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

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Notice
This Preliminary Feasibility Assessment for High Efficiency, Low Emission Wood Heating was prepared by Daniel Parrent, Wood Utilization Specialist, Juneau Economic Development Council for Joe Banghart and Dave Shelborne (Iditarod Area School District) and Natalie Baumgartner (City of McGrath) McGrath, AK. This report does not necessarily represent the views of the Juneau Economic Development Council (JEDC). JEDC, its Board, employees, contractors, and subcontractors make no warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by JEDC nor has JEDC passed upon the accuracy or adequacy of the information in this report.

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ABSTRACT

The potential for heating various facilities in McGrath, AK with high efficiency, low emission (HELE) wood-fired boilers is evaluated for the Iditarod Area School District and the City of McGrath.

Early in 2007, organizations were invited to submit a Statement of Interest (SOI) to the Alaska Wood Energy Development Task Group (AWEDTG). Task Group members reviewed all the SOIs and selected projects for further review based on the selection criteria presented in Appendix A. AWEDTG representatives visited McGrath 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 the facilities in McGrath 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 fuel oil consumption estimates of 7,500 (IASD Office Building), 29,000 (McGrath School and warehouse), and 23,500 (Captain Snow Center) gallons per year, these projects would be considered medium to large in terms of their relative scales.

- 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 facilities are considered in this report: The Iditarod Area School District (IASD) Administration Building (which includes IASD Offices, McGrath Library and UAF Museum), IASD McGrath School, and the City of McGrath's Captain Snow Center (which includes offices, health clinic, public safety, washeteria, water plant, and city shop (in a separate building)). Each major facility will be considered separately as appropriate.

1.3.1. IASD Administration Building

• Overview. The IASD Administration Building is a two-story frame building occupying approximately 8,000 square feet. Heat is provided by two Armstrong L5B168DC20-1 oil-fired furnaces, each rated at 166 MBH. One furnace is located on the first floor and another is located on the second floor. Supplemental heat is provided, as needed, by small electric space heaters in individual offices.

• Fuel Consumption. The IASD Administration Building consumes approximately **7,500** gallons of **#1** fuel oil per year.

• Potential Savings. At the current price of about $5.50 per gallon (June 2008), the IASD will pay approximately $41,250 per year for fuel oil. The HELE *cordwood* fuel equivalent of 7,500 gallons of #1 fuel oil is approximately 88 cords, and at $275 per cord represents a potential annual fuel cost savings of $17,050 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the IASD Administration Building is approximately 258,052 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 reasonably viable. Further consideration is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the relatively small heating demand, apparent lack of ready fuel supply, and the probable costs of the project, a "bulk fuel" system is not cost-effective for the IASD Administration Building.

1.3.2. IASD McGrath School

• Overview. The McGrath School occupies approximately 32,500 square feet and provides instruction for approximately 50 students. Heat is provided by two 5-year old Burnham V1107 boilers, each rated at 1,114 MBH (net) with maximum firing rates of 11 gallons per hour (each). Heat is distributed via a 4-zone glycol loop. The building and boilers appear to be in good condition and well-maintained. Domestic hot water is supplied by an older PVI Industries 20-G-250-A-O (model) 250-gallon, oil-fired water heater. An adjacent warehouse occupies approximately 3,200 square feet and has its own heating system, although details were not recorded.

• Fuel Consumption. The McGrath School is reported to consume approximately **26,000** gallons of **#1** fuel oil per year, and the warehouse uses approximately **3,000** gallons.

• Potential Savings. At the current price of about $5.50 per gallon (June 2008), the IASD McGrath School will pay approximately $159,500 per year for fuel oil (including fuel for the warehouse). The HELE *cordwood* fuel equivalent of 29,000 gallons of #1 fuel oil is approximately 340 cords, and at $275 per cord represents a potential annual fuel cost savings of $66,000 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the McGrath School is approximately 966,060 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 economically and operationally viable. Further consideration is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the apparent lack of ready fuel supply, and the probable costs of the project, a "bulk fuel" system is not cost-effective for the IASD McGrath School.

