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

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Key words: HELE, LEHE, bulk fuel, cordwood

ABSTRACT

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

Early in 2007, 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 Northway during the summer of 2007 and information was obtained for the various facilities. Preliminary assessments were made and challenges identified. Potential wood energy systems were considered for the projects 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 Northway 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 and maintenance 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, sustainability of the wood supply, community support, and project implementation, operation and maintenance.

- Given annual fuel oil consumption estimates of 4,500 gallons (Community Hall and Village Office Building) and 8,900 gallons plus 1,300 gallons of propane (Truck Garage and Clinic Building), these projects would be considered small to medium terms of their relative sizes. The Emergency Services Building, with an annual fuel consumption estimate of 2,800 gallons would be considered small in terms of oil consumption.

- 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

Three facility "clusters" are considered in this report:

1.3.1. Community Hall and Northway Village Council (NVC) Office Building

• Overview. The Community Hall and NVC Office Building are located next to one another and could potentially be served by a common wood-fired boiler of appropriate size.

1.3.1.1. The Community Hall, occupies approximately 2,900 square feet; is of 3-sided log construction, and is approximately 20 years old. Primary heat is provided by a Weil-McLain Gold A/B-WTGO-7 boiler rated at 210,000 Btu per hour (net), in fair condition.

Heat from this boiler, in the form of hot water, is distributed via fin tube pipe around the interior perimeter (2"x2" fins, approximately 65 fins per foot). This fin tube pipe is damaged almost everywhere in the building (i.e., bent fins). And probably needs to be replaced throughout. In addition, most of the fin tube is covered by perimeter bench seating, which impedes air circulation. There are also four radiator-type heat exchangers that appear to be functional.

Supplemental heat is provided by a Monitor 441 space heater rated at 40,000 Btu/hour. NOTE: The 441 model is notorious for failures, and service/repair-ability is exceedingly limited; the model has been discontinued.

Domestic hot water is provided by a single, 52-gallon, Kenmore®, electric water heater.

1.3.1.2. The NVC Office Building, occupies approximately 2,400 square feet, is of frame construction, and is in fair to poor condition overall (apparently poor insulation, poor/no vapor barriers, poor foundation, etc.). Heat is provided by a Weil-McLain Gold P-WGO-5 boiler, rated at 152,000 Btu per hour (net), in good condition. Heat, in the form of hot water, is distributed in 5 zones, via plumbing located in the ceiling.

• Fuel Consumption. The Community Hall reportedly consumes approximately **2,500** gallons of #1 fuel oil per year. The NVC Office Building reportedly consumes approximately **2,000** gallons of #1 fuel oil per year.

• Potential Savings. At the current price of about $5.00 per gallon, the current cost of heating the Community Hall and NVC Office Building amounts to $22,500 per year. The HELE *cordwood* fuel equivalent of 4,500 gallons of #1 fuel oil is approximately 53 cords, and at $175 per cord represents a potential annual fuel cost savings of $13,225 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the Community Hall and NVC Office Building (combined) is approximately 151,123 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 is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the relatively small heating demand, lack of known fuel supplies, and the probable costs of such a project, a "bulk fuel" system is not cost-effective for the Community Hall and NVC Office Building.

1.3.2. Maintenance/Truck Garage and Clinic/Washeteria/Water Plant

• Overview. The "Garage and Clinic" buildings are located near one another and could possibly be served by a common wood-fired boiler of appropriate size:

> 1.3.2.1. The Maintenance/Truck Garage is a modern steel building, approximately 2,400 square feet in size. There are two Weil-McLain P-WTGO-6 boilers, rated at 184,000 Btu per hour (net, each). Heat, via hot water, is distributed by two ceiling-mounted radiator-type heat exchangers in each of the two garage bays. These boilers also supply heat to the water line that feeds the Water Plant/Washeteria and Clinic.
>
> 1.3.2.2. The Clinic, Washeteria and Water Plant are co-located in one building occupying approximately 2,400 square feet. There are two boilers. The primary boiler is a Weil-McLain P-WTGO-6, rated at 184,000 Btu per hour (net), and the backup boiler is a Burnham V-905, rated at 464,000 Btu per hour (net). These boilers provide heat and domestic hot water to the entire building and to two hot-water-heated clothes driers. There are also four propane-fired clothes driers.

