

BIOMASS FEASIBILITY STUDY

Black Hills Region, South Dakota

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For:

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OVERVIEW

Commercially available biomass heating systems use low-grade biomass fuel to provide clean and efficient heat. There are many advantages to using a locally available, renewable heating fuel, such as supporting local industry and keeping money in the local economy. Also, biomass fuels are typically one-half to one-third the cost of fossil fuels, like oil or propane, on a Btu basis. This technology is being used quite successfully in several areas of the United States and Canada to reduce heating costs for schools, facilities and small businesses.

The Biomass Energy Resource Center (BERC) was hired by South Dakota Resource Conservation and Forestry (SD RC&F) to study the viability of using wood as an energy source to heat public buildings in the Black Hills region of South Dakota. Ten reports were written to summarize the preliminary assessments completed for installing biomass heating systems at each of the six schools and four facilities being studied; an engineering feasibility study was written to summarize the more detailed assessment of a conversion to biomass heating at Belle Fourche High School. The purpose of the feasibility reports was to provide the necessary information to determine whether biomass heating should be pursued at each of the seven schools and four larger facilities.

This final report is supplementary to the individual summary reports. It includes a brief summary of project activities, findings and recommendations for each facility. The schools ranged in size from 77,000 square feet (SF) to 312,000 SF and the larger facilities ranged in size from 130,000 SF to 900,000 SF. All of the schools and facilities studied had the potential to save 40% or more on their annual heating bills.

There are several questions which typically come up around the idea of converting to biomass heating. The effect of burning wood on air quality is typically one of these questions. While all forms of combustion produce emissions, the emissions from wood-fired boilers are different than emissions from natural gas, propane or oil. A number of emissions components from wood combustion are air pollutants and are discussed here. The SD Department of Environment and Natural Resources (DENR) Air Quality Program requires an operating permit for any project with



the potential to emit 25 tons of any criteria pollutant per year, and there is a calculated PM_{10} emissions limit based on system size. In addition the Rapid City area has an off-setting program for particulates, which will be a consideration for Stevens High School, St. Elizabeth Seton and St. Thomas More Schools and the Central High School and Rushmore Plaza Civic Center complex.

Fuel supply is typically another concern in the discussion of biomass heating. Very important questions to ask are “What does the fuel supply look like for the Black Hills? How many facilities can this supply sustain?” If all eleven schools and facilities studied here were to come on-line next year with biomass heating systems, they would require a total of 11,983 tons of green wood chips and 102 tons of wood pellets per year. Assuming that a wood-chip system can replace 85% of the annual heating load and a pellet system can replace 95% of the annual heating load, biomass fuels would replace 76,315 decatherms (DK) of natural gas, 109,540 gallons of propane and 138,208 gallons of oil.

Using the assumption that 50% of the area’s sawmill residues were available and that 30% of the slash from on-going harvesting could be recovered and chipped, the region would have 155,000 green tons of chips for use as a fuel to heat facilities throughout the region. All ten wood-chip systems combined would use up only 8% of this material. Hot Springs K-12 Schools was the only facility for which a pellet heating system was recommended. While the installation of a pellet system appears economically and logistically feasible at this facility, securing a reliable and affordable fuel supply may be a problem at this time. However, Pope and Talbot sawmill currently has plans to add bulk pellet delivery capabilities and several new distributors of bulk pellets may come on line in the near future.



This report also focuses more programmatically on how biomass heating could be implemented in the Black Hills region. From a programmatic perspective, there are numerous opportunities to make a state-wide effort to convert schools, municipal buildings and other facilities to biomass, well within the amount of biomass available for use. Among the schools, those using oil, propane, or more than 6,000 DK of natural gas per year for space heating were found to have the highest potential for savings with a biomass heating system. Schools using less than 6,000 DK natural gas per year may be good candidates for semi-automated wood-chip systems. Among the facilities studied, those using oil or propane for space heating were found to have the highest potential for savings; facilities using natural gas for space heating had a better potential for savings when natural gas consumption was more than 25,000 DK per year. BERC intends to work with SD RC&F to distribute this report widely and to present the findings from the project to national audiences so that this report may be a model for other states and regions.

In all cases except for the Belle Fourche High School, a more detailed engineering study, including preliminary design and budget-ready cost estimation, will have to be undertaken by each school or facility before a final decision to construct is made.



INTRODUCTION

Eleven reports were written to summarize the findings of the feasibility of installing a biomass heating system at each of the schools and facilities being studied. These reports are titled *Biomass Heating Feasibility Report* and are available for Belle Fourche Middle School, East Elementary School (Spearfish), Hot Springs K-12 Schools, Lead-Deadwood High School, St. Elizabeth Seton / St. Thomas More Schools (Rapid City), Stevens High School (Rapid City), Black Hills State University (Spearfish), Central High School and Rushmore Plaza Civic Center (Rapid City), South Dakota State Veterans Home (Hot Springs) and Star Academy (Custer). An *Engineering Feasibility Report* was completed for Belle Fourche High School. Copies of these reports may be obtained by contacting SD Resource Conservation & Forestry Division.

South Dakota Department of Agriculture, Resource Conservation & Forestry

The South Dakota Department of Agriculture is committed to promoting forest health treatments designed to restore and maintain the health of fire-prone ecosystems by increasing the use of woody biomass as an energy source. The South Dakota Department of Agriculture, Resource Conservation & Forestry Division (SD RC&F), serves to conserve, protect, improve and develop the natural resources for the citizens of South Dakota. As a state government office, SD RC&F provides private land owners with the technical assistance to conserve and manage their forests.

Biomass Energy Resource Center

The Biomass Energy Resource Center (BERC) is a national not-for-profit organization based in Montpelier, Vermont. BERC's mission is to develop energy projects using sustainable biomass resources for environmental benefit and local economic development. BERC uses staff expertise in community-scale wood energy systems to help institutions and communities get biomass projects initiated and built for their heating and power needs. Since its inception in 2001, BERC has established itself as a national leader in biomass heating and power generation from forest and agricultural sources.

Project Background

BERC was hired by SD RC&F to determine the viability of using wood as an energy source to heat buildings in the Black Hills area of South Dakota.



SCOPE OF WORK

BERC undertook feasibility assessments for seven schools and four campus facilities to determine the viability of using wood as the primary energy source for heating. BERC prepared the feasibility reports which described project activities, findings and recommendations for each facility. This report is a more detailed and comprehensive report addressing all seven schools and four facilities studied. It includes an overview of the information given in the feasibility reports, but expands on the issues of air quality, permitting and fuel supply. This report also focuses more programmatically on how wood heating could be implemented in the Black Hills region and what the advantages of this program and its policies would be.



METHODOLOGY

This study was carried out by the following BERC staff:

1. Timothy Maker, Executive Director
2. Kamalesh Doshi, Program Director
3. Adam Sherman, Business Development/Project Manager
4. Sarah Galbraith, Program Assistant
5. Jeff Forward, Contractor
6. John Hey, PE, Contractor
7. John McCollough, AIA, Contractor

In the fall of 2005, SD RC&F and BERC issued a letter to school districts and public facilities in the Black Hills region as an invitation to participate in an assessment of the feasibility of using biomass to heat their buildings. As a part of this project, SD RC&F and BERC sponsored a forum in Rapid City, South Dakota, on November 1, 2005, to discuss the potential of biomass heating in schools and public buildings.

BERC conducted preliminary research to identify the total universe of potential candidates and potential biomass suppliers, facilitated several meetings with stakeholders and visited potential candidates to get a sense of feasibility and generate interest. BERC staff worked with SD RC&F to design a process for soliciting applications, including a request for information needed to facilitate the identification of suitable candidates for biomass heating conversions. SD RC&F and BERC conducted site visits to facilities in November, 2005, and April, 2006.

BERC evaluated the sites and collected the data necessary to conduct these studies. In order to assess biomass fuel availability and pricing for the Black Hills region, SD RC&F created a list of primary forest producers. BERC field staff spoke with many of these suppliers and visited the Pope and Talbot saw mill, the largest wood supplier in the region.



BERC collected the following information for each of the facilities being studied:

- Master site plan
- Listing and identification of all existing buildings by function and square footage
- Heating requirements on hourly, weekly, monthly and yearly basis, as available, with fuel consumption of each of the heating fuels used by each of the buildings
- Present heating system details (heating media, pressure and temperature ratings, installed capacities)
- Present heating fuel used with average current fuel price and on-site fuel storage capabilities
- Layout details of present heat distribution system
- Expansion plans
- Existing air emissions permit details
- Restrictions (height of stack, permitting) which are likely to have bearing on the installation of a biomass heating system

The studies completed for each facility provided estimates, based on figures from vendors, of costs and an overall assessment of the feasibility of converting to biomass heating at each site. System capacities were based on current fuel consumption rates. Based on the preliminary feasibility assessment, the facilities are now in the position to decide whether to explore biomass heating further or not. In all cases except for the Belle Fourche High School, a more detailed engineering study, including preliminary design and budget-ready cost estimation, will have to be undertaken by each facility before a final decision to construct is made. Belle Fourche High School has done this.

Boiler sizes were calculated based on the data given during the application process; where peak Btu/month or Btu/day data was available, this was used. Alternatively, total average annual fuel consumption was entered into a boiler size calculator, which assumes that peak month fuel consumption is 20% of the annual consumption, peak per day fuel consumption is 5% of the total peak month consumption and peak per hour is 6% of the total peak day consumption.