1.3.3. Captain Snow Center

• Overview. The City of McGrath's Captain Snow Center is a two-story frame building, approximately 30 years old, occupying approximately 12,000 square feet. It is a multi-purpose facility housing city offices, the health clinic, public safety, washeteria and water treatment plant. The city's shop/garage is a small, separate structure located on the same site. Also located on the same site is the McGrath fuel tank farm.

Heat to the Captain Snow Center and clinic is provided by two Burnham PF-37 boilers, each rated at 457.4 MBH (net) with a maximum firing rate of 4.6 gallons per hour (each). The water treatment plant utilizes one Weil-McLain PL-586-WF boiler rated at 940 MBH (gross) with a maximum firing rate of 8.25 gallons per hour. This boiler also pre-heats air going into the Captain Snow Center. There are three small heat exchangers that are scheduled for replacement in the near future. Domestic hot water and washeteria water is supplied by a single 85-gallon Bock 541E oil-fired water heater. The details regarding the heating system in the shop/garage were not recorded.

• Fuel Consumption. The Captain Snow Center, excluding the water treatment plant, reportedly consumes **14,000 to 15,000** gallons of **#1** fuel oil per year. The water treatment plant reportedly consumes **6,500 to 7,000** gallons of **#1** fuel oil per year, and the shop/garage consumes approximately **1,900 to 2,000** gallons of **#1** fuel oil per year, for a total of 22,400 to 24,000 gallons per year (an average figure of **23,500** is used in the report).

• Potential Savings. At the current price of about $5.50 per gallon, the City will pay approximately $129,250 per year for fuel oil for the Captain Snow Center (inclusive of all facilities). The HELE *cordwood* fuel equivalent of 23,500 gallons of #1 fuel oil is approximately 275 cords, and at $275 per cord represents a potential annual fuel cost savings of $53,625 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the Captain Snow Center is approximately 738,616 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 economically and operationally viable. Further consideration is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the apparent lack of ready fuel supply, and the probable costs of the project, a "bulk fuel" system is not cost-effective for the Captain Snow Center.

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 the criteria listed in Appendix A. The McGrath projects meet the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, use of local processing residues, 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* wood supply from forest resources or local processing residues appears adequate and matches the application. Currently, "bulk fuel" (sawdust, wood chips, bark, planer shavings, pellets, etc.) is very limited or non-existent in/around McGrath, and therefore is not a viable fuel for consideration.

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 or implement a wood-burning project. (NOTE: This is not necessarily the case with the projects in McGrath 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. For this report, it is assumed that new personnel would be hired or existing personnel would be assigned as necessary, and that "boiler duties" would be included in the responsibilities and/or job description of facility personnel.

There is some pre-existing forest industry infrastructure and activity in/around McGrath, although additional harvesting and processing capacity would probably have to be developed in order to supply wood on a scale as would be necessary for the success of the proposed projects (i.e., 700 cords per year). The wood supply *must* be verified before embarking upon a wood-fired boiler construction project.

2.3 Classes of Wood Energy Heating Systems

There are, basically, two classes of wood energy 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 McGrath will generally be in the form of cordwood or large unprocessed sawmill residues (i.e., slab wood). 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.

Currently there is no local supply of bulk fuel (wood chips, sawdust, bark, pellets, etc.), and the cost of mobilizing that capacity and producing such fuel would probably be prohibitive. Furthermore, the cost of a bulk fuel heating system (over $1 million) would probably preclude it from being cost-effective in the McGrath applications.

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 the benchmark. [It should be noted that other species are also present, including black spruce, birch, cottonwood/poplar, willow and aspen. And although white spruce is used as the "benchmark", any species of wood can be burned in cordwood fuel systems; the most critical factor being moisture content, not species.]

The HHV of white spruce at 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

Many 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 regulations[6,7,8,9] or have already implemented them. But since there are no 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 boiler 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 correctly be considered high efficiency, low emission (HELE). These systems are designed to burn cordwood fuel cleanly and efficiently.

Table 4-1 lists four HELE cordwood boiler suppliers, two of which have units operating in Alaska. HS Tarm/Tarm USA has 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 recently installed in Tanana, AK (on the Yukon River) to provide heat to the washeteria and water plant, and two more were recently installed near Kasilof on the Kenai Peninsula.