The two buildings are approximately 240 feet apart, and are separated by undeveloped land covered with native, woody and herbaceous vegetation. It appears that this land may be suitable for the construction/installation of a common, central wood-fired heating plant.

• Fuel Consumption. The Garage building reportedly consumes about **4,400** gallons of **#1** fuel oil per year, and the Clinic building uses about **4,500** gallons, plus **1,350** gallons of **propane** per year.

• Potential Savings. At the current price of about $5.00 per gallon, the cost of oil for the Garage and Clinic buildings amounts to $44,500 per year. The HELE *cordwood* fuel equivalent of 8,900 gallons of #1 fuel oil is approximately 104 cords, and at $175 per cord represents a potential annual fuel cost savings of $26,300 (debt service and non-fuel OM&R costs notwithstanding).

The annual cost of propane (for the clothes driers), at the current price of $3.50 per gallon, amounts to $**4,725**. The HELE *cordwood* fuel equivalent of 1,350 gallons of propane is approximately 11 cords, and at $175 per cord represents a potential annual fuel cost savings of $2,800 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the Garage and Clinic buildings during the coldest 24-hour period cannot be determined with the information provided (See Table 5-3, Footnote F).

• 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 is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the heating demand, lack of known fuel supplies, and the probable costs of such a project, a "bulk fuel" system is not cost-effective for the Garage and Clinic buildings.

1.3.3. Emergency Services Building (Fire Hall)

• Overview. The Emergency Services Building (Fire Hall) occupies approximately 2,300 square feet and houses the ambulance and fire truck. It is not in close proximity to any other Village-operated facility and it is not regularly occupied. The building was locked at the time of the AWEDTG field visit, and detailed information regarding the heating system was not available. Apparently, there is an oil-fired furnace that is set to keep the building and vehicles minimally warm.

• Fuel Consumption. The Fire Hall reportedly consumes approximately **2,800** gallons of **#1** fuel oil per year.

• Potential Savings. At the projected price of about $5.00 per gallon, it costs approximately $14,500 per year for fuel oil to heat the Fire Hall. The HELE *cordwood* fuel equivalent of 2,800 gallons of #1 fuel oil is approximately 33 cords, and at $175 per cord represents a potential annual fuel cost savings of $8,725 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the Northway Fire Hall is approximately 94,280 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 is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the heating demand, lack of known fuel supplies, and the probable costs of such a project, a "bulk fuel" system is not cost-effective for the Emergency Services Building.

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 Northway projects meet the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, use of local processing residues (from Tok), sustainability of the wood supply, community support, and the ability to implement, operate and maintain the project.

In the case of a cordwood boiler system, the potential to supply wood from local forests appears adequate and matches the application. Currently, "bulk fuel" in the form of sawmill residues is non-existent. Any bulk fuel heating system would be largely reliant upon forest-derived whole tree chips unless/until local sawmills install residue chippers.

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.

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(s) would sponsor and/or implement a wood-burning project. (NOTE: This is not necessarily the case with the projects in Northway but this issue should be addressed.)

With manual systems, boiler stoking and/or maintenance is required for approximately 5-15 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. Bulk fuel systems, although automated, also have a daily labor requirement. 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 in Northway is virtually non-existent. However, the forest industry infrastructure in Tok (approximately 60 miles away) is fairly well-developed. 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 heating 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, 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 downtime in the wood system.

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Currently, wood fuels in Northway will generally be in the form of cordwood and/or large unprocessed sawmill residues (slabs, edgings). There is also a chance that whole tree chips might be developed (near Tok) as a fuel in the future, if they can be produced at a reasonable cost. Currently, there is no local supply of bulk pellets, although there has been talk (and some action) of building pellet plants in Fairbanks, Delta Junction and Glennallen. Residential use of cordwood has

increased significantly in the past 18 months due to sharply higher fuel oil costs. Given that higher demand, prices for firewood have gone up accordingly.