The capital cost was based on estimates obtained from vendors and engineers, and this was entered into a Life Cycle Cost (LCC) analysis tool. The LCC tool is used to analyze the cost-effectiveness of purchasing, operating and maintaining a biomass heating system over its 30 year life. Several inputs, including wood chip price, fossil fuel price, system cost and operation and



maintenance costs, are weighed against the savings in fuel costs generated each year. The following assumptions were made in the analysis:

- Peak heating season is four months out of the year and 3 months out of the year are fringe months where some heating is still required, though not all the time or to a lesser degree, termed the “off-season;”
- Western woody biomass fuels average 18 million British thermal units (MMBtus) per ton delivered dry;
- The moisture content of wood chips is 40% meaning 10.8 million Btus per ton wet and the moisture content of wood pellets is 6% meaning 16.6 million Btus per ton wet;
- The average seasonal efficiency is 65% for wood-chip combustion equipment, 80% for pellet combustion equipment, 85% for natural gas systems, 65% for oil systems and 75% for propane systems;
- Wood chips cost \$35/ton;
- The wood-chip heating system will offset 85% of the school or facility’s total heating load and the pellet system will off-set 95% of the school or facility’s total heating load;
- Total incremental operation and maintenance (O&M) expense was based on the following assumptions:
 - Estimated staff time was 1 hour per day in peak heating season and 0.5 hours per day in the off-season, totaling 167 hours per year for fully automated wood-chip, pellet and corn systems;
 - Estimated staff time was 1.5 hours per day during peak season and 1.0 hours per day during the off-season for semi-automated systems, totaling 273 hours per year;
 - The current pay rate for maintenance staff is \$20 per hour including benefits;
 - The current electric rate is \$0.06 per kilowatt hour (kWh);
 - Estimated electric usage for the fully automated wood-chip system was 1,033 kWh per million Btus per hour (MMBH) per month in peak heating season and 667 kWh/MMBH per month in the off-season;
 - Estimated electric usage for the semi-automated wood-chip system was 362 kWh/MMBH per peak heating month and 233 kWh/MMBH per off-season heating month;
 - Estimated electric usage for the pellet and corn systems was 500 kWh/MMBH per peak heating month and 250 kWh/MMBH per off-season heating month;
 - Annualized routine parts, repairs and services are estimated to be 0.43% of the total project cost;
- The most recent charge (including taxes and delivery) for the current fuel was used as the base rate;
- The estimated salvage value of the biomass system after 30 years is calculated as 30% of the capital cost before mark-up after 30 years, without inflation;
- The analysis did not include the cost of any changes to the heating distribution system within the school or facility, nor did it include any other work that might need to be completed before the installation of a biomass heating system.



Two calculations are of particular interest when assessing the outcome of the LCC analysis: first year fuel cost savings, and the 30 year net present value (NPV) of savings. First year fuel cost savings can be shown as a percentage or dollar amount: facilities with a fuel cost savings of 40% or more are good candidates for biomass heating. Thirty year NPV of savings is the difference, in current year dollars, between the value of the cash inflows and the value of the cash outflows associated with an investment. A positive 30 year NPC indicates that, from society's economic perspective, the project is worth doing. A negative 30 year NPV of savings indicates a project that is not worth doing. The dollar amount of the NPV of savings is the difference between continuing to operate the existing system and installing a new biomass heating system.

BERC staff returned to South Dakota for follow-up meetings to present findings and recommendations from the project to each of the facilities. BERC worked with RC&F to identify the best audiences and venues for these follow-up meetings.



BIOMASS HEATING OVERVIEW

Commercially available biomass heating systems use low grade biomass fuel to provide clean and efficient heat. School wood energy projects are attractive from a public policy perspective for a number of reasons:

- The money spent on biomass keeps energy dollars in the local economy and supports jobs in the forest products industry.
- Burning wood for energy has a positive impact in moderating global climate change. (See *Preliminary Assessment of Emissions from Biomass* section.)
- Biomass typically comes from either sawmill residues or timber harvesting residues. These residues can be viewed either as wastes or byproducts of the forest industry. Where biomass fuels come from sawmills, they are a waste that must be disposed of or sold. Where biomass fuels come from harvesting operations in the woods, the purpose is to remove tops and limb residues from sawlogs and small diameter trees from the forest which can improve overall forest health. In both cases, wood that is processed for fuel implies the productive use of a low-grade waste product.
- By establishing a market for low grade wood fuels, biomass energy projects help mitigate costs for hazardous fuel reduction in western forests.

While all of these benefits are important from a public policy perspective, probably the most compelling reason for a school district or facility to decide on biomass heating is that the cost of biomass fuel is generally half to one third the cost of fossil fuels, such as natural gas, on a Btu basis. These hard dollar savings often make the investment in biomass heating technology a win-win for school boards and facility managers looking to reduce annual budgets.



Fuel Characteristics and Cost of Combustion						
Fuel Type	Unit	Cost per Unit	Moisture Content	MMBtu per Unit (wet)	Average Seasonal Efficiency	Cost per MMBtu After Combustion
Natural Gas	Decatherm	\$8.90	0%	1.0	80%	\$11.13
Oil	Gallon	\$2.45	0%	0.138	75%	\$14.01
Propane	Gallon	\$1.30	0%	0.092	80%	\$17.66
Wood Pellets	Ton	\$125 ¹	6%	16.9	80%	\$9.23
Wood Pellets	Ton	\$165 ²	6%	16.9	80%	\$12.19
Corn	Ton	\$125	15.5%	13.9	65%	\$14.46
Wood Chips	Ton	\$35	40%	10.8	65%	\$4.99

When compared to fossil fuels like oil, natural gas and propane, wood is a cost-effective alternative fuel. Wood chips typically offer better savings than wood pellets; both woody biomass fuels typically offer better savings than corn. At the heart of this application of wood energy is the attraction of using a renewable, locally produced energy source that is generally the least expensive fuel available.

Fuel Type	Unit	Cost per Unit	Savings per MMBtu with Wood Pellets (\$125/ton)	Savings per MMBtu with Wood Pellets (\$165/ton)	Savings per MMBtu with Corn	Savings per MMBtu with Wood Chips
Natural Gas	Therm	\$0.89	\$1.90	- \$1.06	- \$3.33	\$6.14
Oil	Gallon	\$2.45	\$4.78	\$1.82	- \$0.45	\$9.02
Propane	Gallon	\$1.30	\$8.43	\$5.47	\$3.20	\$12.68

This technology is being used quite successfully in several areas of the United States and Canada to reduce heating costs for schools and small businesses.

¹ The price per ton for wood pellets used in the Hot Springs K-12 Preliminary Feasibility Assessment was \$125/ton.

² The price per ton for wood pellets used in the Belle Fourche High School Engineering Feasibility Assessment was \$165/ton.



BIOMASS TECHNOLOGY OVERVIEW

FULLY AUTOMATED WOOD-CHIP BOILER SYSTEMS

Fully automated systems employ a chip storage bin, typically below grade, that can hold one and a half to two tractor loads of chips (35-50 tons). The bin is loaded by a self-unloading truck with no need for on-site staff assistance. From the chip storage bunker, the fuel is fed automatically to the boiler. No operator intervention is required for fuel handling. Vendor systems vary in terms of capacity and automation features.

Fully automated systems generally require very little operator attention – typically about one hour daily. They are a good match for buildings where the maintenance staff has a large work load and does not want to spend much time on the heating plant. These systems are best suited to larger schools and other buildings with significant heat loads and high conventional fuel costs since the capital cost of the system is relatively high.

Equipment provided and installed by the vendor includes the automated equipment to unload the bin, the fuel handling equipment that carries wood-chip fuel to the boiler (conveyors and augers), the combustion chamber and boiler, combustion air supply fans, boiler connection to the stack, controls, safety devices and possibly emissions control equipment.

SEMI-AUTOMATED WOOD-CHIP BOILER SYSTEMS

Fully automated wood-chip heating systems, which feed the chips from the storage area automatically to the boiler, can be very expensive. A more cost-effective alternative for smaller facilities with lower heating loads is the “semi-automated” system. The semi-automated system is typically installed in a slab-on-grade building that includes both a boiler room and chip storage (a chip pile



on the slab floor). The system also includes a day-bin fuel hopper of sufficient capacity to supply



the boiler automatically for one to two days without reloading. In the fully automated system, fuel delivery to the boiler is achieved with augers and conveyors. The day-bin of a semi-automated wood-chip system is loaded by an operator using a small tractor with a front end bucket or skid steer. Semi-automated systems have automated controls to manage fuel supply and combustion air, although the controls are simpler than those in a fully-automated system. These systems can range in capacity from 500,000 Btu/hour to 2.0 MMBtu/hour.

The attraction of a semi-automated system is that both the building that houses the system and the vendor equipment are less expensive than a fully-automated system. The system takes the operator an estimated additional 30 minutes per day over the typical operation and maintenance time required for a fully automated system; this additional time is for loading the day bin. The semi-automated wood-chip system is a good match for a smaller rural school or office building where the additional time in fuel handling is not a significant burden to maintenance staff.

Vendor supplied equipment includes the day bin and the automated fuel handling system from the day bin to the boiler, the boiler and combustion chamber with combustion air fans, connection from the boiler to the chimney and controls. No emission controls are anticipated for these small-scale systems.

SLAB-ON-GRADE FULLY AUTOMATED WOOD-CHIP BOILER SYSTEMS

Fully automated, slab-on-grade systems combine the functionality of a fully automated wood-chip system with the lower capital cost of a semi-automated system. While fully automated systems incorporate conveyors and augers for all movement of chips, semi-automated systems reduce capital cost by manually moving the chips to the day bin with a tractor. The fully automated slab-on-grade system utilizes the slab-on-grade chip storage of a semi-automated system, thereby reducing building construction costs, and the full automation of chip movement (although a small tractor or lawnmower equipped with the right front end may be needed to push chips).

Self-unloading trucks deliver chips to the storage area with no need for on-site staff assistance. The chips are stored directly on the floor at a two foot level difference between the chip storage



floor and the boiler room floor, rather than in a below-grade bin. From the chip storage area, the fuel is fed automatically to the boiler. No additional operator intervention is required for fuel handling. Not all vendors offer this version of a wood-chip system. These systems are effective in a size range from 1-3 MMBtu/hr.

These systems, like the conventional fully automated systems described above, generally require very little operator attention – typically about one hour daily. Fully automated slab-on-grade wood-chip systems are a good match for buildings where the maintenance staff has a large work load and does not want to spend much time on the heating plant. These systems are best suited to larger schools and other buildings with significant heat loads and high conventional fuel costs since the capital cost of the system is relatively high.

Equipment provided and installed by the vendor includes the automated equipment to unload the chip storage area, the fuel handling equipment that carries wood-chip fuel to the boiler (conveyors and augers), the combustion chamber and boiler, combustion air supply fans, boiler connection to the chimney, controls, safety devices and possibly emissions control equipment.

PELLET SYSTEMS

Pellet boilers are fully automatic in fuel feed and ash removal. Minimal space is required for them, and they can be installed directly into existing boiler rooms, and there is the potential for direct venting versus having to install a full stack. Typically a silo is installed outdoors to store pellet fuel. The maintenance time for these systems is estimated to



be about one hour per day, but is often less than that. These systems are effective in a size range from 150,000 Btu/hr to 1.5 MMBtu/hr. These systems typically have lower capital costs in comparison to wood chip systems.