Table 4-1. HELE Cordwood Boiler Suppliers		
	Btu/hr ratings	Supplier
EKO-Line	85,000 to 275,000	New Horizon Corp www.newhorizoncorp.com
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.dectra.net/garn
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. However, it should be noted 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	

Cordwood boilers are suitable for applications from 100,000 Btu/hr to 1,000,000 Btu/hr, although both larger and smaller applications are possible.

4.3 Bulk Fuel Boiler Systems

The term "bulk fuel" refers, generically, to sawdust, wood chips, shavings, bark, pellets, etc. Since the availability of bulk fuel is very limited or non-existent in McGrath, the cost of bulk fuel systems being so high (i.e., $1 million and up), and the relatively small heating demand for the facilities under consideration (i.e., less than 1 million Btu per hour), 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	250/cord	27.278
				275	30.005
				300	32.733

Notes:
[a] from Appendix D
DHV = RHV x Conversion Efficiency

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 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 $55.970 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $470.22 per cord is equal to the cost of #1 fuel oil at $5.50 per gallon (i.e., $51.306 per MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $275 per cord, a high-efficiency cordwood boiler will deliver heat at less than 59% of the cost of #1 fuel oil at $5.50 per gallon ($30.005 versus $51.306 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.

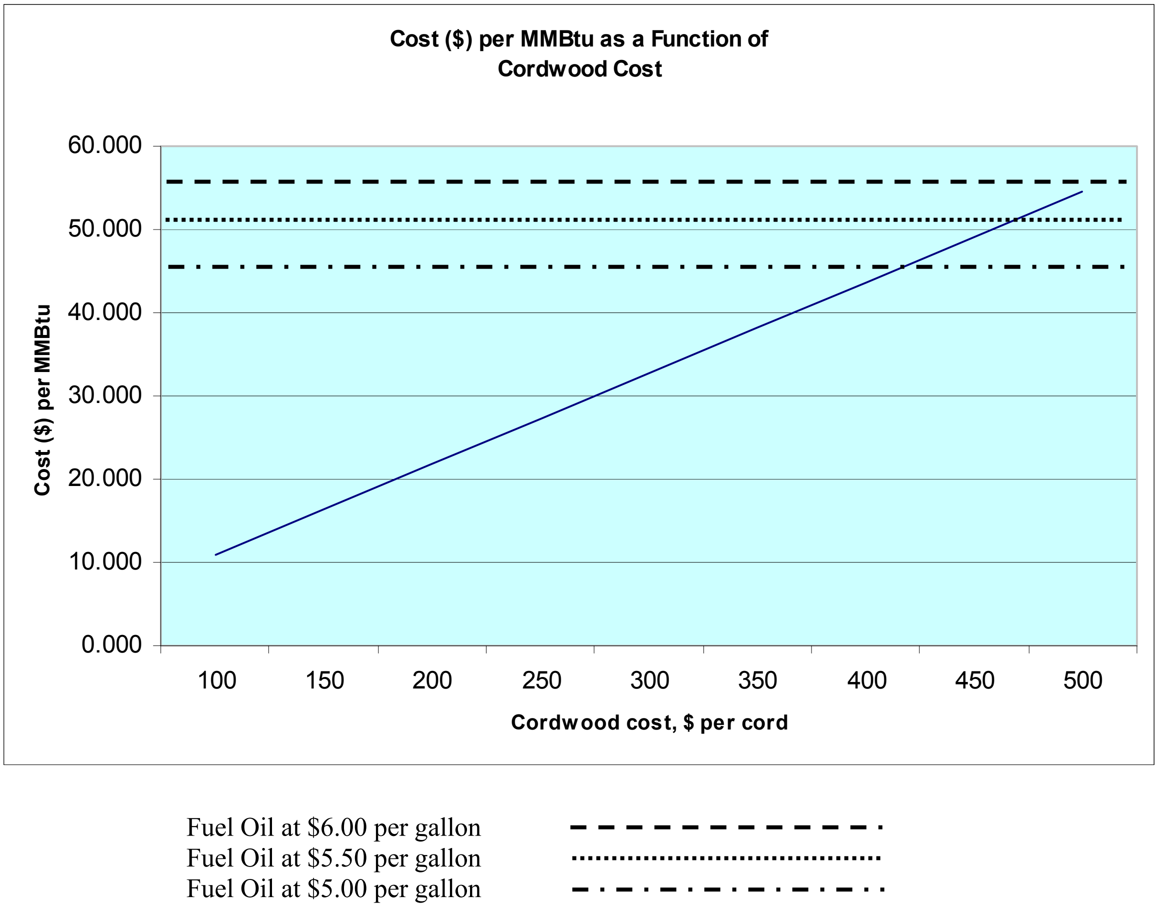

Figure 5-1. Effect of White Spruce Cordwood Price on Cost of Delivered Heat

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 the facilities in McGrath.

Table 5-2. Reported Annual Fuel Oil Consumption in McGrath

Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $5.50/gallon*
IASD Administration Bldg	7,500	41,250
IASD McGrath School	29,000	159,500
Captain Snow Center	23,500	129,250
TOTAL	**60,000**	**330,000**

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 McGrath 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.

Table 5-3. Estimate of Heat Required in Coldest 24-Hour Period, McGrath Facilities

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]
IASD Admin. Bldg.	7,500	14,574	55,167	-47	258,052	332,000
McGrath School	29,000		213,311		996,060	2,228,000
Captain Snow (excluding shop)	21,500		158,145		738,616	1,854,800

Notes:
[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

Typically, installed oil-fired heating capacity at most sites is two-to-four times the demand for the coldest day, and this is generally true for the facilities in McGrath. However, the installed capacity at the IASD Administration Building appears to be well-below that general guideline, which may explain the need for supplemental heat on very cold days.