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 recognized 'heating values': 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 weight basis (also called green weight basis), is used as benchmark. [It should be noted that other species are also present, including black spruce, white birch, cottonwood/poplar, willow and aspen. And although white spruce is used as the "benchmark", any species of wood can be burned in either cordwood or bulk fuel systems; the most critical factor being moisture content, not species.]

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

The RHV for white spruce cordwood (MC30) 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.

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

Outdoor wood boilers (OWBs) are relatively low-cost and can save fuel but most 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. The State of New York instituted a moratorium in 2006 on new LEHE OWB installations due to concerns over emissions and air quality[5]. Other states are also considering or have implemented new regulations[6,7,8,9]. But since there are no federal standards for OWBs (wood-fired boilers and furnaces were exempted from the 1988 EPA regulations[10]), OWB ratings are inconsistent and can be misleading. Standard procedures for evaluating wood boilers do 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 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 1 standard calls for emissions not to exceed 0.60 pounds of

particulate emissions per million Btu of heat **input**. The Phase 2 standard, which will follow 2 years after Phase 1, 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. As a result, 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 correctly be considered high efficiency, low emission (HELE). These systems are designed to burn cordwood fuel cleanly and efficiently.

Table 4-1 lists three HELE cordwood boiler suppliers, all of which have units operating in Alaska. Greenwood and Tarm 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 #2 fuel oil.[14] Two Garn boilers were also recently installed in Tanana, AK (on the Yukon River) to provide heat to the washeteria and water plant, and two were installed near Kasilof on the Kenai Peninsula.

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 results for a Garn WHS 1350 boiler that was tested at 157,000 to 173,000 Btu/hr 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 essentially non-existent around Northway, the cost of bulk fuel systems is so high (i.e., $1 million and up), and the relatively small heating demand for the projects 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.

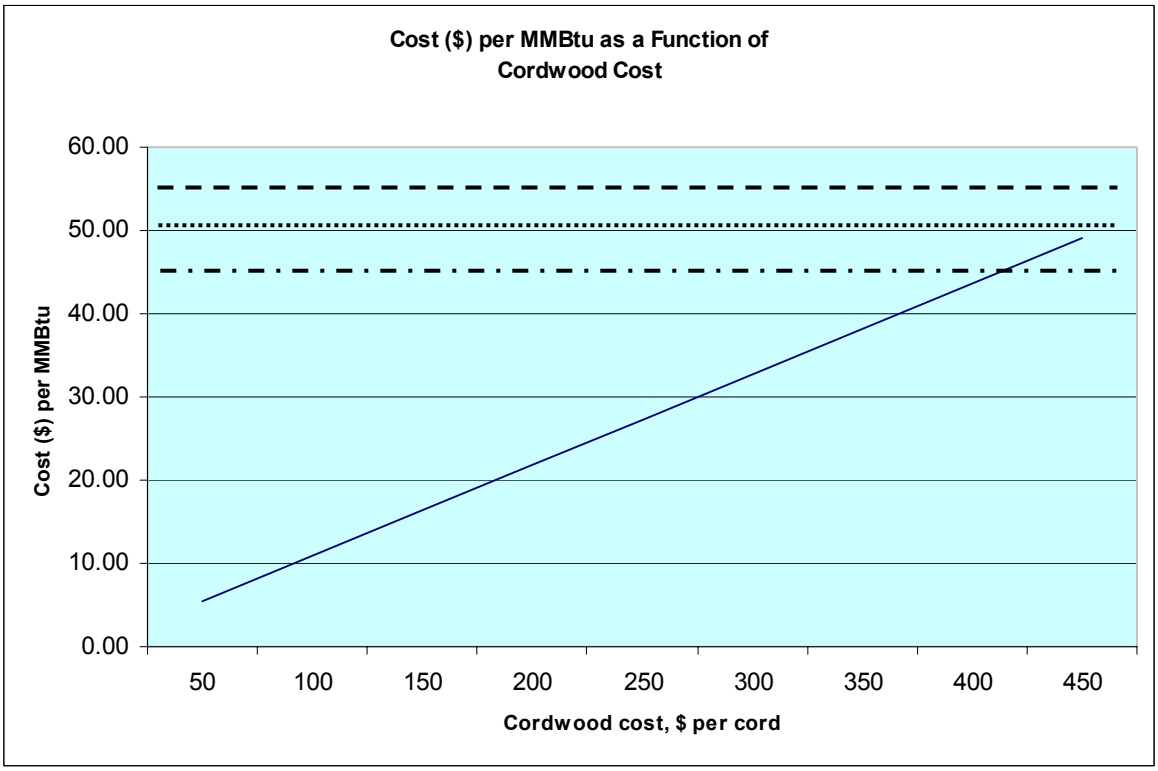
Table 5-1. Comparative Cost of Fuel Oil vs. Wood Fuels					
FUEL	RHV[a] (Btu)	Conversion Efficiency[a]	DHV[a] (Btu)	Price per unit ($)	Cost per MMBtu (delivered, ($))
Fuel oil, #1, (per 1 gallon)	134,000	80%	107,200 per gallon	5.00/gal	46.642
				5.50	51.306
				6.00	55.970
White spruce, (per 1 cord, MC30)	12.22 million	75%	9.165 million	150/cord	16.367
				175	19.094
				200	21.822