CORN SYSTEMS

Corn burning boilers are fairly simple in design and function and are very similar to wood pellet systems. The major difference is that the corn systems are capable of combusting this higher ash content fuel without major issues, whereas the pellet systems are designed to burn low ash wood. If corn were feed into a standard wood pellet boiler it would present problems due to the higher concentration and types of minerals in the corn. The corn boilers provide a high degree of fuel delivery automation from the fuel storage to the boiler. Corn systems require one hour per day of staff time on average during peak heating season, and a half hour per day in the off-season. A majority of this time is spent on ash removal.

Corn systems utilize existing agricultural infrastructure, including silos and auger systems. Standard agricultural feed silos can be used for the storage of bulk corn on the outside of the building and inexpensive flexible augering equipment is used to automatically feed the fuel to the boiler inside the building.



FEASIBILITY STUDIES

Schools

1. BELLE FOURCHE MIDDLE SCHOOL

This school building is approximately 105,000 square feet (SF) and serves about 430 students. The school district averaged 6,225 decatherms (DK) of natural gas per year for space heating between 2001 and 2005 on two metered accounts. At the current natural gas price of \$10.07/DK, the school will be paying over \$65,000 next year for heating fuel.

The Belle Fourche Middle School appears to be a good site for the installation of a centralized fully automated wood-chip heating system only after all four independent heating systems at the school are connected. The district can save around \$34,000 on fuel bills in the first year by adding a wood-chip heating system to their facility; 30 year NPV of savings will be over \$190,000 (2006 dollars).

2. BELLE FOURCHE HIGH SCHOOL

The Belle Fourche High School is a 130,000 SF high school that serves about 425 students. The facility is heated from a central boiler, using 3,950 DK of natural gas per year. The average cost of natural gas over the past year was \$9.60/DK; at this price, the school can expect to pay almost \$40,000 next year for space heating.

Four biomass heating options were considered for the Belle Fourche High School. These were a semi-automated wood-chip system, a slab on-grade fully automated wood-chip system, a corn system and a pellet system. The corn and pellet systems did not yield positive economics because fuel cost savings were minimal; the slab on-grade fully automated system has a very high project cost that outweighs the high fuel cost savings with wood chips.



A semi-automated wood-chip system at the Belle Fourche High School yields the highest fuel cost savings possible for this school with a relatively low project cost. Fuel cost savings in the first year of operation are estimated to be \$20,050, or 50%. At the current natural gas price, the project is positive with a 30 year NPV of savings of \$29,982.

3. EAST ELEMENTARY

The school building is 77,023 SF and serves approximately 447 students in grades K – 6. The school district averaged 4,344 DK of natural gas per year over the last two years to heat the facility and, at the current price of \$8.92/DK, will spend over \$40,000 for space heating next year.

If East Elementary School were to connect the two heating distribution systems today and install a centralized wood-chip heating system, the project would lose money for the school. If the natural gas price became \$9.50/DK and all other assumptions were held the same, the wood-chip system could save the school over \$19,000 per year in annual fuel bills; 30 year NPV of savings would be \$35,724 (2006 dollars).

Price/DK natural gas	\$8.92/DK	\$9.50/DK
Year 1 fuel cost savings (%)	48%	50%
Year 1 fuel cost savings (\$)	\$19,414	\$21,662
30 year net present value of savings	- \$28,523	\$35,724

4. HOT SPRINGS K-12 SCHOOLS

This school consists of six buildings in close proximity. The feasibility analysis for this school considered only the buildings that were compatible with wood-chip heating (totaling 125,000 SF) and connected to the main boiler. These were the High School, Middle School, Activity Center and Shop. These buildings averaged 14,850 gallons of oil for space heating and, at \$1.70/gallon, will spend over \$26,500 on heating next year. The possibility of also adding a 0.3 MMBH pellet system at the Case auditorium and a 0.3 MMBH pellet system at the elementary school was not cost-effective.



A pellet boiler was recommended to heat the shop and adjacent high school, middle school and activity center. With the pellet boiler, the district could save over \$10,600 per year in annual fuel bills, or 40%, translating to a 30 year NPV of savings of over \$164,000 (2006 dollars).

5. LEAD-DEADWOOD HIGH SCHOOL

The school building is about 157,000 SF and serves approximately 325 students. The school district uses 11,680 DK of natural gas per year on average to heat the facility and, at \$11.38/DK, the school will spend well over \$100,000 next year on space heating.

The Lead-Deadwood High School is a very good site for a fully automated wood-chip heating system. The district can save over \$75,000 in the first year on annual fuel bills by adding a wood-chip heating system to their facility; 30 year NPV of savings would be over \$1 million (2006 dollars).

6. ST. ELIZABETH SETON SCHOOL AND ST. THOMAS MORE SCHOOL

This K-12 parochial school consists of two buildings on one site. Together the buildings are 103,000 square feet; however a major capital improvement project is being planned for the near future that will include an additional 80,000 SF of space for a middle school adjacent to the St. Thomas More High School. The combined schools averaged 2,926 decatherms of natural gas per year over the last two years and, at the current price of \$10/DK, will spend over \$25,000 next year on space heating. With an additional 80,000 square feet of space, the school can expect to require about 2,273 more DK per year for space heating, which will put their annual heating bill over \$50,000 next year at current prices.

The St. Elizabeth Seton and St. Thomas More Schools do not appear to be a good site for biomass heating at this time; however, it appears to be an ideal site for a semi-automated wood-chip heating system with the addition of 80,000 SF. The district could save over \$28,000 per year in annual fuel bills; 30 year NPV of savings would be over \$16,000 (2006 dollars).



7. STEVENS HIGH SCHOOL

This school is 312,000 SF in size and serves approximately 1,800 students. The school district averaged 11,135 decatherms of natural gas per year over the last two years to heat the facility and, at the current price of \$8.74/DK, will spend well over \$90,000 next year on space heating.

Stevens High School is a very good site for a fully automated wood-chip heating system. Fuel cost savings would be over \$47,000 in the first year; 30 year NPV of savings would be over \$187,000 (2006 dollars).

SUMMARY

Below is a summary of the findings for each of the seven schools studied:

School	Summary of Findings at Seven Schools		30 Year NPV of Savings
	First Year Fuel Cost Savings (%)	First Year Cost Savings (\$)	
Belle Fourche Middle School	52%	\$34,209	\$192,395
Belle Fourche High School	50%	\$20,050	\$29,982
East Elementary	48%	\$19,414	- \$28,526
Hot Springs K-12	40%	\$10,699	\$164,421
Lead-Deadwood	56%	\$78,143	\$1,062,976
Seton/More	52%	\$28,251	\$16,986
Stevens	47%	\$47,974	\$187,316



District Energy Facilities

1. BLACK HILLS STATE UNIVERSITY

The Black Hills State University is a 902,841 square foot (SF) residential university campus that serves about 3,000 students. A central boiler plant on campus serves fourteen buildings that vary in nature and use. The University uses 25,987 decatherms (DK) of natural gas per year, at an average cost of \$7.40 per DK, to heat the buildings connected to the central plant. At this price, the University can expect to be paying about \$200,000 next year for space heating.

A fully automated wood-chip boiler is recommended for the Black Hills State University. Estimated savings in heating costs would be 40%, or over \$80,000 per year: 30 year NPV of savings would be \$612,624 (2006 dollars).

2. CENTRAL HIGH SCHOOL AND RUSHMORE PLAZA CIVIC CENTER

The Central High School in Rapid City, South Dakota, shares a common energy plant with the city's Rushmore Plaza Civic Center. The high school is approximately 284,000 SF and serves about 2,300 students. The civic center is approximately 392,120 SF. Total average natural gas consumption is 21,262 decatherms (DK) per year and the current natural gas price is \$7.50/DK, translating to a heating bill of about \$167,438 next year.

A fully automated wood-chip boiler would be a good fit for the High School and Civic Center. The infrastructure for a shared utility already exists, and both facilities would decrease their annual operating budgets by 41% or a total of \$68,075 in year 1 of operation. Thirty year NPV of savings would be \$273,216 (2006 dollars).



3. STAR ACADEMY

Star Academy is a 130,000 SF residential youth correctional facility with a population of around 175 residents. The average fuel consumption for this facility is 75,500 gallons of oil, at \$2.47/gal, plus about 84,450 gallons of propane, at \$1.31/gal, per year for space heating.

A centralized fully automated wood-chip boiler would save Star Academy over \$200,000 in the first year of operation, or 67%. Thirty year NPV of savings would be \$4.7 million (2006 dollars).

4. SOUTH DAKOTA STATE VETERANS HOME

The South Dakota State Veterans Home is a campus of residential, office, dining, leisure, and maintenance/shop buildings close to 205,000 SF in total size. Currently, approximately 140,700 SF of the total area is heated by two central boilers. The buildings connected to the central plant are currently heated with about 70,500 gallons of oil, at \$2.45/gal, and 44,420 gallons of propane at \$1.29/gal. The Veterans Home can expect to pay over \$287,000 for space heating next year.

A fully automated wood-chip heating system would decrease the annual heating budget at the facility by about 65%, a savings of more than \$185,000 in the first year of operation. Thirty year NPV of savings would be over \$4 million (2006 dollars).

Several renovation projects are planned for the campus in the near future which will increase the square footage slightly and may improve the overall efficiency of the buildings and heat distribution systems. After these changes occur, the required capacity of the wood-chip boiler could be less than that required for the current heating demand, perhaps around 5.5 MMBH (output), because of the improvements in efficiency. BERC recommends that the South Dakota State Veterans Home install the wood-chip boiler prior to these changes to the campus so that the generated savings in fuel costs can be put towards efficiency and capital improvements to the campus in the future.



SUMMARY

Below is a summary of the findings from all four facilities studied:

Facility	Summary of Findings at Four Larger Facilities		30 Year NPV of Savings
	First Year Fuel Savings (%)	First Year Fuel Savings (\$)	
Black Hills State University	40%	\$80,884	\$596,689
Central High and Civic Center	41%	\$68,075	\$273,216
Star Academy	67%	\$208,055	\$4,722,717
Veterans Home	65%	\$187,267	\$4,037,660

If all seven schools and four facilities were to install biomass heating systems, and assuming that a wood-chip system can replace 85% of the annual heating load and a pellet system can replace 95% of the annual heating load, biomass fuels would replace 76,315 DK of natural gas, 109,540 gallons of propane and 138,208 gallons of oil in the Black Hills region of South Dakota. Each facility would save 40% or more on their annual heating budgets, with two of the larger facilities saving as much as 65-67%.