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 single Garn WHS 3200 can store more than 2 million Btu, which would be enough to heat the IASD Administration Building during the coldest 24-hour period for nearly 8 hours (2,064,000 ÷ 258,052).

** 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.*

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 McGrath. [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 ($)		
		5.00/gal	*5.50/gal*	*6 .00/gal*	W. spruce, MC30, CE 75%	*250/cord*	*275/cord*	*300/cord*	*Low*	*Medium*	*High*
IASD Admin. Bldg.	7,500	37,500	41,250	45,000	88	22,000	24,200	26,400	11,100	17,050	23,000
McGrath School	29,000	145,000	159,500	174,000	340	85,000	93,500	102,000	43,000	66,000	89,000
Captain Snow Center	23,500	117,500	129,250	141,000	275	68,750	75,625	82,500	35,000	53,625	72,250
Total	**60,000**	**300,000**	**330,000**	**360,000**	**703**	**175,750**	**193,325**	**210,900**	**89,100**	**136,675**	**184,250**

NOTES:
[a] From Table 5-2
[b] From Table D-3, Fuel Oil Equivalents; 85.5 gallons per cord (MC30)

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, 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 (on the next page) presents hypothetical scenarios of initial investment costs for cordwood systems in a medium heating demand situation. Three alternatives 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 to achieve favorable financial returns, especially at smaller facilities. 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 or improvements to the existing heating/heat distribution system currently in place.

Table 6-1. Initial Investment Cost Scenarios for Hypothetical HELE Cordwood Systems				
Fuel oil consumption (gallons per year)		(IASD Admin Bldg) 7,500	(McGrath School) 29,000	(Captain Snow Center) 23,500
Required boiler capacity (RBC), Btu/hr		258,052	996,060	738,616
Cordwood boiler	(#) Garn model	(1) Garn WHS 3200	(3) WHS 3200 (combined capacity)	(2) WHS 3200 (combined capacity)
	Rating -Btu/hr [e]	950,000	2,850,000	1,900,000
	Btu stored	2,064,000	6,192,000	4,128,000
		Building and Equipment (B&E) Costs, **$** (for discussion purposes only)		
Fuel storage building[a] (fabric bldg, gravel pad, $25 per s.f.)		44,000 (88 cds @ 20 s.f./cd)	170,000 (340 cds @ 20 s.f./cd)	137,500 (275 cds @ 20 s.f./cd)
Boiler building @ $150 per sf (minimum footprint w/concrete pad)[b]		30,000 (10'x20')	90,000 (30'x20')	60,000 (20'x20')
Boilers				
Base price[c]		32,900	98,700	65,800
Shipping to Fairbanks[d]		4,500	13,500	9,000
Bush delivery [d]		2,000	6,000	4,000
Plumbing and electrical[d]		35,000	70,000	80,000
Installation[d]		17,500	35,000	40,000
Subtotal - B&E Costs		**165,900**	**483,200**	**396,300**
Contingency (25%)[d]		**41,475**	**120,800**	**99,075**
Grand Total		**207,375**	**604,000**	**495,375**

