Preliminary Feasibility Assessment for High Efficiency, Low Emission Wood Heating In Beaver, Alaska

Prepared for:

Rhonda Pitka
Beaver Village Council

Prepared by:

Daniel Parrent,
Wood Utilization Specialist
Juneau Economic Development Council

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Key words: HELE, LEHE, bulk fuel, cordwood

ABSTRACT

The potential for heating various facilities in Beaver, Alaska with high efficiency, low emission (HELE) wood-fired boiler(s) is evaluated for the Beaver Village Council (BVC).

Early in 2008, organizations were invited to submit a Statement of Interest (SOI) to the Alaska Wood Energy Development Task Group (AWEDTG). Task Group representatives reviewed all the SOIs and selected projects for further review based on selection criteria presented in Appendix A. AWEDTG representatives visited Beaver in July 2008 and information was obtained for the various facilities. Preliminary assessments were made and challenges identified. Potential wood energy systems were considered for the project(s) using AWEDTG, USDA and AEA objectives for energy efficiency and emissions. Preliminary findings are reported.

SECTION 1. EXECUTIVE SUMMARY

1.1 Goals and Objectives

- Identify facilities in Beaver as potential candidates for heating with wood
- Evaluate the suitability of the facilities and sites for siting a wood-fired boiler
- Assess the type(s) and availability of wood fuel(s)
- Size and estimate the capital costs of suitable wood-fired system(s)
- Estimate the annual operation, maintenance and repair costs of a wood-fired system
- Estimate the potential economic benefits from installing a wood-fired heating system

1.2 Evaluation Criteria, Project Scale, Operating Parameters, General Observations

- This project meets the AWEDTG objectives for petroleum fuel displacement, use of hazardous forest fuels or forest treatment/processing residues, community support, and project implementation, operation and maintenance. (Sustainability of the wood supply could not be determined.)

- Given the combined annual fuel oil consumption estimate of 14,600 (6,800 gallons per year at the multi-purpose building and 7,800 gallons per year at the water plant/ washeteria), this project would be considered “medium” in terms of its relative size.

- Medium and large energy consumers have the best potential for feasibly implementing a wood-fired heating system. Where preliminary feasibility assessments indicate positive financial metrics, detailed engineering analyses are usually warranted.

- Cordwood systems are generally appropriate for applications where the maximum heating demand ranges from 100,000 to 1,000,000 Btu per hour. “Bulk fuel” systems are generally applicable for situations where the heating demand exceeds 1 million Btu per hour. However, these are general guidelines; local conditions can exert a strong influence on the best system choice.

- Efficiency and emissions standards for Outdoor Wood Boilers (OWB) changed in 2006, which could increase costs for small systems.

1.3 Assessment Summary and Recommended Actions

Two facilities are included in this report:

1.3.1. Beaver Village Council (BVC) Multi-purpose building

• Overview. The BVC multi-purpose building is a 2-story structure of conventional frame construction encompassing approximately 5,600 square feet. It houses BVC offices and the health clinic, and is used daily. The building was built in 2003.

Heat is provided via two Weil McLain Gold, A/B-WTGO-7, Series 3, oil-fired boilers rated at 210,000 Btu per hour (net, each). These appear to be in good condition. Domestic hot water is produced by the same boilers and held in a separate storage tank.

• Fuel Consumption. The BVC multi-purpose building reportedly consumes **6,800** gallons of **#1** fuel oil per year, which is flown in by Everts Air of Fairbanks, AK.

• Potential Savings. At the current price of about $6.00 per gallon, the Beaver Village Council will spend approximately $40,800 per year for fuel oil for the multi-purpose building. The HELE *cordwood* fuel equivalent of 6,800 gallons of #1 fuel oil is approximately **80 cords**, and at $300 per cord represents a potential **annual fuel cost savings of $16,800** (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the multi-purpose building is approximately **216,000** Btu/hr during the coldest 24-hour period.

• Recommended action regarding a cordwood system. Given the initial assumptions and cost estimates for the alternatives presented in this report, this project appears to be marginally viable. Further consideration may be warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the relatively small heating demand, apparent lack of bulk fuel(s), and the probable cost of such a project, a "bulk fuel" system would not be cost-effective for the BVC multi-purpose building.

1.3.2. Water plant / washeteria

• Overview. This building is a single story structure of conventional frame construction encompassing approximately 1,340 square feet. It houses the water treatment plant, laundry and shower facilities, and is used daily. The building was built in 1978 and underwent renovation in the early 1990s.

• Fuel Consumption. The water plant/washeteria reportedly consumes **7,800** gallons of **#1** fuel oil per year, most of which is used to heat water for treatment for domestic use.

• Potential Savings. At the current price of about $6.00 per gallon, the cost of fuel oil for the water plant/washeteria is approximately $46,800 per year. The HELE *cordwood* fuel equivalent of 7,800 gallons of #1 fuel oil is approximately **91 cords**, and at $300 per cord represents a potential annual fuel cost savings of $19,500 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. Given that most of the oil is used for water heating and treatment, discussion of "required boiler capacity" (for space heating) is moot. However, if all the oil *was* used for space heating, the estimated required boiler capacity (RBC) would be approximately **248,000** Btu/hr during the coldest 24-hour period.