Notes:
[a] from Appendix D

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 (on the 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 $5.00, $5.50 and $6.00 per gallon ($46.642, $51.306 and $55.97 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $427.47 per cord is equal to the cost of #1 fuel oil at $5.00 per gallon (i.e., $46.642 per MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $175 per cord, a high-efficiency cordwood boiler will deliver heat at about 41% of the cost of #1 fuel oil at $5.00 per gallon ($19.094 versus $46.642 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 $6.00 per gallon
Fuel Oil at $5.50 per gallon
Fuel Oil at $5.00 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 Northway, Alaska.

Table 5-2. Reported Annual Fuel Oil Consumption, Northway, AK

Facility	Reported Annual Fuel Consumption	
	Gallons	*Cost ($) @ $5.00/gallon*
Community Hall and NVC Office Building	4,500	22,500
Garage and Clinic	8,900 (plus 1,350 gal propane)	44,500 (plus 4,725)
Fire Hall	2,800	14,000
TOTAL	**16,200** (plus 1,350 gal propane)	**81,000** (plus 4,725)

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 Northway 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.

Typically, installed oil-fired heating capacity at most sites is two-to-four times the demand for the coldest day. It appears that the installed heating capacity at Community Hall and Village Office Building (combined) falls within this range, but the heating capacity of the furnace at the Fire Hall is unknown. And although the installed heating capacity of the boilers at the Truck Garage and Clinic Building *is* known, it is not known how much fuel is consumed for space heating purposes and how much is used to heat water (for water treatment, domestic use or drying clothes). Therefore, the RBC to satisfy the heating requirements only could not be determined.

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 425,000 Btu/hr (heat into storage), a Garn WHS 2000 can store about 1.27 million Btu, which, theoretically, would be enough to heat the Community Hall and Village Offices during the coldest 24-hour period for about 8½ hours (1,272,000 ÷ 151,123).

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]
Community Hall Village Offices Total	2,500 2,000 4,500	15,763 (Fairbanks data)	30,603	-53	151,123	210,000+40,000 152,000 402,000
Truck Garage Clinic Bldg. Total	4,400 4,500 8,900		60,527		298,246[f]	368,000 648,000 1,016,000
Fire Hall	2,800		19,042		94,280	unknown

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] The estimate of RBC is based on total oil consumption. However, in addition to providing space heat, some fuel is used to heat water for water treatment, domestic use, and/or to dry clothes. Caution must be used when applying this number.