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 (s.f.) 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.

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			
	IASD Admin Bldg	**McGrath School**	**Captain Snow Center**
System	(1) WHS 3200	(3) WHS 3200	(2) WHS 3200
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	62.16	239.4	193.6
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	44.1	170.1	137.7
Total Annual labor (hrs/yr)[b]	20	60	40
Total labor (hrs/yr)	126.26	469.5	371.3
Total annual labor cost ($/yr) (total hrs x $20)	**2,525.20**	**9,390.00**	**7,426.00**

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. One estimate predicted that, at $0.30 per kWh, the cost of operating the fan would be approximately $100-$200 per boiler per year[4] depending to a large extent on the heating load. 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, and water treatment chemicals. This has been suggested at $300-$500 per year[4].

Table 6-3. Summary of Total Annual Non-Fuel OM&R Cost Estimates			
Item	Cost/Allowance ($)		
	IASD Admin Bldg	**McGrath School**	**Captain Snow Center**
	(1) WHS 3200	(3) WHS 3200	(2) WHS 3200
Labor	2,525.20	9,390.00	7,426.00
Electricity	393.36	1,514.95	1,225.25
Maintenance/Repairs	400.00	1,200.00	800.00
Total non-fuel OM&R ($)	**3,318.56**	**12,104.95**	**9,451.25**

6.4 Calculation of Financial Metrics

Biomass heating projects are viable over the long run, when 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 a fossil fuel 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 financial 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)
Life Cycle Cost (LCC)

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

	IASD Admin Bldg	McGrath School	Captain Snow Center
	(1) WHS 3200	(3) WHS 3200	(2) WHS 3200
Fuel oil cost ($ per year @ $5.50 per gallon)	41,250	159,500	129,250
Cordwood cost ($ per year @ $275 per cord)	24,200	93,500	75,625
Annual Fuel Cost Savings ($)	17,050	66,000	53,625
Annual, Non-fuel OM&R costs[a]	3,319	12,105	9,451
Net Annual Savings ($) (Annual Cash Flow)	13,731	53,895	44,174
Total Investment Costs ($)[b]	207,375	604,000	495,375
Simple Payback (yrs)[c]	**12.16**	**9.15**	**9.24**

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

	IASD Admin Bldg	McGrath School	Captain Snow Center
	(1) WHS 3200	(3) WHS 3200	(2) WHS 3200
Discount Rate[a] (%)	3		
Time, "t", (years)	20		
Initial Investment ($)[b]	207,375	604,000	495,375
Annual Cash Flow($)[c] (Net Annual Savings)	13,731	53,895	44,174
Present Value (of expected cash flows, $ at "t" years)	204,283	801,822	657,198
Net Present Value ($ at "t" years)	-3,092	197,822	161,823
Internal Rate of Return (% at "t" years)	2.84	6.29	6.28
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, Energy Price Indices and Discount Factors for Life Cycle Cost Analysis, April 2007
[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 $204,283 today (PV), which is less than the initial investment of $207,375. The resulting NPV of the project is -$3,092, 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. However, the internal rate of return IS positive (2.84%), and given that this report is only a pre-feasibility assessment, this option could "pencil out" given "real" numbers.

Note #2. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $801,822 today (PV), which is greater than the initial investment of $604,000. The resulting NPV of the project is $197,822 and the project achieves an internal rate of return of 6.29% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears financially and operationally feasible.

Note #3. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $657,198 today (PV), which is greater than the initial investment of $495,375. The resulting NPV of the project is $161,823 and the project achieves an internal rate of return of 6.28% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears financially and operationally feasible.