• Recommended action regarding a cordwood system. Given the initial assumptions and cost estimates for the alternatives presented in this report, this project appears to be marginally viable. Further consideration may be warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the relatively small heating demand, apparent lack of bulk fuel(s), and the probable cost of such a project, a "bulk fuel" system would not be cost-effective for the water plant/washeteria.

1.3.3 Combined, common heating system

While it is possible to install a small individual wood-fired boiler at each of the buildings under consideration, a more practical solution would be to install a single, large, centralized heating plant, and then distribute heat to both buildings via hot water and insulated, underground plastic tubing. Even though relatively small, this would be considered a "district heating system," and could have significant advantages over individual installations. This is the model I would propose for these facilities in Beaver.

SECTION 2. EVALUATION CRITERIA, IMPLEMENTATION, WOOD HEATING SYSTEMS

The approach being taken by the Alaska Wood Energy Development Task Group (AWEDTG) regarding biomass energy heating projects follows the recommendations of the Biomass Energy Resource Center (BERC), which advises that, "[*T*]*he most cost-effective approach to studying the feasibility for a biomass energy project is to approach the study in stages*." Further, BERC advises "*not spending too much time, effort, or money on a full feasibility study before discovering whether the potential project makes basic economic sense*" and suggests, "[*U*]*ndertaking a pre-feasibility study . . . a basic assessment, not yet at the engineering level, to determine the project's apparent cost-effectiveness*". [Biomass Energy Resource Center, Montpelier, Vermont. www.biomasscenter.org]

2.1 Evaluation Criteria

The AWEDTG selected projects for evaluation based on criteria listed in Appendix A. The Beaver project meets the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, community support, and the ability to implement, operate and maintain the project.

NOTE: The potential to sustainably provide adequate supplies of wood from local forests was not positively determined. The assumption that such supplies are sufficient is based on information provided in the original Statement of Interest. If there is any doubt that local supplies of wood are satisfactory, then such a determination must be made before installing a wood-fired heating system.

One of the objectives of the AWEDTG is to support projects that would use clean-burning, energy-efficient wood heating systems, i.e., high efficiency, low emission (HELE) systems.

2.2 Successful Implementation

In general, four aspects of project implementation have been important to wood energy projects in the past: 1) a project "champion", 2) clear identification of a sponsoring agency/entity, 3) dedication of and commitment by facility personnel, and 4) a reliable and consistent supply of fuel.

In situations where several organizations are responsible for different community services, it must be clear which organization would sponsor and/or implement a wood-burning project. (NOTE: This is not necessarily the case with the facilities in Beaver but this issue should be addressed.)

With manual cordwood systems, boiler stoking and/or maintenance is required for approximately 5 to 15 minutes per boiler several times a day (depending on the heating demand), and dedicating personnel for the operation is critical to realizing savings from wood fuel use. For this report, it is assumed that new personnel would be hired or existing qualified personnel would be assigned as necessary, and that "boiler duties" would be included in the responsibilities and/or job description of facility personnel.

The forest industry infrastructure in/around Beaver is not well-developed, although there is one firewood dealer and there is an effort being made to clear a firebreak around d the village. Over 60% of the local residents rely on woodstoves as their primary heat source. Most people cut and/or process their own firewood. Although surrounded by forests, there are numerous ownerships, including Native allotments, Doyon, Inc. and the U.S. Government; there are no agreements in place for commercial wood harvesting. Ownership and access issues must be resolved before installing a wood-fired heating plant of any significance, but for this report, it is assumed that wood supplies are sufficient to meet the demand.

2.3 Classes of Wood Heating Systems

There are, essentially, two classes of wood energy systems: manual cordwood systems and automated "bulk fuel" systems. Cordwood systems are generally appropriate for applications where the maximum heating demand ranges from 100,000 to 1,000,000 Btu per hour, although smaller and larger applications are possible. "Bulk fuel" systems are systems that burn wood chips, sawdust, bark/hog fuel, shavings, pellets, etc. They are generally applicable for situations where the heating demand exceeds 1 million Btu per hour, although local conditions, especially fuel availability, can exert strong influences on the feasibility of a bulk fuel system.

Usually, an automated bulk fuel boiler is tied-in directly with the existing oil-fired system. With a cordwood system, hot water or glycol from the existing oil-fired boiler system would be circulated through a heat exchanger at the wood boiler ahead of the existing oil boiler. A bulk fuel system is usually designed to replace 100% of the fuel oil used in the oil-fired boiler, and although it is possible for a cordwood system to be similarly designed, they are usually intended as a supplement, albeit a large supplement, to an oil-fired system. In either case, the existing oil-fired system would remain in place and be available for peak demand or backup in the event of a failure or other downtime (scheduled or unscheduled) in the wood system.