PRELIMINARY ASSESSMENT OF EMISSIONS FROM BIOMASS

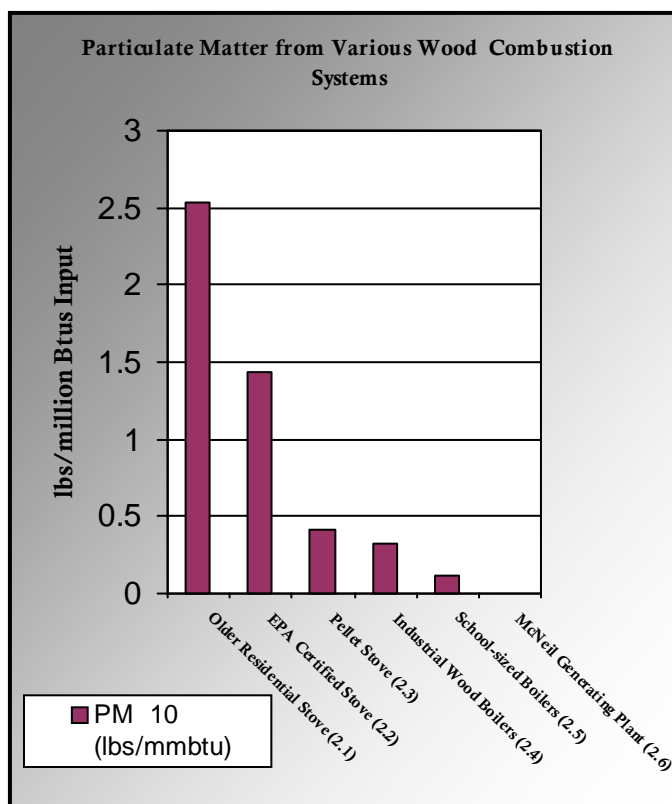
The emissions from wood-fired boilers are different than emissions from natural gas, propane or oil. A number of these components are air pollutants and are discussed below. These emissions are typically measured in pounds of pollutant per million British thermal units (a million British thermal units is the amount of heat energy roughly equivalent to that produced by burning 8 gallons of gasoline), or lbs/MMBtu.

In terms of health impacts from wood combustion, particulate matter is the air pollutant of greatest concern. Particulates are pieces of solid and liquid matter (or very fine droplets), ranging in size from visible to invisible. Relatively small PM, ten micrometers or less in diameter, is called PM₁₀ and is equal to 1/7th the diameter of a single human hair. Small PM is of greater concern for human health than larger PM, since small particles remain air-borne for longer distances and can be inhaled deep within the lungs.

Modern wood systems are clean-burning and efficient and should not be confused with residential wood stoves in the amount of pollutants emitted. Unlike home woodstoves, there are virtually no visible emissions or odors associated with biomass systems. In addition, the respiratory health risk to a child attending a wood-heated school is negligible compared to the risk of living in a home where a wood stove is in regular use.



The *Particulate Matter from Various Wood Combustion Systems* chart shown here shows the PM₁₀ emission rates for a number of wood energy technologies, ranging from common wood stoves to a clean-burning wood power plant. In general, a school wood energy system emits only 8% of the PM₁₀ emitted by an EPA-certified wood stove in use today for the same level of fuel energy input. Over the course of a year, a large, wood-heated high school (150-200,000 square feet) may have the same particulate emissions as four or five houses heated with wood stoves. Also, children are potentially at much greater risk from particulate matter in the exhaust of idling school buses than from wood heating plant emissions.



Based on air emissions tests performed on small scale wood-chip fired boilers, typical 2-3 million Btu input units without particulate control systems produce 0.12 – 0.15 lbs/MMBtu/hr of PM₁₀³. All but the very best wood burning systems, whether in buildings or power plants, have higher PM emissions than do corresponding gas and oil systems⁴.

Oxides of sulfur (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs) are other air pollutants of concern emitted during fuel combustion. Modern wood systems emit more SO₂ than natural gas, but have less than 2% the SO₂ emissions of fuel oil and about 50% the SO₂ emissions of propane. Wood, propane and fuel oil combustion have similar levels of NO_x emissions; however burning wood emits almost twice as much NO_x as natural gas. All fuel combustion processes produce carbon monoxide (CO). The level produced by wood combustion depends very much on how well the system is tuned. Even so, wood

³ Resource Systems Group. *Air Pollution Control Technologies for Small Wood-fired Boilers*. 2001.

⁴ Resource Systems Group. *Air Pollution Control Technologies for Small Wood-fired Boilers*. 2001.



combustion produces significantly more CO than oil, natural gas and propane. This, in addition to PM, is a good reason to make sure the stack is tall enough to disperse any emissions away from ground level. However, CO emissions from burning wood are of relatively minor concern to air quality regulators, except in areas like cities that have high levels of CO in the air from automobile exhaust.

	Wood	Distillate Oil	Natural Gas	Propane
	lb/MM Btu	lb/MM Btu	lb/MM Btu	lb/MM Btu
PM 10	0.1	0.014	0.007	0.004
NOx	0.165	0.143	0.09	0.154
CO	0.73	0.035	0.08	0.021
SO2	0.0082	0.5	0.0005	0.016
TOC	0.0242	0.0039	0.01	0.005
CO2	gross 220 (net 0)	159	118	137

Figure 1 This table is from the Resource Systems Group report titled *Air Pollution Control Technologies for Small Wood-fired Boilers* (2001). VOC, discussed here, are one component of total organic compounds (TOC) shown in the table above.

Volatile organic compounds (VOCs) are a large family of air pollutants, some of which are produced by fuel combustion. Some are toxic and others are carcinogenic. In addition, VOCs elevate ozone and smog levels in the lower atmosphere, causing respiratory problems. Both wood and oil combustion produce VOCs – wood is higher in some compounds and oil is higher in others. VOC emissions can be minimized with good combustion practices.

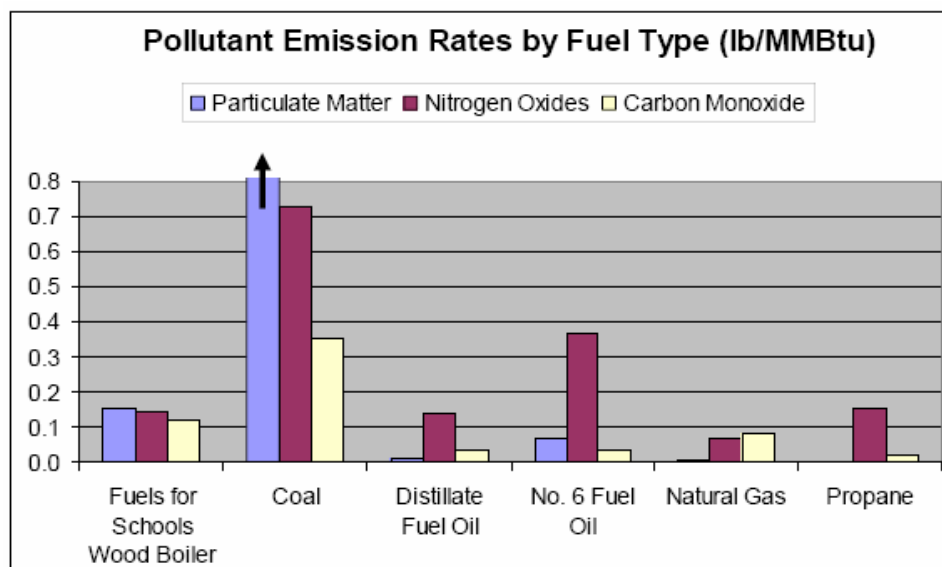
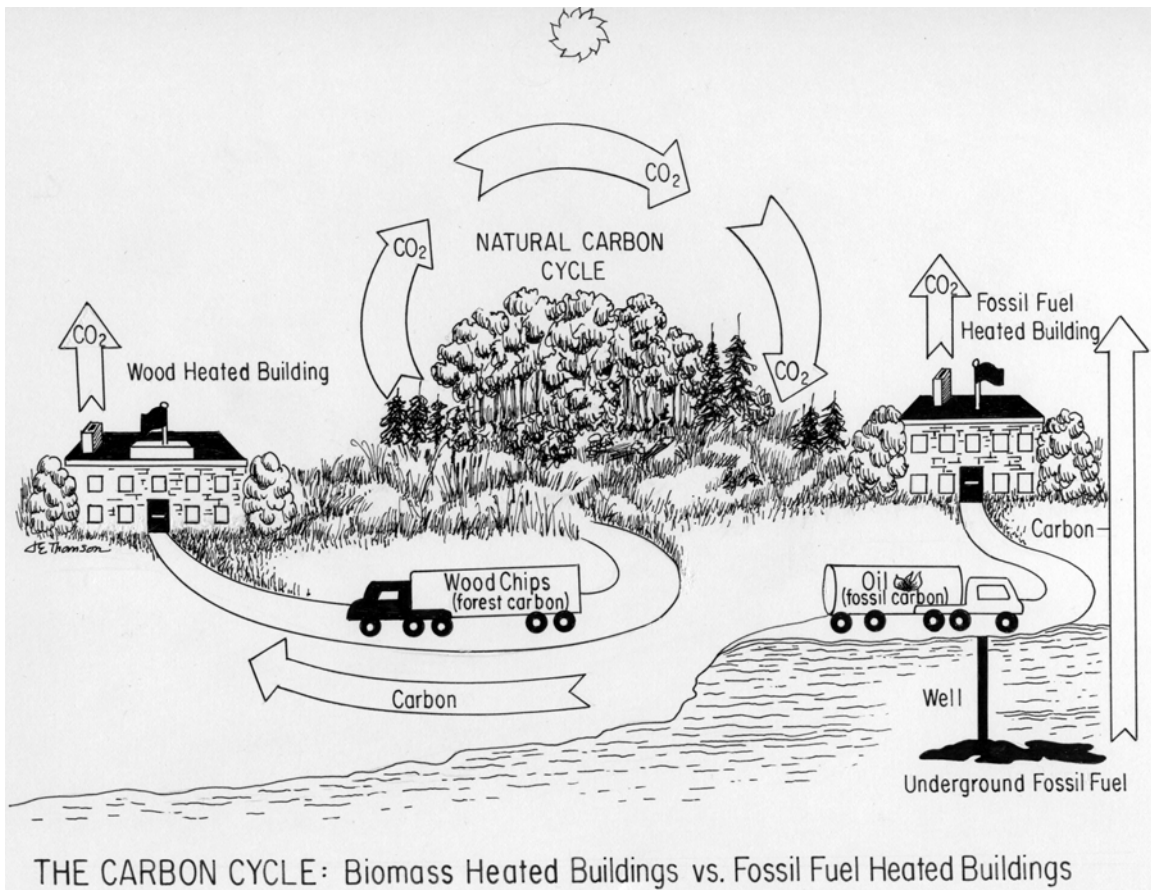


Figure 2 This chart is from the Fuels for Schools webpage titled *Air Quality Issues Associated with Wood Boilers* (2006) located at www.fuelsforschools.org.



