Small Outdoor Manual Wood Heating System

| Capital Costs | | |
|---|---|---|
| Wood Doctor Outdoor Wood-Burning System[a] | $ | 12,000 |
| System Building[b] | $ | 20,000 |
| Contingencies (10%) | $ | 1,200 |
| **Total** | **$** | **33,200** |
| NDFS FFS @ 80% | $ | 26,560 |
| UTTC Responsibility | $ | 6,640 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006<br>1** | **2007<br>2** | **2008<br>3** | **2009<br>4** | **2010<br>5** | **2011<br>6** | **2012<br>7** | **2013<br>8** | **2014<br>9** | **2015<br>10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 1,581 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 16,000 | $ 16,640 | $ 17,306 | $ 17,998 | $ 18,718 | $ 19,466 | $ 20,245 | $ 21,055 | $ 21,897 | $ 22,773 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 124 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation[c] | $ | 20.27 | per ton | $ 2,504 | $ 2,604 | $ 2,708 | $ 2,816 | $ 2,929 | $ 3,046 | $ 3,168 | $ 3,294 | $ 3,426 | $ 3,563 |
| Additional Labor | | 320 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 8,640 | $ 8,873 | $ 9,113 | $ 9,359 | $ 9,612 | $ 9,871 | $ 10,138 | $ 10,411 | $ 10,692 | $ 10,981 |
| Ash Production | | 4 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 32 | $ 33 | $ 34 | $ 35 | $ 36 | $ 37 | $ 38 | $ 39 | $ 40 | $ 41 |
| Subtotal B | | | | $ 11,176 | $ 11,510 | $ 11,855 | $ 12,210 | $ 12,576 | $ 12,954 | $ 13,343 | $ 13,745 | $ 14,159 | $ 14,585 |
| **Savings (A-B)** | | | | **$ 4,824** | **$ 5,130** | **$ 5,451** | **$ 5,788** | **$ 6,142** | **$ 6,513** | **$ 6,902** | **$ 7,310** | **$ 7,739** | **$ 8,188** |
| Project Simple Payback | | 6.9 | | | | | | | | | | | |
| Payback for UTTC | | 1.4 | | | | | | | | | | | |

[a]1.3-MMBtu industrial outdoor furnace, wholesale price (i.e., no dealers in area), includes furnace only; [b]assuming 500 sq ft at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services; [d]Transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX D2d

# UNITED TRIBES TECHNICAL COLLEGE ECONOMIC ANALYSIS FOR LARGE OUTDOOR MANUAL WOOD HEATING SYSTEM APPLICATION

## Appendix D2d. United Tribes Technical College Economic Analysis for Large Outdoor Manual Wood Heating System Application

| Capital Costs | | |
|---|---|---|
| Wood Doctor Outdoor Wood-Burning Systems[a] | $ | 48,000 |
| System Building[b] | $ | 80,000 |
| Contingencies (10%) | $ | 4,800 |
| **Total** | **$** | **132,800** |
| NDFS FFS @ 80% | $ | 106,240 |
| UTTC Responsibility | $ | 26,560 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 6,176 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 62,500 | $ 65,000 | $ 67,600 | $ 70,304 | $ 73,116 | $ 76,041 | $ 79,082 | $ 82,246 | $ 85,536 | $ 88,957 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 482 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation[c] | $ | 20.27 | per ton | $ 9,779 | $ 10,171 | $ 10,577 | $ 11,000 | $ 11,440 | $ 11,898 | $ 12,374 | $ 12,869 | $ 13,384 | $ 13,919 |
| Additional Labor | | 1280 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 34,560 | $ 35,493 | $ 36,451 | $ 37,436 | $ 38,446 | $ 39,484 | $ 40,551 | $ 41,645 | $ 42,770 | $ 43,925 |
| Ash Production | | 14 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 126 | $ 129 | $ 133 | $ 136 | $ 140 | $ 144 | $ 148 | $ 152 | $ 156 | $ 160 |
| Subtotal B | | | | $ 44,465 | $ 45,793 | $ 47,162 | $ 48,572 | $ 50,027 | $ 51,526 | $ 53,072 | $ 54,666 | $ 56,309 | $ 58,004 |
| **Savings (A-B)** | | | | **$ 18,035** | **$ 19,207** | **$ 20,438** | **$ 21,732** | **$ 23,089** | **$ 24,514** | **$ 26,010** | **$ 27,580** | **$ 29,226** | **$ 30,953** |
| Project Simple Payback | | 7.4 | | | | | | | | | | | |
| Payback for UTTC | | 1.5 | | | | | | | | | | | |