One of the objectives of the AWEDTG is to support projects that would use energy-efficient and clean burning wood heating systems, i.e., high efficiency, low emission (HELE) systems.

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Wood fuels in Beaver will generally be in the form of cordwood; there are no sawmill residues or bulk fuel supplies. Firewood is the primary heating fuel in the majority of houses in Beaver and most residents cut or process their own firewood.

3.2 Heating Value of Wood

Wood is a unique fuel whose heating value is quite variable, depending on species of wood, moisture content, and other factors. There are also several 'heating values', namely *high* heating value (HHV), *gross* heating value (GHV), *recoverable* heating value (RHV), and *deliverable* heating value (DHV), that may be assigned to wood at various stages in the calculations.

For this report, white spruce cordwood at 30 percent moisture content (MC30, calculated on the "wet" or "green" weight basis) is used as the benchmark.

The HHV of white spruce at 0% moisture content (MC0) is 8,890 Btu/lb[1] and the GHV at 30% moisture content (MC30) is 6,223 Btu/lb

The RHV for white spruce cordwood (MC30), given the variables in Appendix B, is calculated at 12.22 million Btu per **cord**, and the DHV, which is a function of boiler efficiency (assumed to be 75%), is 9.165 million Btu per cord. The delivered heating value of **1 cord** of white spruce cordwood (MC30) equals the delivered heating value of **85.5 gallons** of #1 fuel oil when the wood is burned at 75% conversion efficiency and the oil is burned at 80% efficiency.

A more thorough discussion of the heating value of wood can be found in Appendix B and Appendix D.

SECTION 4. WOOD-FUELED HEATING SYSTEMS

4.1 Low Efficiency High Emission (LEHE) Cordwood Boilers

Most manual outdoor wood boilers (OWBs) that burn cordwood are relatively low-cost and can save fuel oil but have been criticized for low efficiency and smoky operation. These could be called low efficiency, high emission (LEHE) systems and there are dozens of manufacturers. In 2006, the State of New York instituted a moratorium on new LEHE OWB installations due to concerns over emissions and air quality[5]. Other states have also considered or implemented new regulations[6,7,8,9]. Since there are no standards for OWBs ("boilers" and "furnaces" were exempt from the 1988 EPA regulations[10]), OWB ratings are inconsistent and can be misleading. Prior to 2006, standard procedures for evaluating wood boilers did not exist, but test data from New York, Michigan and elsewhere showed a wide range of apparent [in]efficiencies and emissions among OWBs.

In 2006, a committee was formed under the American Society for Testing and Materials (ASTM) to develop a standard test protocol for OWBs[11]. The standards included uniform procedures for determining performance and emissions. Subsequently, the ASTM committee sponsored tests of three common outdoor wood boilers using the new procedures. The results showed efficiencies as low as 25% and emissions **more than nine times** the standard for other industrial boilers. Obviously, these results were deemed unsatisfactory and new OWB standards were called for.

In a news release dated January 29, 2007[12], the U.S. Environmental Protection Agency announced a new voluntary partnership agreement with 10 major OWB manufacturers to make cleaner-burning appliances. The new phase-one standard calls for emissions not to exceed 0.60 pounds of particulate emissions per million Btu of heat **input**. The phase-two standard, which will follow 2 years after phase-one, will limit emissions to 0.30 pounds per million Btus of heat **delivered**, thereby creating an efficiency standard as well.

To address local and state concerns over regulating OWB installations, the Northeast States for Coordinated Air Use Management (NeSCAUM), and EPA have developed model regulations that recommend OWB installation specifications, clean fuel standards and owner/operator training. (http://www.epa.gov/woodheaters/ and http://www.nescaum.org/topics/outdoor-hydronic-heaters)

Implementation of the new standard will improve air quality and boiler efficiency but will also increase costs as manufacturers modify their designs, fabrication and marketing to adjust to the new standards. Some low-end models will no longer be available.

4.2 High Efficiency Low Emission (HELE) Cordwood Boilers

In contrast to low efficiency, high emission cordwood boilers there are a few units that can be considered high efficiency, low emission (HELE). These systems are designed to burn cordwood fuel cleanly and efficiently.

Table 4-1 lists three HELE boiler suppliers, all of which have units operating in Alaska. TarmUSA, Inc. and Greenwood and have a number of residential units operating in Alaska, and a Garn boiler manufactured by Dectra Corporation is used in Dot Lake, AK to heat several homes and the washeteria, replacing 7,000 gallons per year (gpy) of fuel oil.[14] Two Garn boilers were recently installed in Tanana, AK to provide heat to the washeteria and water plant, and two others were installed near Kasilof. Several more are being planned for other installations in other communities.

Table 4-1. HELE Cordwood Boiler Suppliers

	Btu/hr ratings	Supplier
Tarm	100,000 to 198,000	HS Tarm/Tarm USA www.tarmusa.com/wood-gasification.asp
Greenwood	100,000 to 300,000	Greenwood www.GreenwoodFurnace.com
Garn	350,000 to 950,000	Dectra Corp. www.garn.com

Note: Listing of any manufacturer, distributor or service provider does not constitute an endorsement.