Unlike fossil fuels, biomass is a renewable, carbon-neutral heating fuel. Carbon dioxide (CO_2) buildup in the atmosphere is a significant contributor to global climate change. Fossil fuel combustion takes carbon that was locked away underground (as crude oil and gas) and transfers it to the atmosphere as CO_2 . When wood is burned, however, it recycles carbon that was already in the natural carbon cycle. Consequently, the net effect of burning wood fuel is that no new CO_2 is added to the atmosphere.





South Dakota Department of Environment and Natural Resources - Air Quality Program

The mission of the South Dakota Department of Environment and Natural Resources (DENR) is to “protect public health and the environment by providing natural resources assessment, financial assistance, and regulation in a manner that promotes a good business climate and exceeds the expectations of our customers.” SD DENR accomplishes this through several programs relating to air, land and water quality.

The goal of the Air Quality Program is to “maintain air quality levels in South Dakota that protect human health, safety and welfare,” as well as meet the National Air Quality Standards set forth via the Federal Clean Air Act. SD DENR has on-going air quality monitoring projects that test ambient air quality at areas around the state with potentially high air pollution (see map below). The department achieves its goal of healthy air quality through monitoring, permitting and ensuring compliance with state regulations.

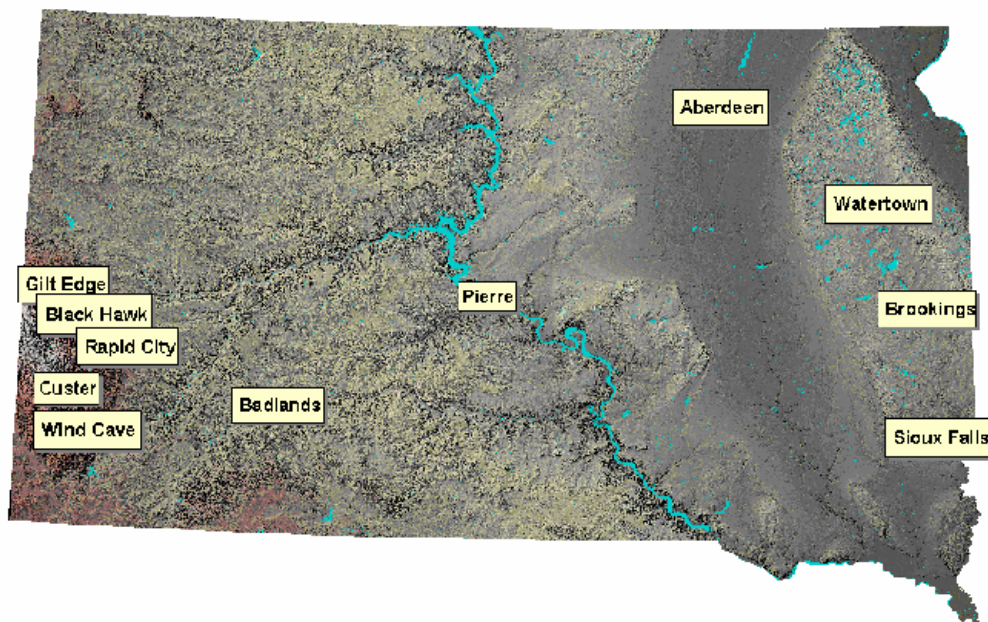


Figure 3 This map is from the SD DENR *Air Quality Monitoring Sites* webpage at the Air Quality home page (<http://www.state.sd.us/denr/DES/AirQuality/airprogr.htm>).



The Clean Air Act requires the US Environmental Protection Agency (EPA) to set *National Ambient Air Quality Standards* (NAAQS) for pollutants considered harmful to public health. These can be found in the US EPA publication 40 CFR, part 50, and are also posted on the South Dakota Department of Environment and Natural Resources (SD DENR) website (<http://www.state.sd.us/denr/DES/AirQuality/airprogr.htm>).

Permitting

The SD DENR Air Quality Program requires an operating permit, referred to as a Title V (Title V of the Clean Air Act), part 70 permit (the regulations that establish minimum standards for State permit programs are found in the Code of Federal Regulations (CFR) part 70), for any project with the potential to emit 25 tons of any criteria pollutant per year. There is also a calculated PM₁₀ emissions limit based on system size⁵. Common examples of criteria air pollutants include volatile organic compounds (VOCs), which can react with nitrogen oxides (NO_x) to form ozone (smog), carbon monoxide (CO), particulate matter, sulfur dioxide (SO₂), and lead. There is also a 20% stack exhaust opacity limit, and the limit in South Dakota for SO₂ is 3 lbs/MMBtu heat input.

Title V operating permits are issued by the SD DENR Air Quality Program, and are intended to reduce violations and improve enforcement of state and federal air pollution laws. Title V operating permits include conditions, enforceable by law, with which the school or facility owner must comply. The permit establishes the types and amounts of pollutants that are allowable and requirements for pollution control, prevention and monitoring. Title V permits are issued after the source of potential pollutants begins operation and must be renewed every five years. If a permit is acquired prior to the installation of the biomass boiler, a time frame will be established by SD DENR Air Quality Program.

There is an annual fee charged for obtaining a Title V operating permit, which is structured so that sources that emit more air pollutants pay more for their Title V permits than sources that emit less. The amount of time that it takes to obtain a permit depends on the circumstances of the application; contacting the SD DENR Air Quality Program may help determine an expected time frame. If a school or facility were in violation of its permit, the school or facility would be subject to penalties and corrective action.

⁵ These calculations assume that the boiler is in operation at high fire 24/7 throughout the entire year, or 8,760 hours.



School or Facility	System Size (heat output)	Calculated PM ₁₀ Permit Level ⁶	Facility's Estimated PM ₁₀ Emissions Rate ⁷	Estimated Tons per Year ⁸	Permit Required?
Belle Fourche High School	1.6 MMBH	1.62 lbs	0.32 lbs	1.6 tons/yr	No
Belle Fourche Middle School	4.5 MMBH	4.76 lbs	0.9 lbs	3.9 tons/yr	No
Black Hills State University	11.5 MMBH	12.33 lbs	2.3 lbs	10 tons/yr	No
Central High School and Rushmore Plaza Civic Center	13.0 MMBH	13.95 lbs	2.6 lbs	11.4 tons/yr	No
East Elementary School	2.3 MMBH	2.38 lbs	0.46 lbs	2 tons/yr	No
Hot Springs K-12 Schools	0.9 MMBH pellet system ⁹	0.87 lbs	--	--	--
Lead-Deadwood High School	5.5 MMBH	5.84 lbs	1.1 lbs	4.82 tons/yr	No
Seton/More Schools	3.5 MMBH	3.68 lbs	0.7 lbs	3.1 tons/yr	No
Star Academy	6.0 MMBH	6.38 lbs	1.2 lbs	5.3 tons/yr	No
Stevens High School	5.5 MMBH	5.84 lbs	1.1 lbs	4.82 tons/yr	No
South Dakota State Veterans Home	6.5 MMBH	6.71 lbs	1.3 lbs	5.69 tons/yr	No

⁶ Based on the SD DENR formula $E=0.811H^{-0.131}$, where E= the calculated emissions rate per year and H= the system capacity in heat input (25% more than capacity given as heat output).

⁷ This calculation is based on 0.15 lbs/MMBtu/hour of PM₁₀.

⁸ This calculation assumes the system is emitting PM₁₀ at the rate given 24 hours per day 7 days per week, or 8,760 hours per year.

⁹ Emissions rates for pellet systems are not currently known.



It does not appear that any of the schools or facilities studied here will require an operating permit; however, each school and facility should contact state air quality regulators to make sure of this. Each of the schools and facilities studied here should obtain information on air quality permitting and determine whether a permit will be necessary prior to purchasing and installing the new boiler. Anyone with questions regarding the impact of a biomass boiler on air quality should contact SD DENR, at (605) 773-3151.

Rapid City

In addition to the emissions limits given above, the Rapid City area has an off-setting program for particulates. This means that if the calculated potential emissions of PM_{10} from the biomass boiler is greater than the previous 2-year average level of particulate emissions from the existing heating system, then the school or facility must off-set the difference in PM_{10} emissions. An example of an off-setting project would be paving a dirt parking lot. The Central High School and Rushmore Plaza Civic Center, St. Elizabeth Seton and St. Thomas More Schools, and Stevens High School should contact state air quality regulators to get more information on PM off-setting during the design phase of the project; there may be additional costs associated with any necessary off-setting work that were not considered in the preliminary studies.



FUEL SUPPLY

Fuel Quality

Not all biomass heating systems will require the same quality of fuel, so matching the right fuel source and quality to the right system and application is extremely important. Factors that should be closely examined and considered early in the planning process are the biomass heating system's technology and capability of handling various wood fuels, the existing regional forest products industry, the regional forest management objectives and the facility operator's willingness and enthusiasm. Each project will be different. Each heating system operator will have different expectations. Each area throughout the state will have different fuel type availability or potential. There is no one-size-fits-all wood fuel specification for biomass heating. Please see *Wood Fuel Sources, Processing and Quality* in the Appendix for more information on the quality of chips produced through different methods and from varying materials.

Biomass heating systems will function and perform better with a high quality fuel. Systems that are fueled with consistent, uniform sized wood chips experience fewer mechanical jams of the fuel feeding equipment. Systems that are fed lower moisture content wood chips typically require less fuel to produce the same amount of heat. Systems that are fed cleaner wood chips (bark, needle, dirt and debris free) produce less ash and can burn longer without maintenance and removal of ash. However, burning the highest quality chip possible may not be the primary intent of the installation of a wood-chip combustion system.

On the contrary, most systems are installed for the purpose of using locally available low-grade wood and reducing heating fuel bills. Many wood-chip combustion systems are designed to handle a wider range of chip quality. However, smaller wood-chip combustion systems tend to be more sensitive to the quality of the wood chips than larger systems. To keep the capital costs of smaller systems down, fuel handling equipment is not over-sized to handle inconsistent and low-grade wood chip fuel. Larger systems that off-set more fossil fuel by burning greater amounts of wood often have better paybacks and can afford the necessary fuel handling equipment to handle



any fuel. So, matching the right fuel source and quality to the right system and application is extremely important. Following is a discussion of wood chip production, availability and supply.