[a]Four 1.3-MMBtu Industrial outdoor furnaces in parallel, wholesale price (i.e., no dealers in area), includes furnace only; [b]assuming 2000 sq ft at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services; [d]transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX D2e

# UNITED TRIBES TECHNICAL COLLEGE ECONOMIC ANALYSIS FOR SMALL OUTDOOR (OR OPTIONAL INDOOR) AUTOMATED WOOD HEATING SYSTEM

## Appendix D2e. United Tribes Technical College Economic Analysis for Small Outdoor (or optional indoor) Automated Wood Heating System

| **Capital Costs** | | | Escalation Rates | |
|---|---|---|---|---|
| Pro-Fab Outdoor Wood-Burning System[a] | $ | 45,000 | Natural Gas | 4% |
| System Building[b] | $ | 20,000 | Wood Chips | 4% |
| Contingencies (10%) | $ | 4,500 | Labor | 2.7% |
| **Total** | **$** | **69,500** | Ash | 2.7% |
| NDFS FFS @ 80% | $ | 55,600 | | |
| UTTC Responsibility | $ | 13,900 | | |

| **Cash Flow Analysis** | | | **Year** | **2006**<br>**1** | **2007**<br>**2** | **2008**<br>**3** | **2009**<br>**4** | **2010**<br>**5** | **2011**<br>**6** | **2012**<br>**7** | **2013**<br>**8** | **2014**<br>**9** | **2015**<br>**10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 1,581 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 16,000 | $ 16,640 | $ 17,306 | $ 17,998 | $ 18,718 | $ 19,466 | $ 20,245 | $ 21,055 | $ 21,897 | $ 22,773 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 124 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation[c] | $ | 20.27 | per ton | $ 2,504 | $ 2,604 | $ 2,708 | $ 2,816 | $ 2,929 | $ 3,046 | $ 3,168 | $ 3,294 | $ 3,426 | $ 3,563 |
| Additional Labor | | 90 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 2,430 | $ 2,496 | $ 2,563 | $ 2,632 | $ 2,703 | $ 2,776 | $ 2,851 | $ 2,928 | $ 3,007 | $ 3,088 |
| Ash Production | | 4 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 32 | $ 33 | $ 34 | $ 35 | $ 36 | $ 37 | $ 38 | $ 39 | $ 40 | $ 41 |
| Subtotal B | | | | $ 4,966 | $ 5,132 | $ 5,305 | $ 5,483 | $ 5,668 | $ 5,859 | $ 6,057 | $ 6,261 | $ 6,473 | $ 6,693 |
| **Savings (A-B)** | | | | **$ 11,034** | **$ 11,508** | **$ 12,001** | **$ 12,515** | **$ 13,050** | **$ 13,607** | **$ 14,188** | **$ 14,793** | **$ 15,424** | **$ 16,080** |
| Project Simple Payback | | 6.3 | | | | | | | | | | | |
| Payback for UTTC | | 1.3 | | | | | | | | | | | |

[a]1.5-MMBtu output (PC 2520), includes feed auger, ash auger, cyclone (would need concrete slab, fuel bin), can be indoor or outdoor w/ or w/o metal shed; [b]assuming 500 sq ft at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services; [d]transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX D2f

# UNITED TRIBES TECHNICAL COLLEGE ECONOMIC ANALYSIS FOR LARGE OUTDOOR (OR OPTIONAL INDOOR) AUTOMATED WOOD HEATING SYSTEM APPLICATION

## Appendix D2f. United Tribes Technical College Economic Analysis for Large Outdoor (or optional indoor) Automated Wood Heating System Application