Table 4-2 shows the test results for a Garn WHS 1350 boiler that was tested at 157,000 to 173,000 Btu per hour using the new ASTM testing procedures, compared with EPA standards for wood stoves and boilers. It is important to remember that wood fired boilers are not entirely smokeless; even very efficient wood boilers may smoke for a few minutes on startup.[4,15]

Table 4-2. Emissions from Wood Heating Appliances

Appliance	Emissions (grams/1,000 Btu delivered)
EPA Certified Non Catalytic Stove	0.500
EPA Certified Catalytic Stove	0.250
EPA Industrial Boiler (many states)	0.225
GARN WHS 1350 Boiler*	0.179

Source: Intertek Testing Services, Michigan, March 2006.
Note: *With dry oak cordwood; average efficiency of 75.4% based upon the high heating value (HHV) of wood

4.3 Bulk Fuel Boiler Systems

The term "bulk fuel" as used in this report refers, generically, to sawdust, wood chips, shavings, bark, pellets, etc. Since the availability of bulk fuel is non-existent in Beaver, the cost of bulk fuel systems is so high (i.e., $1 million and up), and the relatively small heating demand for the facilities under consideration, the discussion of bulk fuel boiler systems has been omitted from this report.

SECTION 5. SELECTING THE APPROPRIATE SYSTEM

Selecting the appropriate heating system is, primarily, a function of heating demand. It is generally not feasible to install automated bulk fuel systems in/at small facilities, and it is likely to be impractical to install cordwood boilers at very large facilities. Other than demand, system choice can be limited by fuel availability, fuel form, labor, financial resources, and limitations of the site.

The selection of a wood-fueled heating system has an impact on fuel economy. Potential savings in fuel costs must be weighed against initial investment costs and ongoing operating, maintenance and repair (OM&R) costs. Wood system costs include the initial capital costs of purchasing and installing the equipment, non-capital costs (engineering, permitting, etc.), the cost of the fuel storage building and boiler building (if required), the financial burden associated with loan interest, the fuel cost, and the other costs associated with operating and maintaining the heating system, especially labor.

5.1 Comparative Costs of Fuels

Table 5-1 compares the cost of #1 fuel oil to white spruce *cordwood* (MC30) In order to make reasonable comparisons, costs are provided on a "per million Btu" (MMBtu) basis.

Table 5-1. Comparative Cost of Fuel Oil vs. Wood Fuels

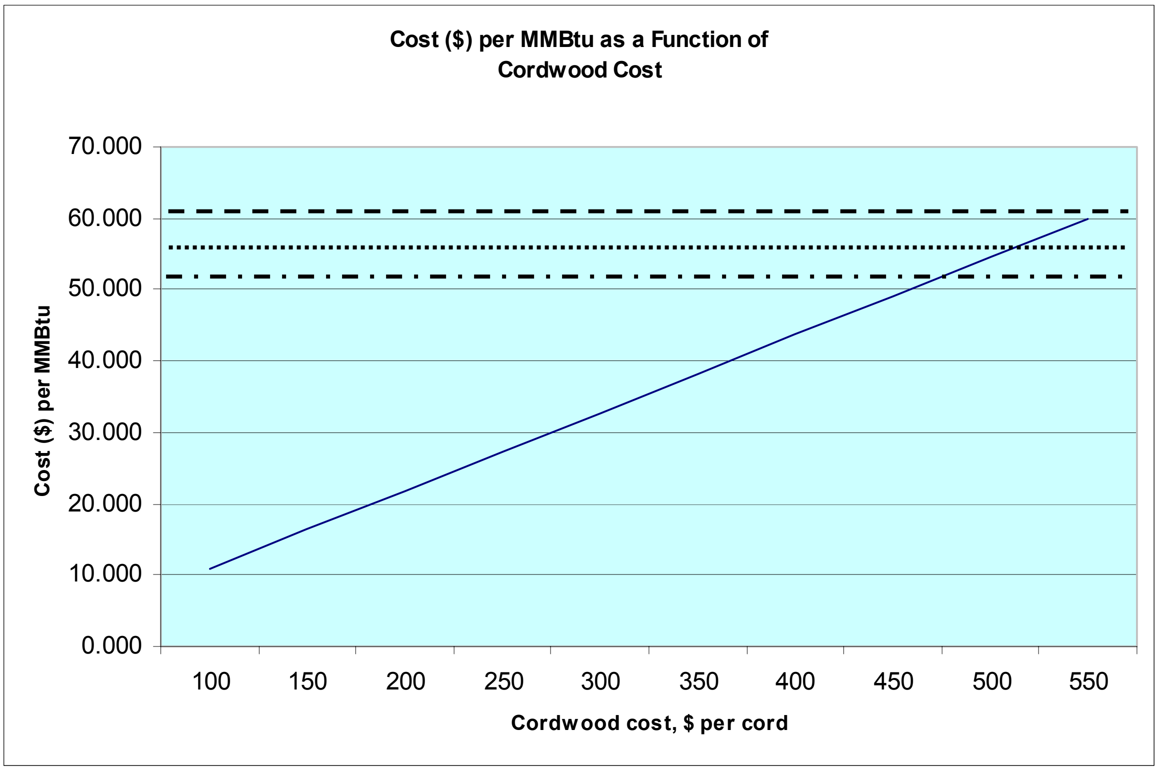
FUEL	RHV[a] (Btu)	Conversion Efficiency[a]	DHV[a] (Btu)	Price per unit ($)	Cost per MMBtu (delivered, ($))
Fuel oil, #1, (per 1 gallon)	134,000	80%	107,200 per gallon	5.50/gal	51.31
				6.00	55.97
				6.50	60.63
White spruce, (per 1 cord, MC30)	12.22 million	75%	9.165 million	250/cord	27.28
				300	32.73
				350	38.19