According to these calculations (Table 5-3), it appears that the Northway facilities 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 Northway. [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		*5.00/gal*	*5.50/gal*	*6.00/gal*	W. spruce, MC30, CE 75%	*150/cord*	175/cord	*200/cord*	*Low*	*Medium*	*High*
Community Hall and NVC Office Building	4,500	22,500	24,750	27,000	**53**	7,950	9,275	10,600	11,900	15,475	19,050
Garage and Clinic	8,900	44,500	48,950	53,400	**104**	15,600	18,200	20,800	23,700	30,750	37,800
Fire Hall	2,800	14,000	15,400	16,800	**33**	4,950	5,775	6,600	7,400	9,625	11,850
Total	**16,200**	**81,000**	**89,100**	**97,200**	**190**	**28,500**	**33,250**	**38,000**	**43,000**	**55,850**	**68,700**

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 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, several hypothetical, though hopefully realistic, system scenarios are 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 hypothetical scenarios of initial investment costs for cordwood systems in small and medium heating demand situations. Three scenarios are presented.

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 and/or iron 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 very 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 <u>gross estimates</u>.

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

Table 6-1. Initial Investment Cost Scenarios for Hypothetical HELE Cordwood Systems				
Fuel oil consumption, gallons per year		4,500 (Hall and Offices)	8,900 (Garage and Clinic)	2,800 (Fire Hall)
Required boiler capacity (RBC), Btu/hr		151,123	298,246[f]	94,280
Cordwood boiler	Garn model	(1) Garn WHS 2000	(2) Garn WHS 2000 (combined capacity)	(1) Garn WHS 1500
	Rating -Btu/hr [e]	425,000	850,000	350,000
	Btu stored	1,272,000	2,544,000	920,000
Building and Equipment (B&E) Costs, **$** (for discussion purposes only)				
Fuel storage building[a] (fabric bldg, gravel pad, $20 per sf)		21,200 (53 cds @ 20 sf/cd)	41,600 (104 cds @ 20 sf/cd)	13,200 (33 cds @ 20 sf/cd)
Boiler building @ $125 per sf (minimum footprint w/concrete pad)[b]		16,000 (8'x16')	32,000 (16'x16')	12,000 (8'x12')
Boilers				
Base price[c]		14,900	29,800	12,000
Shipping[d]		2,500	5,000	2,500
Bush delivery [d]		NA	NA	NA
Plumbing and electrical[d]		35,000	60,000	20,000
Installation[d]		17,500	30,000	10,000
Subtotal - B&E Costs		**107,100**	**198,400**	**69,700**
Contingency (25%)[d]		26,775	49,600	17,425
Grand Total		**133,875**	**248,000**	**87,125**

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

[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.

[f] As noted in Table 5-3, the estimate of RBC is based on total oil consumption at these facilities. However, in addition to providing space heat, some fuel is used to heat water for water treatment, domestic use, and/or to dry clothes. Caution must be used when applying this number.

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 HELE Cordwood Systems

System	(1) Garn WHS 2000 53 cds	(2) Garn WHS 2000 (combined capacity) 104 cds	(1) Garn WHS 1500 33 cds
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	147.0	378.2	56.9
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	26.5	52.0	16.5
Total Annual labor (hrs/yr)[b]	20	40	20
Total labor (hrs/yr)	193.5	470.2	93.4
Total annual labor cost ($/yr) (total hrs x $20)	**3,870**	**9,404**	**1,868**

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 examples, 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 ($)		
	(1) Garn WHS 2000 53 cds/yr	(2) Garn WHS 2000 (combined capacity) 104 cds/yr	(1) Garn WHS 1500 33 cds/yr
Labor	3,870	9,404	1,868
Electricity[a]	295	578	183
Maintenance/Repairs	1,000	2,000	1,000
Total non-fuel OM&R ($)	**5,165**	**11,982**	**3,051**

Notes:
a Electrical cost based on a formula of horsepower x kWh rate x operating time. Assumed kWh rate = $0.20

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 hypothetical multiple HELE cordwood boiler installations.