| **Capital Costs** | | |
|---|---|---|
| Pro-Fab Outdoor Wood-Burning Systems[a] | $ | 180,000 |
| System Building[b] | $ | 80,000 |
| Contingencies (10%) | $ | 18,000 |
| **Total** | **$** | **278,000** |
| NDFS FFS @ 80% | $ | 222,400 |
| UTTC Responsibility | $ | 55,600 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 6,176 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 10.12 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 62,500 | $ 65,000 | $ 67,600 | $ 70,304 | $ 73,116 | $ 76,041 | $ 79,082 | $ 82,246 | $ 85,536 | $ 88,957 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 482 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportation[c] | $ | 20.27 | per ton | $ 9,779 | $ 10,171 | $ 10,577 | $ 11,000 | $ 11,440 | $ 11,898 | $ 12,374 | $ 12,869 | $ 13,384 | $ 13,919 |
| Additional Labor | | 360 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 9,720 | $ 9,982 | $ 10,252 | $ 10,529 | $ 10,813 | $ 11,105 | $ 11,405 | $ 11,713 | $ 12,029 | $ 12,354 |
| Ash Production | | 14 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 8.70 | per ton | $ 126 | $ 129 | $ 133 | $ 136 | $ 140 | $ 144 | $ 148 | $ 152 | $ 156 | $ 160 |
| Subtotal B | | | | $ 19,625 | $ 20,282 | $ 20,962 | $ 21,666 | $ 22,394 | $ 23,147 | $ 23,927 | $ 24,733 | $ 25,569 | $ 26,433 |
| **Savings (A-B)** | | | | **$ 42,875** | **$ 44,718** | **$ 46,638** | **$ 48,638** | **$ 50,723** | **$ 52,894** | **$ 55,156** | **$ 57,512** | **$ 59,967** | **$ 62,524** |
| Project Simple Payback | | 6.5 | | | | | | | | | | | |
| Payback for UTTC | | 1.3 | | | | | | | | | | | |

[a]1.5-MMBtu output (PC 2520), includes feed auger, ash auger, cyclone (would need concrete slab, fuel bin), can be indoor or outdoor w/ or w/o metal shed; [b]assuming 2000 sq ft at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services; [d]transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX D3

# MANDAN MIDDLE SCHOOL ECONOMIC ANALYSIS FOR A WOOD HEATING SYSTEM

## Appendix D3. Mandan Middle School Economic Analysis for a Wood Heating System

**Capital Costs[a]**

| | | |
|---|---|---|
| Messersmith Wood Burning System[b] | $ | 320,000 |
| Contingencies (10%) | $ | 32,000 |
| **Total** | **$** | **352,000** |
| NDFS FFS @ 80% | $ | 281,600 |
| MMS Responsibility | $ | 70,400 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006**<br>**1** | **2007**<br>**2** | **2008**<br>**3** | **2009**<br>**4** | **2010**<br>**5** | **2011**<br>**6** | **2012**<br>**7** | **2013**<br>**8** | **2014**<br>**9** | **2015**<br>**10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption | | 7,791 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price | $ | 9.89 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 77,086 | $ 80,169 | $ 83,376 | $ 86,711 | $ 90,180 | $ 93,787 | $ 97,538 | $ 101,440 | $ 105,498 | $ 109,717 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption | | 609 | tons/yr | | | | | | | | | | |
| Wood Chip Price, including transportatio[n] | $ | 29.50 | per ton | $ 17,958 | $ 18,676 | $ 19,423 | $ 20,200 | $ 21,008 | $ 21,849 | $ 22,723 | $ 23,631 | $ 24,577 | $ 25,560 |
| Additional Labor | | 360 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 9,720 | $ 9,982 | $ 10,252 | $ 10,529 | $ 10,813 | $ 11,105 | $ 11,405 | $ 11,713 | $ 12,029 | $ 12,354 |
| Ash Production | | 18 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate[d] | $ | 10.34 | per ton | $ 189 | $ 194 | $ 199 | $ 204 | $ 210 | $ 216 | $ 221 | $ 227 | $ 234 | $ 240 |
| Subtotal B | | | | $ 27,867 | $ 28,853 | $ 29,874 | $ 30,934 | $ 32,031 | $ 33,169 | $ 34,349 | $ 35,572 | $ 36,839 | $ 38,154 |
| **Savings (A-B)** | | | | **$ 49,219** | **$ 51,317** | **$ 53,502** | **$ 55,778** | **$ 58,148** | **$ 60,618** | **$ 63,189** | **$ 65,868** | **$ 68,658** | **$ 71,564** |
| Project Simple Payback | | 7.2 | | | | | | | | | | | |
| Payback for UTTC | | 1.4 | | | | | | | | | | | |

[a]Assuming no additional building costs due to new construction; [b]5-MMBtu output system including combustor, boiler, storage bin, chip-handling systems (conveying), cyclone (for particulates), training and start-up, one-piece stack for exhaust, control panel, draft fan; [c]Pioneer Construction, Inc. (tractor-trailer); [d]transportation rate for applying ash to fields for use as fertilizer.