Notes:
[a] from Appendix D

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 (next page) illustrates the relationship between the price of white spruce cordwood (MC30) and the cost of delivered heat, (the slanted line). For each $10 per *cord* increase in the price of cordwood, the cost per million Btu increases by $1.091. The chart assumes that the cordwood boiler delivers 75% of the RHV energy in the cordwood to useful heat and that oil is converted to heat at 80% efficiency. The dashed lines represent #1 fuel oil at $5.50, $6.00 and $6.50 per gallon ($51.31, $55.97 and $60.63 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $512.97 per cord is equal to the cost of #1 fuel oil at $6.00 per gallon (i.e., $55.97 per MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $300 per cord, a high-efficiency cordwood boiler will deliver heat at about 58.5% of the cost of #1 fuel oil at $6.00 per gallon ($32.73 versus $55.97 per MMBtu). Figure 5-1 indicates that, at a given efficiency, savings increase significantly with decreases in the delivered price of cordwood and/or with increases in the price of fuel oil.



Fuel Oil at $6.50 per gallon
Fuel Oil at $6.00 per gallon
Fuel Oil at $5.50 per gallon

Figure 5-1. Effect of White Spruce Cordwood Price on Cost of Delivered Heat

5.2(b) Cost per MMBtu Sensitivity – Bulk Fuels

Not included in this report

5.3 Determining Demand

Table 5-2 shows the reported approximate amount of fuel oil used by various facilities in Beaver, Alaska.

Table 5-2. Reported Annual Fuel Oil Consumption, Beaver, AK		
Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $6.00/gallon*
BVC Multi-purpose building	6,800	40,800
Water plant / washeteria	7,800	46,800
TOTAL	**14,600**	**87,600**

Wood boilers, especially cordwood boilers, are often sized to displace only a portion of the heating load since the oil system will remain in place, in standby mode, for "shoulder seasons" and peak demand. Fuel oil consumption for the Beaver facilities was compared with heating demand based on heating degree days (HDD) to determine the required boiler capacity (RBC) for heating only on the coldest 24-hour day (Table 5-3). While there are many factors to consider when sizing heating systems it is clear that, in most cases, a wood system of less-than-maximum size could still replace a substantial quantity of fuel oil and save money.

NOTE: For the water plant and washeteria, required boiler capacity for heating cannot be determined because most of the fuel is used to heat water for domestic consumption.

Typically, installed oil-fired heating capacity at most sites is two-to-four times the demand for the coldest day. It appears that the BVC multi-purpose building heating system falls within this range, while the heating capacity of the boiler system at the water plant/washeteria is slightly more than 4 (although, as noted, most of this capacity is applied to heating water for treatment for domestic consumption, not space heat).

Manual HELE cordwood boilers equipped with special tanks for extra thermal storage can supply heat at higher than their rated capacity for short periods. For example, while rated at 950,000 Btu/hr (heat into storage), a Garn WHS 3200 can store more than two million Btu, which, theoretically, would be enough to heat the multi-purpose building during the coldest 24-hour period for about 9½ hours (2,064,000 ÷ 216,126).

Table 5-3. Estimate of Heat Required in Coldest 24-Hour Period						
Facility	Fuel Oil Used gal/year[a]	Heating Degree Days[d]	Btu/DD[c]	Design Temp[d] F	RBC[e] Btu/hr	Installed Btu/hr[a]
Multi-purpose building	6,800	15,788 (Bettles data)	46,172	-47 (Bettles data)	216,126	420,000
Water plant / washeteria	7,800		52,962		247,813[f]	1,124,000
TOTAL	14,600		99,134		463,281[f]	1,544,000

Table 5-3 Footnotes:

[a] From SOI and site visit; net total Btu/hr

[b] NOAA, July 1, 2005 through June 30, 2006: ftp://ftp.cpc.ncep.noaa.gov/htdocs/products/analysis_monitoring/cdus/degree_days/archives/Heating%20degree%20Days/Monthly%20City/2006/jun%202006.txt

[c] Btu/DD= Btu/year x oil furnace conversion efficiency (0.85) /Degree Days

[d] Alaska Housing Manual, 4th Edition Appendix D: Climate Data for Alaska Cities, Research and Rural Development Division, Alaska Housing Finance Corporation, 4300 Boniface Parkway, Anchorage, AK 99504, January 2000.