Fuel Availability

If all eleven schools and facilities studied here were to come on-line next year with biomass heating systems, they would require a total of 11,983 tons of green wood chips and 102 tons of wood pellets per year. Very important questions to ask are “What does the fuel supply look like for the Black Hills? How many facilities can this supply sustain?” These are excellent questions; no state would want to be in a position where the demand for woody biomass fuels was exceeding the available material. Often there is a fear that converting to biomass heating means depleting the forest resource to heat our nation’s schools. This is not what is intended – BERC is an advocate for the intelligent use of biomass heating within the given area’s sustainable supply capabilities.

Wood Chips

The Black Hills region contains South Dakota’s greatest concentration of forest land. While the state is only less than 4% forested, the Black Hills region in the southwestern corner of the state is over 90% forested. The region has approximately 1.5 million acres of forest land, 1.2 million of which is the Black Hills National Forest (BHNF). The remaining forest land consists of a mix of private, state and other federal agency ownership. Of the 1.5 million acres of forest land in the region, roughly 91 percent is classified as “timber land,” defined as fairly productive forest land (capable of growing 20 cubic feet of bole per acre per year) with unrestricted access for potential harvesting¹⁰.

Ponderosa pine is the dominant species in the region - although oak, aspen, spruce, and birch are also common. Ponderosa pine has a solid track record as a fuel for biomass power and heating applications when processed properly¹¹. Wood chips are widely available in the Black Hills region.

¹⁰ Piva, Haugan, Josten, and Brand. *South Dakota’s Forest Resources*. 2004.

¹¹ Williams. *Biomass Initiation in the Black Hills*. March, 2005.



Wood Chips from Timber Harvest – Theoretical Sustained Yield

The theoretical sustained yield-based supply of wood can be calculated based on existing data provided by the US Forest Service for the Black Hills region. On the 1.37 million acres of timber land there are 43 million green tons of above-ground biomass (excluding foliage). Of this, only 7.3 million tons is material that can be considered saw timber quality (6 inches in diameter and larger logs). Assuming that the Black Hills timber lands are capable of an average net annual growth rate of 2.5%, roughly 800,000 tons of new non-timber biomass is added each year. If all ten wood-chip systems came on-line next year, including the Black Hills State University and other large facilities, they would cumulatively use only 1.5% of this material.

WOODY BIOMASS RESIDUES

While the theoretical calculation of simplified sustained yield is important, the potential biomass fuel supply needs to be examined; this is based on what volumes of wood are actually accessible and suitable for producing biomass fuel. Therefore, looking at current volumes of woody biomass *residues*, material generated as a by-product from other current practices, is a more practical approach. These residues typically consist of bark, sawdust and shavings, and slabs cut from the outer edge of the logs. Slabs, when chipped, are well suited as fuel for biomass energy systems.

SAWMILL RESIDUES

There are 15 sawmills (including post and pole mills) in the Black Hills region processing a total volume of nearly 250 million board feet of lumber, generating an estimated 260,000 tons per year of residues. This alone is enough annual supply to heat 100 facilities identical to Black Hills State University; all ten facilities would consume about 5% of this material per year. The Pope & Talbot mill in Spearfish processes over 120 million board feet of lumber and generates over 150,000 green tons of chips annually. Pope and Talbot alone would be capable of producing more than 12 times the amount of wood chip fuel required by all ten wood-chip heating systems combined per year.



Current outlets for this chipped material include a pulp mill in Washington State and the Merillat particle board plant in Rapid City. Pope & Talbot currently sends a large percentage of their chips to Washington via trucks and railroad. Selling chips to the local heating market is a good opportunity for these businesses to reduce their high shipping costs and put dollars back into the local economy.

HARVESTING AND FIRE HAZARD REDUCTION RESIDUES

Another potential source of biomass fuel supply is the left over wood from commercial saw timber harvesting. The most common method of harvesting in the region uses mechanical harvesting and whole-tree yarding. Based on the current average levels of harvesting from timberland in the Black Hills region, an estimated 119,714 tons of harvesting residues are produced annually¹². If all ten wood-chip heating systems came on-line next year, they would consume almost 10% of this material per year. Currently, this slash is routinely piled at the logging landings, and the piles are burned to dispose of the material build-up.

In addition to the merchantable material removed as part of the allowable sale quantity (ASQ, the amount of timber that can be harvested during a certain time period from an area within National Forest System lands), woody biomass removed as part of forest restoration/fire hazard reduction thinning could further boost the volumes of potential fuel supply in the region.

Using the assumption that 50% of the sawmill residues were available and that 30% of the harvesting slash could be recovered and chipped, the region would have 155,000 green tons of chips for use as a fuel to heat facilities throughout the region. All ten wood-chip systems combined would require only 8% of this material.

¹² This is assuming 83.8 million board feet annual allowable sale quantity (ASQ) for the BHNH and a saw log to biomass ratio of 5.25 to 1. Williams. Biomass Initiation in the Black Hills. March, 2005.

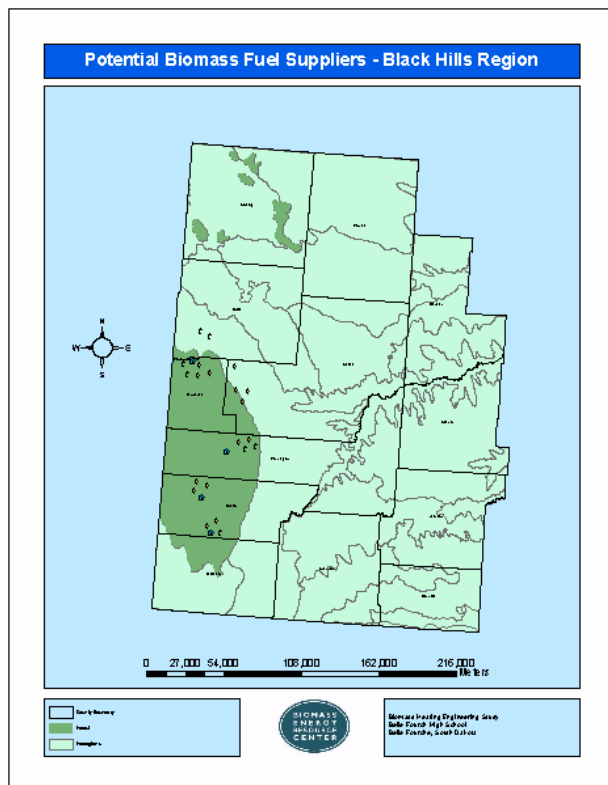


Total Estimated Wood Chip Supply in Black Hills Region

Installing a number of biomass heating systems to replace expensive fossil fuels will not lead to the clear-cutting of the region's forests. On the contrary, it will create vital markets for low grade materials essential for removing hazardous fuels and restoring natural forest conditions.

Potential Fuel Source	Estimated Potential Annual Supply (Green Tons)	Percentage Used by all 11 Facilities (Burning this fuel type only)
Net annual growth of non-timber biomass	800,000	1.5%
Sawmill and wood product mills residue	260,000	5%
Harvesting Slash	119,714	10%
Further Fuel Reduction Treatments	Unknown	Unknown

List of Wood Chip Fuel Suppliers



The Black Hills region of South Dakota has a thriving forest products industry and healthy forest resource with plenty of residual material available to be chipped into wood chip fuel. This fuel is available in the region at an average price of \$35 per green ton; however, prices will vary and the cost per million Btu is dependent on moisture content. Please see the *Price and Moisture Content* chart in the Appendix for an expanded explanation of the effect of moisture content on the cost per million Btu.

Figure 4 A full-page version of this map is included in the Appendix.



During the first stages of the project, the facility administrators should secure a local, reliable fuel source by calling the mills listed below and asking the following questions:

1. Are you willing to provide wood chip fuel to our facility?
2. Are you capable of providing the amount (number of tons) of green wood chips needed per year?
3. What type of delivery trucks will you use?
4. How frequently can you make deliveries?
5. What is your price per ton delivered to our site?

Upon having these questions answered, facility administrators should seek a contract with the fuel supplier that locks in delivery amounts, delivery schedule and price.

Company Name	Address	Address	Phone
Newberg Lumber Co Inc.	Route 1 Box 97	Custer, SD 57730	(605) 673-2398
R.E. Linde Sawmills Inc.	PO Box 712	Custer, SD 57730	(605) 673-4607
Evans Post and Pole	PO Box 3	Pringle, SD 57773	(605) 673-2664
Morgan Sawmill	PO Box 83	Pringle, SD 57773	(605) 673-2681
McLaughlin Sawmill Co	HCR 30 Box 3B	Spearfish, SD 57783	(605) 642-2800
Pope & Talbot Inc	PO Box 850	Spearfish, SD 57783	(605) 642-2363
Wheeler Lumber Operations	PO Box 8	Whitewood, SD 57793	(605) 269-2215
Sturgis Sawmill	3111 Whitewood Service Road	Sturgis, SD 57785	(605) 347-2751
R & R Ventures Log Furniture	11446 Chimney Canyon Road	Piedmont, SD 57769	(605) 787-6935
Aker Woods Company	14347 Mahaffey Drive	Piedmont, SD 57769	(605) 786-1127
Timberline Log & Country Homes	13266 Timberline Plaza	Piedmont, SD 57769	(605) 787-5501
Rushmore Forest Products Inc	PO Box 619	Hill City, SD 57745	(605) 574-2512
Baker Timber Products Inc.	13536 S. Highway 16	Rapid City, SD 57701	(605) 348-8338
Handcrafted Log Homes	PO Box 1377	Rapid City, SD 57709	(605) 355-6933
Devil's Tower Forest Products	51 Hwy 112	Hulett, WY	(307) 467-5252



Pellets

Hot Springs K-12 Schools was the only facility for which a pellet heating system was recommended. While the installation of a pellet system appears economically and logistically feasible at this school, a potential problem at this time may be securing a reliable and affordable fuel supply. Currently there are four suppliers of pellets; however bags are the norm - not bulk delivery. A school system of this size would require bulk delivery, and this may be hard to come by in the Black Hills region.

It is important to note however, that this limited supply is actually a sign of success. The demand for pellet heating has increased hugely, and it has come to surpass supply in most regions. For example, Pope and Talbot is back ordered at this time (this manufacturer currently offers bags of pellets and is looking to add bulk pellet capabilities). As new pellet manufacturers come on-line to meet the increase in demand for pellets, this market will grow – there is a lot of room for expansion. Hot Springs K-12 Schools is in an excellent position to consider converting to pellet heating; but this should only be done when bulk pellet delivery becomes available in the area.