# APPENDIX D4

# EXAMPLE OF UTTC AND MMS COMBINED ECONOMIC ANALYSES FOR WOOD HEATING SYSTEMS

## Appendix D4. Example of UTTC & MMS Combined Economic Analyses for Wood Heating Systems

**Capital Costs**

| | | |
|---|---|---|
| Wood-Burning Systems[a] | $ | 500,000 |
| System Building[b] | $ | 80,000 |
| Contingencies (10%) | $ | 50,000 |
| **Total** | **$** | **630,000** |
| NDFS FFS @ 63% | $ | 417,000 |
| UTTC Responsibility | $ | 93,990 |
| MMS Responsibility | $ | 119,010 |

| Escalation Rates | |
|---|---|
| Natural Gas | 4% |
| Wood Chips | 4% |
| Labor | 2.7% |
| Ash | 2.7% |

| **Cash Flow Analysis** | | | **Year** | **2006**<br>**1** | **2007**<br>**2** | **2008**<br>**3** | **2009**<br>**4** | **2010**<br>**5** | **2011**<br>**6** | **2012**<br>**7** | **2013**<br>**8** | **2014**<br>**9** | **2015**<br>**10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Energy Source | | | | | | | | | | | | | |
| Natural Gas Consumption, total | | 13,967 | MMBtu/yr | | | | | | | | | | |
| Natural Gas Price, average | $ | 9.99 | per MMBtu | | | | | | | | | | |
| Subtotal A | | | | $ 139,586 | $ 145,169 | $ 150,976 | $ 157,015 | $ 163,296 | $ 169,828 | $ 176,621 | $ 183,686 | $ 191,033 | $ 198,674 |
| Wood System Energy Costs | | | | | | | | | | | | | |
| Wood Chip Consumption, total | | 1091 | tons/yr | | | | | | | | | | |
| Wood Chip Price, average, including transpor | $ | 25.42 | per ton | $ 27,737 | $ 28,847 | $ 30,001 | $ 31,201 | $ 32,449 | $ 33,747 | $ 35,097 | $ 36,500 | $ 37,961 | $ 39,479 |
| Additional Labor, total | | 720 | hr/yr | | | | | | | | | | |
| Labor Rate | $ | 27.00 | per hour | $ 19,440 | $ 19,965 | $ 20,504 | $ 21,058 | $ 21,626 | $ 22,210 | $ 22,810 | $ 23,426 | $ 24,058 | $ 24,708 |
| Ash Production, total | | 33 | tons/yr | | | | | | | | | | |
| Ash Disposal Rate, average[d] | $ | 9.61 | per ton | $ 315 | $ 323 | $ 332 | $ 341 | $ 350 | $ 360 | $ 369 | $ 379 | $ 389 | $ 400 |
| Subtotal B | | | | $ 47,492 | $ 49,135 | $ 50,837 | $ 52,599 | $ 54,425 | $ 56,316 | $ 58,276 | $ 60,305 | $ 62,408 | $ 64,586 |
| **Savings (A-B)** | | | | **$ 92,094** | **$ 96,035** | **$ 100,140** | **$ 104,416** | **$ 108,871** | **$ 113,511** | **$ 118,345** | **$ 123,380** | **$ 128,625** | **$ 134,088** |
| Project Simple Payback | | 6.8 | | | | | | | | | | | |
| Payback for UTTC | | 2.2 | | | | | | | | | | | |
| Payback for MMS | | 2.4 | | | | | | | | | | | |

[a]Messersmith unit for MMS and Pro-Fab outdoor unit for UTTC; [b]UTTC only, assuming 40'W x 50'L x 20'H at $30–$50/sq ft for steel building (brick is $100–$125/sq ft); [c]Bismarck Landfill transportation services for UTTC, Pioneer Construction, Inc. (tractor-trailer) for MMS; [d]transportation rate for applying ash to fields for use as fertilizer ($10.00/ton to dispose of in Bismarck Landfill).

# APPENDIX E

# MONTANA FFS PROGRAM EXPERIENCE

# APPENDIX E1

# MONTANA FFS PROGRAM COMMENTS

## Appendix E1. Montana FFS Program Comments

Phillipsburg Public Schools:
- Messersmith boiler using wood chips for 2 years
- Very good experience with few complaints
- Formerly used natural gas which is currently used as a backup
- "No problems, just bugs to work, fine tuning integration"
- Estimated 10 hr/wk additional labor for wood system over gas system

Thompson Falls Public Schools:
- Chiptec system using woodchips since October 2005
- Used No. 2 Diesel, now a backup
- Initially planned on using wood system 85% but had problems with frequent (i.e., daily) start-up and shutdown, "going really good" since
- Few problems:
  - Rock in system from truck which had hauled gravel before chips and bent auger
  - Compacting from wet material
- Estimate 45 min per day to load bin, ½ hr to 1 hr for weekly cleanup and 1 hr to scrap grates (ash), occasionally have to break bridges
- Still working on unloading
  - Currently using dump truck and a bobcat for ½ day per week to unload
  - Looking at truck with walking floor which would reduce loading to ½ hr per week
- Store wood chips indoors
- No smoke noticeable