6.7 Life Cycle Cost Analysis – McGrath School

The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost (LCC) as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time. Life Cycle Cost Analysis (LCCA) is an economic evaluation technique that determines the total cost of owning and operating a facility over a period of time. Alaska Statute 14.11.013 directs the Department of Education and Early Development (EED) to review school capital projects to ensure they are in the best interest of the state, and AS 14.11.014 stipulates the development of criteria to achieve cost effective school construction.[19]

While a full-blown life cycle cost analysis is beyond the scope of this preliminary feasibility assessment, an attempt is made here to address some of the major items and run a rudimentary LCCA using the Alaska EED LCCA Handbook and spreadsheet.

According to the EED LCCA Handbook, the life cycle cost equation can be broken down into three variables: the **costs** of ownership, the period of **time** over which the costs are incurred (recommended period is 20 years), and the **discount rate** that is applied to future costs to equate them to present costs.

There are two major costs of ownership categories: **initial expenses** and **future expenses**. Initial expenses are all costs incurred prior to occupation (or use) of a facility, and future expenses are all costs incurred upon occupation (or use) of a facility. Future expenses are further categorized as **operation costs**, **maintenance and repair costs**, **replacement costs**, and **residual value**. A comprehensive list of items in each of these categories is included in the EED LCCA Handbook.

The discount rate is defined as, "the rate of interest reflecting the investor's time value of money", or, the interest rate that would make an investor indifferent as to whether s/he received payment now or a greater payment at some time in the future. NIST takes the definition a step further by separating it into two types: **real** discount rates and **nominal** discount rates. The **real discount rate** *excludes* the rate of inflation and the **nominal discount rate** *includes* the rate of inflation.[19] The EED LCCA Handbook and spreadsheet focuses on the use of real discount rates in the LCC analysis.

To establish a standard discount rate for use in the LCCA, EED adopted the US Department of Energy's (DOE) real discount rate. This rate is updated and published annually in the Energy Price Indices and Discount Factors for Life Cycle Cost Analysis – Annual Supplement to NIST Handbook 135 (www1.eere.energy.gov). The DOE discount and inflation rates for 2008 are as follows:

Real rate (excluding general price inflation)	3.0%
Nominal rate (including general price inflation)	4.9%
Implied long term average rate of inflation	1.8%

Other LCCA terms

Constant dollars: dollars of uniform purchasing power tied to a reference year and *exclusive of* general price inflation or deflation

Current dollars: dollars of non-uniform purchasing power, *including* general price inflation or deflation, in which actual prices are stated

Present value: the time equivalent value of past, present or future cash flows as of the beginning of the base year.

NOTE: When using the *real discount rate* in present value calculations, costs must be expressed in *constant* dollars. When using the *nominal discount rate* in present value calculations, costs must be expressed in *current* dollars. In practice, the use of constant dollars simplifies LCCA, and any change in the value of money over time will be accounted for by the real discount rate.

LCCA Assumptions

As stated earlier, it is beyond the scope of this pre-feasibility assessment to go into a detailed life cycle cost analysis. However, a limited LCCA is presented here for purposes of discussion and comparison.

Time is assumed to be 20 years, as recommended by EED
The **real discount rate** is 3%
Initial expenses as per Table 6.1
Future expenses as per Table 6.3
Replacement costs – not addressed
Residual value – not addressed

Cordwood Boiler Alternatives

Alternative 1 represents the existing oil-fired boiler systems. The initial investment was assumed to be $50,000. The operation costs included 29,000 gallons of #1 fuel oil at $5.50 per gallon and 40 hours of labor per year at $20 per hour. The annual maintenance and repairs costs were assumed to be $1,000 and no allowances were made for replacement costs or residual value.

NOTE: The value of the existing boiler system ($50,000), the amount and cost of labor (40 hours, $800), and maintenance and repair costs ($1,000) are fictitious, but are held constant for comparative purposes as appropriate.