In the meantime, Hot Springs K-12 Schools can begin contacting potential suppliers to determine who offers bulk pellets nearest to the \$125/ton price used in the preliminary feasibility assessment. A state or national biomass heating program could assist schools or facilities interested in pellet heating, such as Hot Springs K-12 Schools, by facilitating an increase in pellet supply in the region.

Supplier	Location	Phone	Contact Name
Heartland Pellets (Pope & Talbot)	Spearfish, SD	(605) 642-2363	Everett Follette
CNZ Corporation	Sheridan, WY	(307) 672-9797	Orrin Connell
Eureka Pellet Mills Inc.	Missoula, MT	(406) 543-0812	Tony Neumayer
Forest Energy Corp.	Show Low, AZ	(928) 537-1647	Mike Lundy



Corn

South Dakota has abundant supply of all types of corn. The corn kernel used for fueling heating systems is a common live-stock feed commodity and is readily available in bulk throughout South Dakota. While the demand for corn in South Dakota has increased significantly over the past year with the rapid growth of the corn-based ethanol industry, the supply for such small volumes of corn is relatively secure.



NEXT STEPS AND RECOMMENDATIONS FOR SCHOOLS AND FACILITIES

BERC recommends that any facilities wishing to pursue a conversion to biomass heating begin taking the following steps:

- The facility should undertake a preliminary engineering design and budget ready cost estimation study, with the exception of Belle Fourche High School which has already done this. An engineer should make preliminary designs based on the project concept, give firm cost estimates particularly for building construction and interconnections. BERC will be willing to re-visit the project's economics prior to moving into the design phase.
- School decision makers, including board members, administrators and maintenance staff, should tour existing biomass heated schools. Seeing this technology and talking with system operators is extremely valuable in addressing doubts and concerns.
- Identify any potential funding sources available to the school for construction projects or renewable energy incentives.
- Extensive public education about the benefits of biomass should be provided to voters prior to any public vote on the project.
- Learn about the air quality permitting requirements in the area.
- BERC can assist with "Phase II" of these projects, which would include developing performance bid specifications for wood system vendors, providing assistance in the bidding and bid selection process, providing guidance in the mechanical design, and commissioning the final system upon successful installation and one season of operation.



PROGRAM OPPORTUNITIES

The Black Hills region represents an enormous potential for using locally-available, sustainable wood resources to replace fossil fuels and to sharply curtail the outflow of energy dollars from the region's economy. The Black Hills are unusual among regions of the western states in the combination of a very large forest land base and a healthy, diversified forest products industry. There is an immediate opportunity, represented by high oil and gas prices and low prices for available low-grade wood residues, to convert facilities in this region from fossil fuel dependence to wood heating. Ongoing thinning and removal of small-diameter fire hazard trees from the Black Hills National Forest, combined with local use of residues from a thriving forest products industry, can supply more than 10 times the amount of wood fuel required by the schools and larger facilities studied here.

In addition to the direct fuel dollar cost savings associated with using wood energy, there are other significant benefits to society from building and strengthening a vibrant wood energy industry in the region. One is the local control and energy security benefit that comes from replacing fossil fuels from outside the local economy with renewable fuels that are produced in the region. Another is the multiplier effect of strengthening the local forest products industry, creating new jobs, and circulating energy dollars within the region's economy – keeping wealth at home rather than letting it leak away.

While this report focuses on using currently available technology to supply building heat from wood, there is a future opportunity for combined heat and power production (CHP) when technologies now under development become mature. This report studies four large institutional facilities that already have central boiler plants serving multiple buildings. There is a future opportunity to develop and build community district heating systems that would allow whole downtown business districts to get their heat from local, renewable resources. Converting the buildings and institutions of this study to wood heating can serve as the foundation for a whole new biomass energy industry that will make the Black Hills a renewable energy model for the rest of the state and for the nation.



There is no doubt that stimulating the development of the first one or two successful wood energy conversion projects can serve as demonstrations and models to inspire other public entities and building owners. This incremental approach will take time to grow to a level of providing significant impact and benefit for the Black Hills region. An alternate, more aggressive approach is to set up programs designed to identify and overcome barriers to wide-spread implementation. This approach has the benefit of stimulating more buildings to be converted, creating a more powerful critical mass of successful installations, and providing significant societal benefits in a faster time frame.

Following are some ideas for programmatic approaches to implementing wood heating projects in the Black Hills region. Keep in mind that there are different approaches to how “programs” can be designed and implemented. It may not be necessary to create new government bureaucracies or an expansion of permanent jobs in state government to achieve the desired results, particularly when installations can be driven by the dollar savings that accrue from converting from expensive fuels to significantly less costly local fuels.

Campus Program

As can be seen from the individual facility reports of this study, the most attractive wood heating project economics are at those larger facilities that already have a number of large buildings piped together and served from a single boiler plant, particularly when the existing fuel is fuel oil or propane. Not only would projects at these facilities produce the highest level of savings for the building owners, they would also utilize the greatest volumes of low-grade wood residues, whether from fire hazard reduction activities or from sawmill residues.

A program approach might first identify and study other similar candidate facilities in the Black Hills. A project financing plan would be devised and tailored to the way capital projects are usually funded at these facilities. This might involve using an “energy services company” (ESCO) approach, in which one or more ESCOs: does the detailed design, cost estimation and study of project economics needed to prove savings; provides capital; does final engineering design; implements the projects; and gets re-paid out of the savings.



The State could require that each project be designed to facilitate the future addition of CHP equipment when high-efficiency, low-emissions biomass power technology at the appropriate scale becomes available in the future.

A further refinement of the program concept could be to identify large buildings in close proximity that could be combined in small or large district heating configurations that do not exist today. While this adds the complexity and cost of new buried pipe connections, it also extends the reach of biomass heating technology, increases the financial benefit to the region, and utilizes higher volumes of low-grade wood residues. A good example of this type of project is the new wood-heated campus of buildings of the Boulder County Public Works Department in Colorado. This new, multi-building facility was built with a central wood heating plant and buried hot water piping connecting the buildings. Fuel is self-supplied by the County from thinning and fire suppression activities on its own land. Another example is the Crotched Mountain Rehabilitation Center, a 50 year old critical care campus consisting of a hospital, school, and administrative and residential buildings, located in New Hampshire. Crotched Mountain is now building a project that ties its buildings into a new hot water district heating loop that is sourced from a new central wood energy plant, designed to accommodate wood CHP in the future. BERC served as the concept originator and design consultant for both the Boulder County and Crotched Mountain projects.

School Program

“Fuels For Schools” programs that promote wood heating in schools are growing across the country. The program concept started in Vermont and is now being refined by BERC and its state agency partners as the Vermont Fuels For Schools initiative. The state of Vermont now has close to 15 percent of all its public school students attending wood-heated schools. The number of schools is above 30 and growing rapidly. This has been done, over twenty years, without creating any full-time state or federal government positions to administer the program. A key ingredient to the success of Vermont Fuels For Schools was the creation, by the state legislature, of incentive payments to participating schools to assist with the capital cost of projects. Critical to the success of the program has been a close cooperation between state energy, forestry and education departments, supported by BERC and by the interest of equipment vendors in growing this market.



The US Forest Service created the “Fuels For Schools” name and is actively promoting the program in five western states with significant federal forest land areas. The USFS Fuels For Schools program started with the first successful school wood-chip project west of the Mississippi in Darby, Montana, which was designed and managed by BERC and its subcontractors. The Fuels For Schools program, being implemented by the US Forest Service in cooperation with state forestry agencies, now has a growing number of projects built in Montana, Idaho, Utah, Nevada and North Dakota.

Community Program

The impact of modern wood-heating technology on the economies of rural, forested areas can be increased through creating wood-fired community district energy systems that serve the heating needs of whole downtown areas of small and large cities. While this technology is not common in the US, it is widely used in Scandinavia, Austria and other European countries, particularly those with aggressive climate change mitigation and carbon reduction policies and programs at the national level. The largest example in the US is District Energy St. Paul, a twenty year old non-profit energy company in St. Paul, Minnesota, that uses biomass to heat, cool and supply electricity to all of the downtown of the city. Community district energy projects tend to be capital intensive, like any other type of municipal infrastructure. An exploratory initiative could be launched in the Black Hills to identify communities with the best potential and to suggest means for implementation.

New Technology Initiative

This report focuses on currently available technology that uses wood residues, primarily wood chips, to fuel combustion systems for producing space heat, steam and domestic hot water. It touches lightly on the use of wood pellets to heat smaller schools – or similarly-sized institutional and commercial buildings. Until now pellet boilers have been available only as a residential and light-commercial scale technology, but that is beginning to change as new, larger pellet boilers are coming on the market. Since pellet systems are less costly than automated wood-chip systems, they can be advantageous for smaller buildings, by trading off some of the fuel dollar savings for lower capital costs. Corn boilers are also beginning to come into use, although the long-term success of this technology for institutional uses has not been proved. There is an



opportunity to study and promote the use of smaller boilers that use pellets, corn or other agricultural crops grown on fallow farm land as local biomass fuel sources that would complement wood residues as part of a broad policy-based initiative to promote local energy.

Beyond heating applications, there is a large demand for power production using wood fuel, across a wide variety of scales. Today, the only commercially available, mature technology for producing power from wood uses high-pressure steam in systems of the type found in wood-fired power plants and smaller forest products industry applications. This technology has been around for 100 years and is extremely inefficient at any scale, with efficiencies dropping further the smaller the scale. New technologies for producing power from wood, principally *true gasification*, will produce a clean gas that can be used to power engine gensets to make electricity without going through the inefficient steam cycle. Gasifier system efficiency and cost-effectiveness is enhanced when they are used in combined heat and power (CHP) applications, not just for power. Waste heat from the gasifier and the engine can be used both to dry the wood fuel and to meet hot water heat loads. Capturing and using the thermal energy provides both power and heat outputs from the same fuel input, boosting system efficiency and enhancing project economics.

While not commercially mature, gasifier/engine genset systems are being developed in demonstration projects and there is an opportunity to site, run and test such systems as part of the necessary development process. These attractive projects require significant public capital infusion because the gasifier systems are pre-commercial. One way to pave the way for future gasifier CHP projects is to design into biomass heating projects the ready capability to plug in new technology when it becomes available. Much of the system infrastructure for CHP and power production, principally fuel storage and fuel handling systems, can equally well serve a heating boiler or a gasifier.