Darby Public Schools:
- "The better the fuel, the less problems you have"
- Have used hog fuel but wouldn't go it again, too many minerals and labor intensive
- Messersmith unit using wood chips since October 2003
- Ran diesel fuel prior, now used as backup
- Rake it down every other day, pull ash out once a week; about 15 min per day compared to 10 min per day on diesel system
- Infrastructure fees paid by the school were treated as part of the in-kind contribution to the project
- Saving $100,000 in heating expenses this year

Fuels for Schools Program Manager:
- Every system requires a "shake-down" period for adjustments such as smoke, etc.
- Material is very important
  - Moisture, dirt, variety of sources
  - More needles and bark mean more O&M, as experienced with Messersmith systems
  - Rocks lodged in auger, breaking shaft in Chiptec system
- Messersmith has a fuse which shuts down the system before damage occurs
- Different issues occur with different manufacturers

- Maintenance personnel are trained at start-up, both companies monitor the systems through electronic links
- Estimate a couple hours per week for maintenance
  - Chiptec has auto ash removal which requires emptying once a week
  - Messersmith requires manual ash removal, about 15 min/day
- Contract details essential: Thompson Falls initially had a 3-day bin designed, but the contract said “day-bin” so it was built smaller
- Wood chips generally stored in separate buildings with sprinkler systems
- Price of steel can be a factor in construction, especially for piping

Biomass Utilization Coordinator:

- Have had issues with smaller-system bids being higher than projected
- Larger systems are virtually automatic (walking-floor truck to bin w/auger)
- Smaller systems are cheaper but more problems have been experienced
- Newest constructions in Montana will be using pellets
  - Capital costs were higher than anticipated which may have to do with area construction climate
  - Several pellet mills in Montana.
- Phone survey for feed material
  - Can have up to 5% of “pencil-sized” pieces that will break (otherwise globs can form)
  - Up to 30% sized 3” x 3” x ½”, most should be small ~2”–3” or less
  - No wood flour (fine and greasy to touch, highly explosive)
  - Specifications require no dirt or rock but it does occur regardless which can cause problems with the conveyor system
  - Wet fines will put the fire out and create lots of smoke
  - Needles, bark, or dirt can form a silica product that sticks to the grate which is difficult to remove (Chiptec system touts better applicability for handling such problems)

Montana Forester:

- Major problems have been with wood chip quality
  - Currently trying to qualify economic benefits of paying premium for higher quality fuel
  - Dirt, large pieces, or lower quality generates more ash
- “Operation almost without care with quality fuel”
- Installation problems have been with capital costs
  - 10-year payback focus
  - Supplying 50% cost share
- Most schools have required a separate building designed by an architect