[e] RBC = Required Boiler Capacity for the coldest Day, Btu/hr= [Btu/DD x (65 F-Design Temp)+DD]/24 hrs

[f] RBC if all fuel oil was used for space heating purposes

According to these calculations (Table 5-3), it appears that the Beaver multi-purpose building and water plant/washeteria could, technically, supply 100% of their heating needs with one or more high efficiency low emission cordwood boilers. Consultation with a qualified engineer is strongly recommended.

5.4 Summary of Findings and Potential Savings

Table 5-4 summarizes the findings thus far: annual fuel oil usage, range of annual fuel oil costs, estimated annual wood fuel requirement, range of estimated annual wood fuel costs, and potential gross annual savings for the facilities in Beaver. [Note: potential gross annual fuel cost savings do not consider capital costs and non-fuel operation, maintenance and repair (OM&R) costs.]

Table 5-4. Estimate of Total Wood Consumption, Comparative Costs and Potential Savings

	Fuel Oil Used gal/year[a]	Annual Fuel Oil Cost (@ $ ___ /gal)			Approximate Wood Requirement[b]	Annual Wood Cost (@ $ ___ /unit)			Potential Gross Annual Fuel Cost Savings ($)		
CORDWOOD SYSTEMS		*5.50/gal*	*6.00/gal*	*6.50/gal*	W. spruce, MC30, CE 75%	*250/cord*	*300/cord*	*350/cord*	*Low*	*Medium*	*High*
Multi-purpose building	6,800	37,400	40,800	44,200	**80.0**	20,000	24,000	28,000	9,400	16,800	24,200
Water plant / washeteria	7,800	42,900	46,800	50,700	**91.0**	22,750	27,300	31,850	11,050	19,500	27,950
TOTAL	**14,600**	**80,300**	**87,600**	**94,900**	**171.0**	**42,750**	**51,300**	**59,850**	**20,450**	**36,300**	**52,150**

NOTES:
[a] From Table 5-2
[b] From Table D-3, Appendix D

SECTION 6. ECONOMIC FEASIBILITY OF CORDWOOD SYSTEMS

6.1 Initial Investment Cost Estimates

DISCLAIMER: Short of having an actual Design & Engineering Report prepared by a team of architects and/or professional engineers, actual costs for any particular system at any particular site cannot be positively determined. Such a report is beyond the scope of this preliminary assessment. However, a hypothetical, though hopefully realistic, system scenario is offered as a means of comparison. Actual costs, assumptions and "guess-timates" are identified as such, where appropriate. Recalculations of financial metrics, given different/updated cost estimates, are relatively easy to accomplish.

Wood heating systems include the cost of the fuel storage building (if necessary), boiler building (if necessary), boiler equipment (and shipping), plumbing and electrical connections (including heat exchangers, pumps, fans, and electrical service to integrate with existing distribution systems), installation, and an allowance for contingencies.

Before a true economic analysis can be performed, all of the costs (investment and OM&R) must be identified, and this is where the services of qualified experts are necessary.

Table 6-1 (next page) presents a hypothetical scenario of initial investment costs for a cordwood system in a medium-sized heating demand situation. It should be noted, however, that this scenario is strictly hypothetical. The solution presented here is not necessarily the best, correct, or only configuration; consultation with qualified professionals is strongly recommended.

Buildings and plumbing/connections are the most significant costs besides the boiler(s). Building costs deserve more site-specific investigation and often need to be minimized to the extent possible. Piping from the wood-fired boiler is another area of potential cost saving. Long plumbing runs and additional heat exchangers substantially increase project costs. The exorbitant cost of hard copper pipe normally used in Alaska now precludes its use in most applications. If plastic or PEX® piping is used significant cost savings may be possible.

Allowance for indirect non-capital costs such as engineering and contingency are most important for large systems that involve extensive permitting and budget approval by public agencies. This can increase the cost of a project by 25% to 50%. For the examples in Table 6-1, a 25% contingency allowance was used.

NOTES:

a. With the exception of the list prices for Garn boilers, all of the figures in Table 6-1 are gross estimates.

b. The cost estimates presented in Table 6-1 do not include the cost(s) of any upgrades, repairs, or improvements to the existing heating/heat distribution system currently in place.