Table 6-4. Simple Payback Period Analysis for HELE Cordwood Boilers

	(1) Garn WHS 2000 53 cds/yr	(2) Garn WHS 2000 (combined capacity) 104 cds/yr	(1) Garn WHS 1500 33 cds/yr
Fuel oil cost, $ per year @ $5.00 per gallon	22,500 (4,500 gal)	44,500 (8,900 gal)	14,000 (2,800 gal)
Cordwood cost $ per year @ $175 per cord	9,275 (53 cds)	18,200 (104 cds)	5,775 (33 cds)
Annual Fuel Cost Savings, $/yr	13,225	26,300	8,225
Total Investment Costs [b], $	133,875	248,000	87,125
Simple Payback[c], yrs	**10.12**	**9.43**	**10.59**
Annual, Non-fuel OM&R costs[a]	5,165	11,982	3,051
Net Annual Savings ($) (Annual Cash Flow)	8,060	14,318	5,174

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 Various HELE Cordwood Boiler Installation Options

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

Table 6-5. PV, NPV and IRR Values for Various HELE Cordwood Boilers Options

	(1) Garn WHS 2000 53 cds/yr	(2) Garn WHS 2000 (combined capacity) 104 cds/yr	(1) Garn WHS 1500 33 cds/yr
Discount Rate[a] (%)	3		
Time, "t", (years)	20		
Initial Investment ($)[b]	133,875	248,000	87,125
Annual Cash Flow($)[c] (Net Annual Savings)	8,060	14,318	5,174
Present Value (of expected cash flows, $ at "t" years)	119,912	213,016	76,976
Net Present Value ($ at "t" years)	-13,963	-34,984	-10,149
Internal Rate of Return (% at "t" years)	1.84	1.41	1.70
See Note #_ below	1	2	3

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 $119,912 today (PV), which is less than the initial investment of $133,875. The resulting NPV of the project is -$13,936, 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 does not appear to be cost-effective, strictly on a financial returns basis.

The financial metrics would not classify this as a "good 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 $5.00 per gallon and wood at $175/cord, the NPV is only slightly negative and the internal rate of return would be positive 1.84%.

Note #2. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $213,016 today (PV), which is less than the initial investment of $248,000. The resulting NPV of the project is -$34,984, 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 does not appear to be cost-effective, strictly on a financial returns basis.

The financial metrics would not classify this as a "good 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 $5.00 per gallon and wood at $175/cord, the NPV is only slightly negative and the internal rate of return would be positive 1.41%.

Note #3. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $76,976 today (PV), which is less than the initial investment of $87,125. The resulting NPV of the project is -$10,149, 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 does not appear to be cost-effective, strictly on a financial returns basis.

The financial metrics would not classify this as a "good 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 $5.00 per gallon and wood at $175/cord, the NPV is only slightly negative and the internal rate of return would be positive 1.7%.

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 various facilities in Northway, Alaska, and attempts to demonstrate, by use of realistic, though hypothetical, examples the feasibility of installing high efficiency, low emission cordwood boilers to heat these facilities.

The facilities in Northway consist of several distinct entities and are described in greater detail in Section 1.3. They include:

1. Community Hall and NVC Office Building
2. Truck/Maintenance Garage and Clinic/Washeteria/Water Plant building
3. Emergency Services Building (Fire Hall)

In terms of sites, none of the proposed project sites appear to present any geo-physical constraints for the construction of individual wood-fired heating plants. In fact, the conditions in the general area of the projects appear to be quite favorable for construction projects.

Each of the facilities under consideration could be heated with a HELE cordwood boiler system. In the case of the Fire Hall, a single small Garn unit would appear to be sufficient. For the Community Hall and Office Building, a single, medium-sized Garn boiler would appear to be sufficient. And for the Truck Garage and Clinic, a pair of medium-sized Garn boilers would be necessary to provide heat at the desired level and be operationally feasible.

Typically, the greater the fuel oil replacement the better the cost-effectiveness of a given project and that is somewhat evident with these facilities. However, none of the proposed projects shows particularly strong financial metrics. Simple payback periods range from about 9½ years to about 10½ years, and present values of expected cash flows (PV) are all less than the estimated initial investment costs. Internal rates of return, though low, are however, positive; ranging from 1.41 to 1.84 percent.

Keep in mind that this is only a preliminary feasibility report; the financial metrics are only as good as the assumptions. Lower initial investment costs, and/or greater differences between the cost of oil and the cost of wood will improve the cost-effectiveness of these projects. Consultation with qualified professionals is warranted.