# APPENDIX E2

# MONTANA FFS PROJECTS

## Appendix E2. Montana FFS Projects

| | Facility | Location | Square Footage | Project Cost[1] | Peak Output | Annual Wood Fuel Use[1] | Fuel Replaced | Estimated Annual Fuel/ops Savings[1] (price offset) | Date Optn'l[1] |
|---|---|---|---|---|---|---|---|---|---|
| **INSTALLE** | **Darby Public Schools** | Darby, MT | 82,000 | $650,000[1] | 3 million Btu/hr | 750 tons | Fuel oil | $100,000 ($2.50 gal) | 11/03 |
| | **Victor Public Schools** | Victor, MT | 47,000[2] | $628,991 | 4.9 million Btu/hr | 500 tons | Natural gas | $31,898 ($13.82 dkt) | 9/04 |
| | **Philipsburg Public Schools** | Phillipsburg, MT | 99,000 | $650,000 | 3.87 million Btu/hr | 400 tons | Natural gas | $67,558[5] ($11 dkt) | 1/05 |
| | **Thompson Falls Public Schools** | Thompson Falls, MT | 60,474 | $455,000 | 1.6 million Btu/hr | 400 tons | Fuel oil | $60,000 ($2.50 gal) | 10/05 |
| **UNDERWA** | **Troy Public Schools** | Troy, MT | 33,235 | $299,000 | 850,000 Btu/hr | 60 tons of pellets | Fuel oil | $12,500 ($1.92) | 9/06 |
| | **Glacier High School** | Kalispell, MT | 220,000 | $480,000 | 6 million Btu/hr | 1900 tons | New construction | $65,000 ($8 dkt) | 4/07[3] |
| | **University of Montana-Western Campus** | Dillon, MT | 471,370 | $1,422,746 | 13 million Btu/hr | 3600 tons | Natural gas | $118,000 ($8.68 dkt) | 10/06 |
| | **Townsend Elementary & High Schools** | Townsend, MT | 120,000 | $425,000 | Total of 680,000 Btu/hr[4] | 250 tons of pellets | Fuel oil and propane | $19,500 ($8.74/dkt prop $2.41/gal oil) | 10/06 |
| | **Central Montana Medical Center** | Lewistown, MT | 130,000 | $956,000 | 2.5 million Btu/hr | 2000 tons | Natural gas | $100,670 ($10 dkt) | 9/07 |
| **FUNDED** | **Eureka Public Schools** | Eureka, MT | 177,679 | $1,320,000 | 4–5 million Btu/hr | 960 tons | Fuel oil and propane | $103,610 ($2.27/gal oil $1.31/gal prop) | 12/07 |
| | **New Browning HS** | Browning, MT | 130,000 | $475,000 | 3–4 million Btu/hr | 1,250 tons | New construction | $48,600 ($9 dkt) | 3/09 |
| | **Deer Lodge Elementary** | Deer Lodge, MT | 38,000 | $500,000 | 1.5 million Btu/hr | 730 tons | Natural gas | $39,980 ($11 dkt) | 3/07 |
| **MT TOTAl** | | **12 projects** | **1,608,758** | **$8,261,737** | | **12,800 tons** | | **$767,316** | |

[1] Projected numbers are provided for projects not yet completed. Darby costs exclude $268,000 for repairs to the existing heat distribution system. Revised 4-19-06
[2] Victor's boiler is sized to heat an additional 16.000 sq. ft. that will be built in the future – the tons consumed are projected for full heat load.
[3] Glacier High School's first operation date will be during construction with full operation in the fall of 2007.
[4] Two separate pellet plants were originally planned for Townsend. This project is evolving over time and will likely include just one boiler.
[5] This savings figure may be high. Energy efficiency projects at the school have reduced fuel consumption, so we would need to re-calculate the projected fossil fuel consumption to get an accurate picture.

# APPENDIX E3

# WOOD FUEL CONTRACT EXAMPLE

## Appendix E3. Wood Fuel Contract Example

The Department of Administration on behalf of the University of Montana – Western (UMW) is seeking written bids for the supply of woody biomass fuel to use in the planned wood-fired boiler located at the physical plant at the campus located in Dillon, Montana. The boiler will be operational in the fall of 2006, upon which deliveries to the school fuel storage facility will commence. This contract will begin in June of 2006, so that chipping and establishment of a secured stockpile of fuel for UMW will occur prior to the boiler's operation. The facility's approximate usage will be 3600 tons per year, but will vary depending on the heating degree days in the particular year. The rate of consumption will vary throughout the year with greater consumption during the heating months and greatly reduced consumption in the summer and shoulder seasons. Bidders who respond to this solicitation must comply with the instructions and procedures contained herein. A sample contract is attached.

**Contract Term**

This contract will take effect June 1, 2006, and run for 3 years, unless terminated earlier in accordance with the terms of this contract (Mont. Code Ann. § 18-4-313.). During the 3-year term, the parties to the contract will conduct an annual review to determine if significant changes to the operating environment warrant any change in price.

**Contract Renewal**

This contract may, upon mutual agreement between the parties and according to the terms of the existing contract, be renewed in 1-year intervals or any interval that is advantageous to the state for a period not to exceed a total of 7 years. Renewal is dependent upon legislative appropriations.

**Fuel Type**

The following specifications for fuel type are intended to clearly describe the anticipated tolerances of the biomass boiler equipment. In practical terms, compliance with size and material specifications will only occur if and when problems are encountered with fuel feeding through the system or with ash production or other significant maintenance problems associated with fuel composition. If needed, compliance with size specifications will be measured by determining that 90% by weight of a representative sample of fuel delivered passes through an inclined vibratory screen with 3-in.-round holes and not more than 10% passes through a screen with 1/16-in. holes.