Alternative 2 represents the existing oil-fired boiler systems, which would remain in place, plus the installation of **three Garn WHS 3200** wood fired boilers. The initial investment was assumed to be $654,000, which includes the hypothetical value of the existing oil-fired boilers (valued at $50,000 as per Alternative 1) plus the initial investment cost of the Garn boiler system ($604,000, as per Table 6-1). The operation costs include 340 cords of fuelwood at $275 per cord and 469.5 hours of labor per year at $20 per hour (as per Table 6-2). The annual utility, maintenance and repair costs were assumed to be $2,714.95 (as per Table 6-3) for the system and no allowances were made for replacement costs or residual value.

The hypothetical EED LCCA results for the McGrath School cordwood boiler alternative are presented in Table 6-6.

Table 6-6. Estimated Life Cycle Costs of Cordwood System Alternative

	Alternative 1 (existing boilers)	Alternative 2 (existing boilers plus HELE cordwood boilers)
Initial Investment Cost	$50,000	$654,000
Operations Cost	$2,384,859	$1,530,743
Maintenance & Repair Cost	$14,877	$40,392
Replacement Cost	$0	$0
Residual Value	$0	$0
Total Life Cycle Cost	$2,449,737	$2,225,135

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

The term "bulk fuel" refers, generically, to sawdust, wood chips, shavings, bark, pellets, etc. Since the availability of bulk fuel is virtually non-existent in Kake, the cost of bulk fuel systems being 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 8. CONCLUSIONS

This report discusses conditions found "on the ground" at the IASD Administration Building, IASD McGrath School, and Captain Snow Center in McGrath, 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.

Wood is a viable heating fuel in a wide range of institutional applications, however, below a certain minimum and above a certain maximum, it may be impractical to heat with wood, or it may require a different form of wood fuel and heating system. The difference in the cost of heat derived from wood versus the cost of heat derived from fuel oil is significant, as illustrated in Table 5-1. It is this difference in the cost of heat, resulting in monetary savings that must "pay" for the substantially higher investment and OM&R costs associated with wood-fuel systems.

McGrath Facilities

Three facilities in McGrath were identified as potential heating projects: the Iditarod Area School District (IASD) Administration Building, the IASD McGrath School, and the City of McGrath's Captain Snow Center. Each is analyzed in this report.

8.1. The IASD Administration Building is small to medium-sized in terms of its energy usage; consuming a reported 7,500 gallons of #1 fuel oil per year. It is a fair example of a small to medium-sized facility reasonably suitable to a HELE cordwood boiler installation.

With a single large HELE boiler consuming 88 cords of wood per year and being fired approximately 3 times per day, the simple payback period would be 12.16 years given current fuel costs and a cordwood boiler installation costing around $207,375. The present value, net present value and internal rate of return after 20 years, assuming a discount rate of 3%, are $204,283, -$3,092 and 2.84% respectively. This project is marginally cost-effective, but nonetheless warrants closer scrutiny by a professional engineer.

8.2. The IASD McGrath School (and warehouse) is large in terms of its energy usage; consuming a reported 29,000 gallons of #1 fuel oil per year. It is a good example of a facility apparently suitable to a HELE cordwood boiler installation.

With three large HELE boilers consuming a total of 340 cords per year and being fired approximately 4 times per day, the simple payback period would be 9.15 years given current fuel costs and a cordwood boiler installation costing around $604,000. The present value, net present value and internal rate of return after 20 years, assuming a discount rate of 3%, are $801,822, $197,822 and 6.29% respectively. The theoretical difference in life cycle costs between the currently installed system and a wood-fired system is nearly $225,000 over 20 years. Closer scrutiny of this project by qualified professionals appears justified.

8.3. The Captain Snow Center is also large in terms of its energy usage, consuming an average of 23,500 gallons of #1 fuel oil per year. It is another good example of a facility apparently suitable to a HELE cordwood boiler installation.

With a pair of large HELE boilers consuming a total of 275 cords per year and being fired 4 to 5 times per day, the simple payback period would be 9.24 years given current fuel costs and a cordwood boiler installation costing around $495,375. The present value, net present value and internal rate of return after 20 years, assuming a discount rate of 3%, are $657,198, $161,823 and 6.28% respectively. Closer scrutiny of this project by qualified professionals appears justified.