Information and Education

Providing ready access to good information about wood energy technologies and their applications is an inexpensive way to support any biomass energy initiative. Public education for decision makers and for the voting public is also critically important in public-sector project development, as part of the decision-making process. Information and education provides an

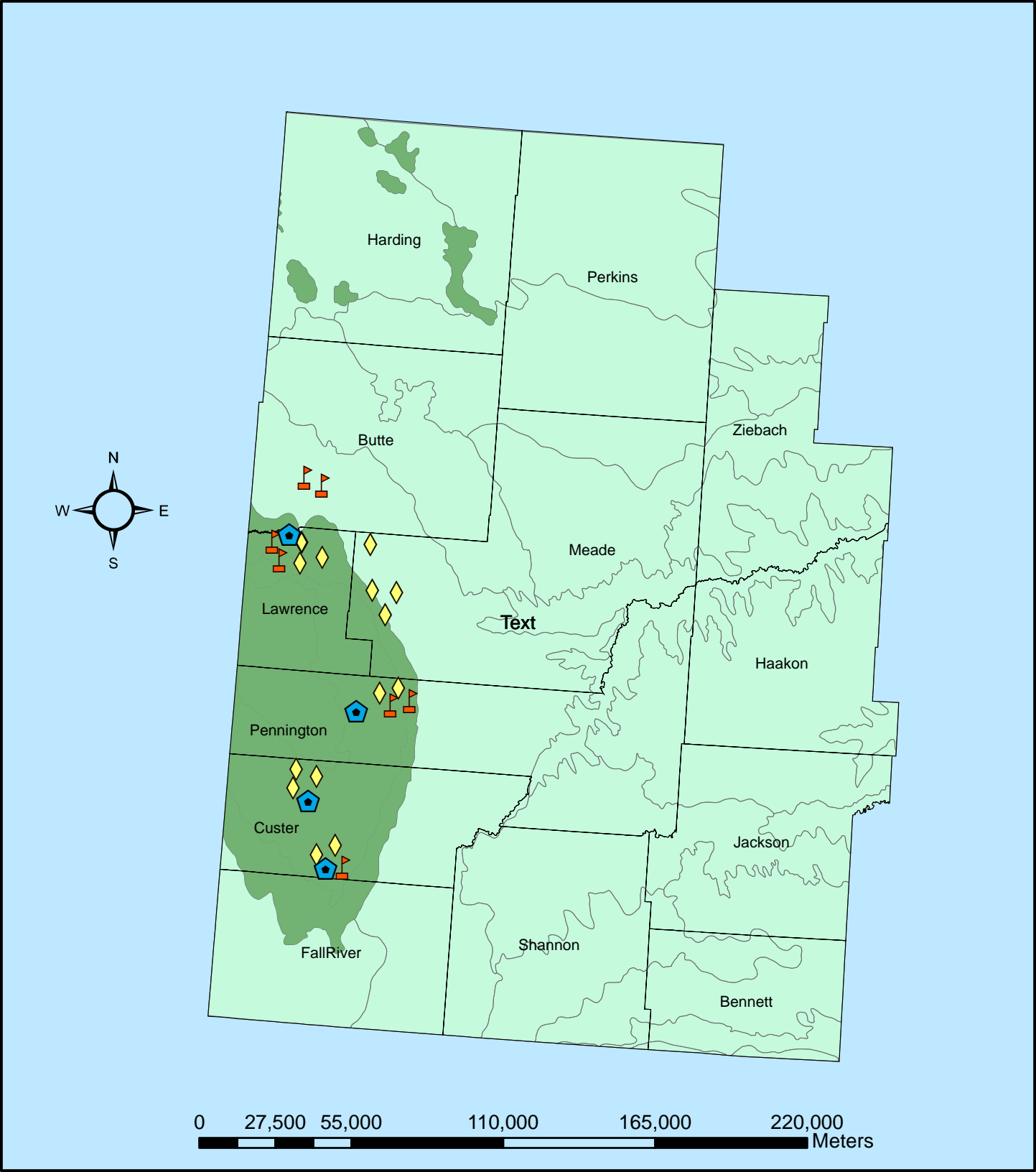


inexpensive means to make programs and initiatives more effective, and increases the public acceptance necessary for implementing projects, particularly when the general public is unfamiliar with the technology for institutional wood energy. The kinds of resources required include educational materials and presentations, technical information and specifications, system information and vendor directories, and fuel supplier directories, among others.

Training for Design Professionals

Well-informed design professionals – engineers and architects – are critically important resources for implementing successful projects. While any skilled design professional will be willing, eager and capable to take on a new challenge, it is not true that successful projects can be carried out by professionals who have no prior experience with wood energy systems – unless provided with specific technical assistance. Trying to “re-invent the wheel” has been the source of many failed or less-than-successful biomass energy projects. BERC is currently designing professional training packages for design professionals, based on our twenty years of experience in implementing successful projects.

Potential Biomass Fuel Suppliers - Black Hills Region



	County Boundary		Sawmills
	Forest		Larger Facilities
	Ecoregions		Schools



Biomass Heating Feasibility
Black Hills Region
South Dakota

Price per Million Btu for Wood Chips at Various Moisture Content Levels

(pre-combustion)

	Btu/lb	Btu/lb	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton	\$/ton
MC	LHV	LHV - LHL	\$ 10.00	\$ 15.00	\$ 20.00	\$ 25.00	\$ 30.00	\$ 35.00	\$ 40.00	\$ 45.00	\$ 50.00	\$ 55.00	\$ 60.00	\$ 65.00	\$ 70.00
5%	7,838	7,778	\$ 0.64	\$ 0.96	\$ 1.29	\$ 1.61	\$ 1.93	\$ 2.25	\$ 2.57	\$ 2.89	\$ 3.21	\$ 3.54	\$ 3.86	\$ 4.18	\$ 4.50
10%	7,425	7,305	\$ 0.68	\$ 1.03	\$ 1.37	\$ 1.71	\$ 2.05	\$ 2.40	\$ 2.74	\$ 3.08	\$ 3.42	\$ 3.76	\$ 4.11	\$ 4.45	\$ 4.79
15%	7,013	6,833	\$ 0.73	\$ 1.10	\$ 1.46	\$ 1.83	\$ 2.20	\$ 2.56	\$ 2.93	\$ 3.29	\$ 3.66	\$ 4.02	\$ 4.39	\$ 4.76	\$ 5.12
20%	6,600	6,360	\$ 0.79	\$ 1.18	\$ 1.57	\$ 1.97	\$ 2.36	\$ 2.75	\$ 3.14	\$ 3.54	\$ 3.93	\$ 4.32	\$ 4.72	\$ 5.11	\$ 5.50
25%	6,188	5,888	\$ 0.85	\$ 1.27	\$ 1.70	\$ 2.12	\$ 2.55	\$ 2.97	\$ 3.40	\$ 3.82	\$ 4.25	\$ 4.67	\$ 5.10	\$ 5.52	\$ 5.94
30%	5,775	5,415	\$ 0.92	\$ 1.39	\$ 1.85	\$ 2.31	\$ 2.77	\$ 3.23	\$ 3.69	\$ 4.16	\$ 4.62	\$ 5.08	\$ 5.54	\$ 6.00	\$ 6.46
35%	5,363	4,943	\$ 1.01	\$ 1.52	\$ 2.02	\$ 2.53	\$ 3.03	\$ 3.54	\$ 4.05	\$ 4.55	\$ 5.06	\$ 5.56	\$ 6.07	\$ 6.58	\$ 7.08
40%	4,950	4,470	\$ 1.12	\$ 1.68	\$ 2.24	\$ 2.80	\$ 3.36	\$ 3.91	\$ 4.47	\$ 5.03	\$ 5.59	\$ 6.15	\$ 6.71	\$ 7.27	\$ 7.83
45%	4,538	3,998	\$ 1.25	\$ 1.88	\$ 2.50	\$ 3.13	\$ 3.75	\$ 4.38	\$ 5.00	\$ 5.63	\$ 6.25	\$ 6.88	\$ 7.50	\$ 8.13	\$ 8.76
50%	4,125	3,525	\$ 1.42	\$ 2.13	\$ 2.84	\$ 3.55	\$ 4.26	\$ 4.96	\$ 5.67	\$ 6.38	\$ 7.09	\$ 7.80	\$ 8.51	\$ 9.22	\$ 9.93
55%	3,713	3,053	\$ 1.64	\$ 2.46	\$ 3.28	\$ 4.10	\$ 4.91	\$ 5.73	\$ 6.55	\$ 7.37	\$ 8.19	\$ 9.01	\$ 9.83	\$ 10.65	\$ 11.47
60%	3,300	2,580	\$ 1.94	\$ 2.91	\$ 3.88	\$ 4.84	\$ 5.81	\$ 6.78	\$ 7.75	\$ 8.72	\$ 9.69	\$ 10.66	\$ 11.63	\$ 12.60	\$ 13.57

Wood HHV

= 8250 Btu/lb

HHV = Higher Heating Value

LHV = Lower Heating Value

LHV- LHL

= Lower Heating Value - Latent Heat Loss

Wood Fuel Sources, Processing and Quality

Wood Source	Primary Activity	Resulting Material	Processing Method	Loading	Heating Fuel Quality
Sawmill	Sawing dimensional lumber from debarked logs	Slabs	Chipped and screened continually	Blown directly into Live bottom trailer	High
	Sawing logs with bark	Slabs with bark	Chipped continually	Blown directly into trailers	High to medium
	Sawing logs with bark	Slabs with bark	Chipped continually	Chips stock-piled on ground and reloaded with front end loader	Medium to low
	Sawing dimensional lumber from debarked logs	Slabs	Ground periodically by contractor	Chips stock-piled on ground and reloaded with front end loader	Low
Post & Pole Mill	Peeling logs	Log peelings	As is	Conveyed directly	Low
	Dowling debarked logs	Dowler chips	As is	Conveyed directly	Medium
Community	Storm clean up and recycling clean wood waste	Various tree trimmings and old pallets	Turn or horizontal grinder	Loaded from stock pile with front end loader	Low
Forest	Commercial Harvesting or Fuel Reduction Treatments	Small diameter logs	Flail debarked & chipped after a couple months	Blown directly into trailer	High
		Small diameter logs	Chipped & screened after a couple months	Blown directly into trailer	High
		Small diameter logs	Chipped green	Blown directly into trailer	High to medium
		Whole trees	Chipped after a couple months	Blown directly into trailer	Medium
		Whole trees	Ground after a couple of months	Conveyed directly into trailer	Medium to low
		Slash	Chipped after a couple of months	Blown directly into trailer	Medium to low
		Slash	Ground after a couple of months	Conveyed directly into trailer	Low
		Bundled Slash	Ground green	Conveyed directly into trailer	Low



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