1. Fuel shall be biomass comprising wood wastes of conifer or deciduous trees processed as described below.

2. Fuel shall be reduced to a size range that can be efficiently fired in the UMW boiler installation. The desired size range is from 1/16 in. in each dimension up to 2½ in. × 2½ in. × ½ in. Up to 50% of the fuel by volume can be up to 3 in. × 3 in. × ½ in. Up to 10% of the material by weight can be sawdust, smaller than 1/16 in. cubed, except that **no wood flour** (see No. 4 below) is permitted. A total of 95%

of the fuel by volume must be within this size range, including the 3-in. and under 1/16-in. material. Percentages are on a per delivery basis.

3. Up to 5% of the fuel by volume could be 3–6-in.-long sticks or peelings, as long as they are not larger than pencil size in combined width/depth, so they are able to break as necessary to continue feeding through the system without causing shutdowns or other system problems. Percentage is on a per delivery basis.

4. Sander dust or wood flour, which is biomass comprising very fine wood powder that feels greasy to the touch and becomes easily airborne, will not be permitted. Typically wood flour is defined as 60–80 mesh.

5. The moisture content of the fuel shall generally not exceed 45% wet weight basis per delivery. Wet basis is calculated by (dry weight ÷ wet weight)100. Desired range of moisture content is between 25% and 35%. Fuels below 10% average moisture content per delivery will generally not be permitted unless prior arrangements have been made (e.g., commercial pellets of 5% or less moisture may occasionally be used).

6. Fuel shall be free from noncombustible and nonbiomass material, such as paint, nails, glues, rocks, and dirt.

7. Fuel supply in the storage bin must be kept at not less than ⅓ capacity, or 25 tons. The bin shall be filled to capacity each Friday.

8. **The contractor shall make every reasonable effort to obtain at least 50% of the fuel from logging slash or other unmerchantable logging residues and/or brush, trees, limbs, and tops removed to reduce wildfire risk or to improve forest health. This requirement is for 50% of the total material delivered to the UMW storage bin during the first two full years of the boiler's operation.** The remainder can be obtained from wood-processing facilities, landfills, or other appropriate sources. The contractor must maintain records of fuel sources and provide them upon request. All wood fuel is to be obtained in a safe and legal manner.

**Moisture Content Surcharges and Penalties**
Monthly payments shall be adjusted as follows for moisture content:

For each delivery between 36% and 40% moisture, a 10% of the price per ton delivered shall be deducted from the next monthly payment.

For each delivery between 41% and 45% moisture, 20% of the price per ton delivered shall be deducted from the next monthly payment.
For each delivery over 45% moisture, 40% of the price per ton delivered shall be deducted from the next monthly payment.

For each delivery between 20% and 24% moisture, 10% of the price per ton shall be added to the next monthly payment.

For each delivery between 15% and 19% moisture, 20% per ton shall be added to the next monthly payment.

For each delivery between 10% and 14% moisture, 28% per ton shall be added to the next monthly payment.

**Storage**

It is the contractor's responsibility to store and protect the fuel in such a manner as to be usable when delivered to UMW. A reserve supply of at least 750 tons of fuel must be established by no later than December 1 of each year of the contract, so that the reserve is available to draw from during inclement weather or hazardous transportation conditions. The reserve supply can be a secured off-site stockpile, an identified and contracted local quantity available from local subsuppliers such as post and pole plants, or a combination of a stockpile and a contracted local quantity. The storage bin will hold approximately 8000 cubic feet of fuel, which equates to roughly three vanloads, or 75 tons.

**Delivery**

The campus will have adequate room to allow a tractor and 52-ft trailer to T-turn into and back up to the below-grade bins. Storage bin door height will be 16 ft. The dimensions of the storage bin door are 12 ft wide × 15 ft high, set 1 ft off the ground. Delivery trucks must therefore have over 1 ft of clearance. It is recommended that delivery trucks have the rear wheel carriage set back 4 ft from the back of the truck to allow trucks to back into the storage bin far enough to avoid spills. The contractor will be responsible for efficiently making deliveries and cleaning up any spills of wood fuel on campus property.

The expected maximum fuel demand will be 24 tons per day. Contractor shall be in contact with the facilities representative or shall visit the site at least twice a week to determine quantities needed and delivery dates and times. All deliveries must be coordinated with facilities personnel and food service deliveries. It is imperative that these parties work together to avoid problems with storage, wait time of the delivery drivers, overloading of the system, and to allow time for maintenance of the system and equipment.

Contractor must be aware of pedestrian and vehicular traffic at all times and take care to prevent personal injury.

Unless otherwise agreed, all wood fuel delivered and accepted under this Contract shall be weighed on a scale agreed upon by UMW and certified by the state of Montana Department of Weights and Measures. The weight thereby determined, in conjunction with moisture content measurements specified below shall be the basis of payment to the contractor.