<table>
<tr><th colspan="3">Table 6-1. Initial Investment Cost Scenario for a Hypothetical HELE Cordwood Systems</th></tr>
<tr><td colspan="2">Fuel oil consumption, gallons per year</td><td>14,600
(BVC multi-purpose building + Water plant/washeteria)</td></tr>
<tr><td colspan="2">Required boiler capacity (RBC), Btu/hr</td><td>463,281</td></tr>
<tr><td rowspan="3">Cordwood boiler</td><td>Garn model</td><td>(2) WHS 3200</td></tr>
<tr><td>Rating -Btu/hr [e]</td><td>950,000 each; 1,900,000 combined</td></tr>
<tr><td>Btu stored</td><td>4,128,000</td></tr>
<tr><td colspan="3">Building and Equipment (B&E) Costs, $ (for discussion purposes only)</td></tr>
<tr><td colspan="2">Fuel storage building[a]
(fabric bldg, gravel pad, $25 per sf)</td><td>$85,500
(171 cds @ 20 sf/cd)</td></tr>
<tr><td colspan="2">Boiler building @ $150 per sf
(minimum footprint w/concrete pad)[b]</td><td>$60,000
(20'x20')</td></tr>
<tr><td colspan="2">Boilers
Base price[c]
Shipping[d]
Bush delivery [d]</td><td>
$68,000
$ 8,000
$ 6,000</td></tr>
<tr><td colspan="2">Plumbing and electrical[d]</td><td>$50,000</td></tr>
<tr><td colspan="2">Installation[d]</td><td>$25,000</td></tr>
<tr><td colspan="2">Subtotal - B&E Costs</td><td>$302,500</td></tr>
<tr><td colspan="2">Contingency (25%)[d]</td><td>$ 75,625</td></tr>
<tr><td colspan="2">Grand Total</td><td>$378,125</td></tr>
<tr><td colspan="3">Notes:
[a] A cord occupies 128 cubic feet. If the wood is stacked 6½ feet high, the area required to store the wood is 20 square feet per cord.
[b] Does not allow for any fuel storage within the boiler building
[c] List price, Alaskan Heat Technologies, April 2008 and September 2008
[d] "guess-timate"; for illustrative purposes only
[e] Btu/hr into storage is extremely fuel dependent. The data provided for Garn boilers by Dectra Corp. are based on the ASTM standard of split, 16-inch oak with 20 percent moisture content and reloading once an hour.</td></tr>
</table>

6.2 Operating Parameters of HELE Cordwood Boilers

A detailed discussion of the operating parameters of HELE cordwood boilers can be found in Appendix F.

6.3 Hypothetical OM&R Cost Estimates

The primary operating cost of a cordwood boiler, other than the cost of fuel, is labor. Labor is required to move fuel from its storage area to the boiler building, fire the boiler, clean the boiler and dispose of ash. For purposes of this analysis, it is assumed that the boiler system will be operated every day for 210 days (30 weeks) per year between mid-September and mid-April. Table 6-2 presents labor/cost estimates for various HELE cordwood systems. A detailed analysis of labor requirement estimates can be found in Appendix F.

Table 6-2. Labor/Cost Estimates for a HELE Cordwood System	
System	(2) WHS 3200 (171 cds/yr)
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	191.07
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	171
Total Annual labor (hrs/yr)[b]	40
Total labor (hrs/yr)	402.07
Total annual labor cost ($/yr) (total hrs x $20)	**$8,041.40**
Notes: a From Table F-2 b From Appendix F	

There is also an electrical cost component to the boiler operation. An electric fan creates the induced draft that contributes to boiler efficiency. The cost of operating circulation pumps and/or blowers would be about the same as it would be with the oil-fired boiler or furnaces in the existing heating system.

Lastly there is the cost of wear items, such as fire brick, door gaskets, water treatment chemicals, etc. For the following example, a value of $1,000 per boiler is used.

Table 6-3. Summary of Total Annual Non-Fuel OM&R Cost Estimates	
Item	Cost/Allowance ($) (2) WHS 3200 (171 cds/yr)
Labor	$8,041
Electricity[a]	$ 992
Maintenance/Repairs	$2,000
Total non-fuel OM&R ($)	**$11,033**
Notes: a Electrical cost based on a formula of horsepower x kWh rate x operating time. Assumed kWh rate = $0.65	

6.4 Calculation of Financial Metrics

Biomass heating projects are viable when, over the long run, the annual fuel cost savings generated by converting to biomass are greater than the cost of the new biomass boiler system plus the additional operation, maintenance and repair (OM&R) costs associated with a biomass boiler (compared to those of an oil- or gas-fired boiler or furnace).

Converting from an existing boiler to a wood biomass boiler (or retrofitting/integrating a biomass boiler with an existing boiler system) requires a greater initial investment and higher annual OM&R costs than for an equivalent oil or gas system alone. However, in a viable project, the savings in fuel costs (wood vs. fossil fuel) will pay for the initial investment and cover the additional OM&R costs in a relatively short period of time. After the initial investment is paid off, the project continues to save money (avoided fuel cost) for the life of the boiler. Since inflation rates for fossil fuels are typically higher than inflation rates for wood fuel, increasing inflation rates result in greater fuel cost savings and thus greater project viability.[17]

The potential economic viability of a given project depends not only on the relative costs and cost savings, but also on the financial objectives and expectations of the facility owner. For this reason, the impact of selected factors on potential project viability is presented using the following metrics:

Simple Payback Period
Present Value (PV)
Net Present Value (NPV)
Internal Rate of Return (IRR)

Total initial investment costs include all of the capital and non-capital costs required to design, purchase, construct and install a biomass boiler system in an existing facility with an existing furnace or boiler system.