**Quality Control**
Facility personnel will periodically inspect delivered wood fuel for compliance on size requirements and noncombustible or nonbiomass material. If problems related to the size specifications arise, a representative sample of fuel will be screened by UMW, as described in bold under "Fuel Type" above, to determine compliance. Average moisture content shall be determined by UMW for each delivery using the following methods:

1. Collect a sample from a load of fuel wood as delivered at the University's tipper sites.
2. Weigh the sample and record as wet weight.
3. Dry sample in microwave at 50% range for 5 minutes; note the weight.
4. Dry sample in microwave at 50% range for 1 minute periods until no weight drops are noted; record the weight as dry weight.
5. Subtract dry weight from weight from wet weight to determine moisture content weight.
6. Divide wet weight into moisture content weight and multiply by 100 to determine % moisture content as delivered.
7. Repeat this process for at least 2 samples from different parts of the load, and average the results.
8. SPECIAL NOTE: Accuracy must be ensured when collecting samples. Samples must be representative of the whole load. Samples that the driver provides are not acceptable. Make sure all information necessary is written on the bag and that there is enough sample to get a processing sample from.

Noncombustible content shall be determined on an as-needed basis as follows**:**

1. Collect a sample from a load of Fuel wood as delivered at the University's tipper sites.
2. Weigh the sample and record as wet weight.
3. Burn sample in muffle furnace at 1200°F for 3 hours.
4. Weigh the material remaining and record as noncombustible weight.
5. Divide the wet weight into the noncombustible weight and multiply by 100 to determine the % noncombustible content as delivered.

**Payment**
Payments shall be made on a 12-month even payment schedule on the 30th of each month, beginning June 30, 2006. Using the bid price for material within the desired moisture content range of 25% to 35%, the total annual requirement of 3600 tons shall be divided by 12 months to determine the even monthly payment amount. June 1 of each subsequent year of the contract, the payment amount shall be adjusted based on actual consumption over the previous year, so the June 30 payment each year will vary based on actual consumption, and the monthly payments in each year of the contract may vary. In addition, the moisture content penalties and bonuses shall be calculated based on tons delivered in each month, and the next monthly payment shall be adjusted accordingly.

**Example of 12-month Payment Calculations**
Bid price is $24 per ton × 3600 tons = $86,400 ÷ 12 = $7200 each month.
Actual first year consumption = 3400 tons × $24 = $81,600. Subsequent monthly payments shall be $81,600 ÷ 12 = $6800, and the June 30, 2007, payment will be further reduced by $4800 ($86,400 estimated annual payment minus $81,600 actual cost).

| | | |
|---|---|---|
| | $2.00 | 0.00% |
| $2.00 | $2.11 | 0.50% |
| $2.11 | $2.22 | 0.75% |
| $2.22 | $2.33 | 1.00% |
| $2.33 | $2.44 | 1.25% |
| $2.44 | $2.55 | 1.50% |
| $2.55 | $2.66 | 1.75% |
| $2.66 | $2.77 | 2.00% |
| $2.77 | $2.88 | 2.25% |
| $2.88 | $2.99 | 2.50% |
| $2.99 | $3.10 | 2.75% |
| $3.10 | $3.21 | 3.00% |
| $3.21 | $3.32 | 3.25% |
| $3.32 | $3.43 | 3.50% |
| $3.43 | $3.54 | 3.75% |
| $3.54 | $3.65 | 4.00% |
| $3.65 | $3.76 | 4.25% |
| $3.76 | $3.87 | 4.50% |
| $3.87 | $3.98 | 4.75% |
| $3.98 | $4.09 | 5.00% |
| $4.09 | $4.20 | 5.25% |
| $4.20 | $4.31 | 5.50% |

**Default in Delivery**
The purpose of this contract is to utilize wood biomass instead of natural gas. On any day in which the fuel storage bin becomes or remains empty for any length of time, there will be assessed a presumed monetary penalty to the contractor of $500 per day, which UMW may use to either purchase natural gas or seek an alternate wood fuel supplier.

**Fuel Escalation**
The state will allow the below table to be utilized for a fuel surcharge. National U.S. Average On-Highway Diesel Fuel Price ($/gallon).

| **At Least** | **But Less Than** | **Surcharge** |
|---|---|---|

If the fuel surcharge rises above 5.5%, the table will be updated. The price of diesel will be the most recent month posted on the U.S. Department of Energy's National U.S. Average On Highway Diesel Fuel Prices. Below is the Web address where the prices can be found.

> **http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/current/pdf/table17.pdf**