A more detailed discussion of Simple Payback Period, Present Value, Net Present Value and Internal Rate of Return can be found in Appendix E.

6.5 Simple Payback Period for HELE Cordwood Boilers

Table 6-4 presents a Simple Payback Period analysis for a hypothetical HELE cordwood boiler installation.

Table 6-4. Simple Payback Period Analysis for a Hypothetical HELE Cordwood Boiler System

	(2) WHS 3200 (171 cds/yr)
Fuel oil cost, $ per year @ $6.00 per gallon	87,600 (14,600 gal)
Cordwood cost $ per year @ $300 per cord	51,300 (171 cds)
Annual Fuel Cost Savings, $/yr	36,300
Total Investment Costs [b], $	378,125
Simple Payback[c], yrs	**10.42**
Annual, Non-fuel OM&R costs[a]	11,033
Net Annual Savings ($) (Annual Cash Flow)	25,267

Notes:
a From Table 6-3
b From Table 6-1
c Total Investment Costs divided by Annual Fuel Cost Savings

6.6 Present Value (PV), Net Present Value (NPV) and Internal Rate or Return (IRR) Values for a Hypothetical HELE Cordwood Boiler Installation

Table 6-5 presents PV, NPV and IRR values for a hypothetical HELE cordwood boiler installation.

Table 6-5. PV, NPV and IRR Values for a Hypothetical HELE Cordwood Boilers Installation	
	(2) WHS 3200 (171 cds/yr)
Discount Rate[a] (%)	3
Time, "t", (years)	20
Initial Investment ($)[b]	378,125
Annual Cash Flow($)[c] (Net Annual Savings)	25,267
Present Value (of expected cash flows, $ at "t" years)	375,909
Net Present Value ($ at "t" years)	-2,216
Internal Rate of Return (% at "t" years)	2.94
See Note #_ below	1

Notes:
[a] real discount (excluding general price inflation) as set forth by US Department of Energy, as found in NIST publication NISTIR 85-3273-22 (Rev 5/08), Energy Price Indices and Discount Factors for Life Cycle Cost Analysis, April 2008
[b] From Table 6-1
[c] Equals annual cost of fuel oil minus annual cost of wood minus annual non-fuel OM&R costs (i.e., Net Annual Savings)

Note #1. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $375,909 today (PV), which is less than the hypothetical initial investment of $378,125. The resulting NPV of the project is -$2,216, which means that the project, given the stated assumptions and cost estimates, will not achieve the stated return [i.e., 3%] at the end of 20 years. Given the assumptions and cost estimates for this example, this project appears to be only marginally cost-effective.

The financial metrics would not classify this as a strong positive investment, even though it is possible to save money by installing a wood-fired system. Annual cash flows *will* increase as oil prices continue to increase above the general rate of inflation and/or disproportionately to the cost of wood fuel. Given fuel oil prices at $6.00 per gallon and wood at $300/cord, the NPV is only slightly negative and the internal rate of return would be positive 2.94%.

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

The discussion of bulk fuel systems is not included in this report

SECTION 8. CONCLUSIONS

This report discusses conditions found "on the ground" at two facilities in Beaver, Alaska, and attempts to demonstrate, by use of a realistic, though hypothetical, example, the feasibility of installing a high efficiency, low emission cordwood boiler to heat these facilities.

The facilities in Beaver consist of two distinct entities in close proximity that could be served by a single cordwood boiler (i.e., small district heating system). These facilities are described in greater detail in Section 1.3, and include:

1. Beaver Village Council multi-purpose building
2. Water plant/washeteria

In terms of siting a central heat plant, the easiest location appears to be in a vacant lot directly behind the water plant/washeteria. It may be possible to locate a heating plant in a more mutually beneficial location (to both buildings), but that site is currently occupied by an unoccupied house whose disposition is unknown.

Typically, the greater the amount of fuel oil displacement, the better the cost-effectiveness of a given project. However, the relative cost of cordwood versus fuel oil exerts a strong influence on the financial metrics. Viable projects are characterized by having a simple payback period of 10 years or less, a positive net present value, and an internal rate of return greater than the stated/assumed discount rate. The financial metrics in this scenario are all somewhat less that optimal. With a simple payback period of 10.42 years, net present value of -$2,216 and an internal rate of return of 2.94 percent, the cost-effectiveness of this project is marginal. That does not mean that a wood-fired heating system won't save money; it will. And the value of keeping the money (money that would otherwise leave the community), in Beaver, providing jobs and income to local residents, cannot be minimized.

However, the ultimate success of the project is predicated on two assumptions: 1) that sufficient volumes of wood can be provided at a reasonable cost and 2) that someone will tend the boilers. Failure on either count will compromise the success of the project.