Preliminary Feasibility Assessment for High Efficiency, Low Emission Wood Heating

In Gulkana, Alaska

Prepared for:

LaMonica Claw, Tribal Administrator and
Rick Young, Water Resource Manager
Gulkana Village Council
Gulkana, Alaska

Prepared by:

Daniel Parrent,
Wood Utilization Specialist
Juneau Economic Development Council

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Notice

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ABSTRACT

The potential for heating various public buildings and residential duplexes in the village of Gulkana with high efficiency, low emission (HELE) wood boilers is evaluated for the Gulkana Village Council (GVC).

Early in 2006, 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 Gulkana during the summer of 2006 and 2007 and information was obtained for each facility. Preliminary assessments were made and challenges identified. Potential wood energy systems were considered for each project using AWEDTG, USDA and AEA objectives for energy efficiency and emissions. Preliminary recommendations are made for each facility.

SECTION 1. EXECUTIVE SUMMARY

1.1 Goals and Objectives

- Identify various public buildings and residential duplexes as potential candidates for heating with wood
- Evaluate the suitability of the facility(s) and site(s) for siting a wood-fired boiler
- Assess the type(s) and availability of wood fuels
- 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 residues, sustainability of the wood supply, project implementation, operation and maintenance, and community support

- Wood-fired systems are not feasible for very small applications. These may be satisfied with domestic wood appliances, such as wood stoves or pellet stoves/furnaces

- Individual facilities consuming less than 2,000 gallons per year represent minimal savings with wood-fired systems unless such systems can be enclosed in an existing structure, and wood and labor are very low cost or free

- Marginal economic metrics (such as those associated with small installations) can be improved with low-cost buildings and piping systems

- Medium and large energy consumers have the best potential for feasibly implementing a wood energy system and deserve detailed engineering analysis

- 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

- Overview. The buildings under consideration in Gulkana consist of the Shop/Garage, Fitness Center, Teen Center, Village Hall and Administrative Offices, Clinic, New Office building and four residential duplexes.

  These various buildings range in age from 2 to 33 years old. The duplexes were built in 2006 and are in new condition. Five others are in good condition, while one (fitness center) is considered to be in poor condition.

  Heat is provided by a variety of individual oil-fired appliances. The smaller facilities are heated with Toyo or Monitor space heaters. The shop is heated with a ceiling-mounted hot air 'unit heater', and the duplexes have hydronic systems with hot water supplied by small boilers.

  The topography around the village is gentle, presenting no readily apparent physical impediments to one or more external boiler installations.

- Fuel consumption. Altogether, the reported total fuel consumption estimate is 13,100 gallons of fuel oil per year. (Although a mix of grades 1 and 2 are used, #1 is used as the benchmark fuel for this report.)

- Potential savings. At $3.35 per gallon and 13,100 gallons of fuel oil per year, the annual fuel oil cost is nearly $44,000. The high-efficiency, low-emission (HELE) cordwood fuel equivalent of 13,100 gallons of fuel oil is about 160 cords, and at $100/cord represents a potential gross annual fuel cost savings of about $28,000.

- Required boiler capacity. The estimated required boiler capacity (RBC) to provide heat to the Gulkana Village district heating system is 439,308 Btu/hr during the coldest 24-hour period. It would appear that a single large or a pair of medium HELE cordwood boilers could supply 100% of that RBC with a margin similar to that of oil and/or gas fired furnaces or boilers.

- Recommended action regarding a bulk fuel wood system. Due to its relatively small heating demand, a "bulk fuel" system is not feasible for the Gulkana Village district heating system. Given the likely cost ($1 million+) and lack of bulk fuel supplies, a bulk fuel system is not feasible.

- Recommended action regarding a cordwood system. Two hypothetical HELE boiler installations were considered. Option 1 consisted of a pair of medium-sized Garn WHS 2000 boilers, rated at 425,000 Btu/hr, each. Option 2 consisted of a single large Garn WHS 3200 boiler rated at 950,000 Btu/hr. Under the stated assumptions and estimated costs, both options were cost-effective. Net present values at 20 years were greater than the initial investment costs and internal rates of return were positive at 4.29% and 5.72% respectively. However, this is a preliminary assessment based on estimated costs. Closer scrutiny of this project by a professional engineer is warranted.

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, VT. www.biomasscenter.org]

2.1 Evaluation Criteria

The AWEDTG selected projects for evaluation based on the criteria listed in Appendix A. The Gulkana Village district heating project meets the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, use of local residues (though limited), sustainability of the wood supply, project implementation, operation and maintenance, and community support.

In the case of cordwood boiler applications, the wood supply from forest fuels and/or local processing residues appears adequate and matches the application. Currently, "bulk fuel" (chips, bark, sawdust, etc.) supplies are very limited.

2.2 Successful Implementation

In general, three aspects of project implementation have been important to wood energy projects in the past: clear identification of a sponsoring agency/entity, dedication of personnel, and 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 Gulkana project but the issue should be addressed.)

Boiler stoking and/or maintenance is required for approximately 5-15 minutes per boiler several times a day (depending on the heating demand) for manual wood-fueled systems, 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 facilities personnel.

The forest industry infrastructure in the Copper River Valley is small, but appears to be stable. For this report, it is assumed that wood supplies, in the form of cordwood and/or mill residues, are sufficient to meet the heating needs of the project.

2.3 Classes of Wood Energy Systems

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

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

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

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Wood fuels in south-central Alaska are most likely to be in the form of cordwood and/or large, unprocessed sawmill residues, primarily slabwood. Sawdust and planer shavings currently supply the limited demand for bulk fuel in the area (i.e., SAPA in Kenny Lake). Other than sawdust and shavings, there is relatively little bulk fuel available. In the recent past, a whole-tree harvesting and chipping operation took place near Glennallen, but that is no longer the case. And while there has been some discussion of building a pellet plant in the area, it does not currently exist and therefore pellets were not considered a viable fuel option.

3.2 Heating Value of Wood

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

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

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

The RHV for white spruce cordwood (MC30), given the variables in Appendix B, is 11,778,000 Btu per **cord**, and the DHV, which is a function of boiler efficiency (assumed to be 75%), is 8,835,000 Btu per cord. The delivered heating value of 1 **cord** of white spruce cordwood (MC30) equals the delivered heating value of **82.4** gallons of #1 fuel oil when 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

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

In 2006, a committee was formed under the American Society for Testing and Materials (ASTM) to develop a standard test protocol for OWBs[11]. The standards included uniform procedures for determining performance and emissions. Subsequently, the ASTM committee sponsored tests of three common outdoor wood boilers using the new procedures. The results showed efficiencies as low as 25% and emissions **more than nine times** the standard for industrial boilers. Obviously, these results were deemed unsatisfactory and new 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 boiler suppliers, two of which have units operating in Alaska. HS Tarm Co./Tarm USA, Inc. 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 to provide heat to the washeteria and water plant.

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 Co./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 by the State of Michigan 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

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" as used in this report refers, generically, to sawdust, wood chips, shavings, bark, pellets, etc. Since the availability of bulk fuel is virtually non-existent around Glennallen, the cost of bulk fuel systems is so high (i.e., $1 million and up), and the relatively small heating demand for the project 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 (form) availability, 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 calculated on a "per million Btu (MMBtu)" basis.

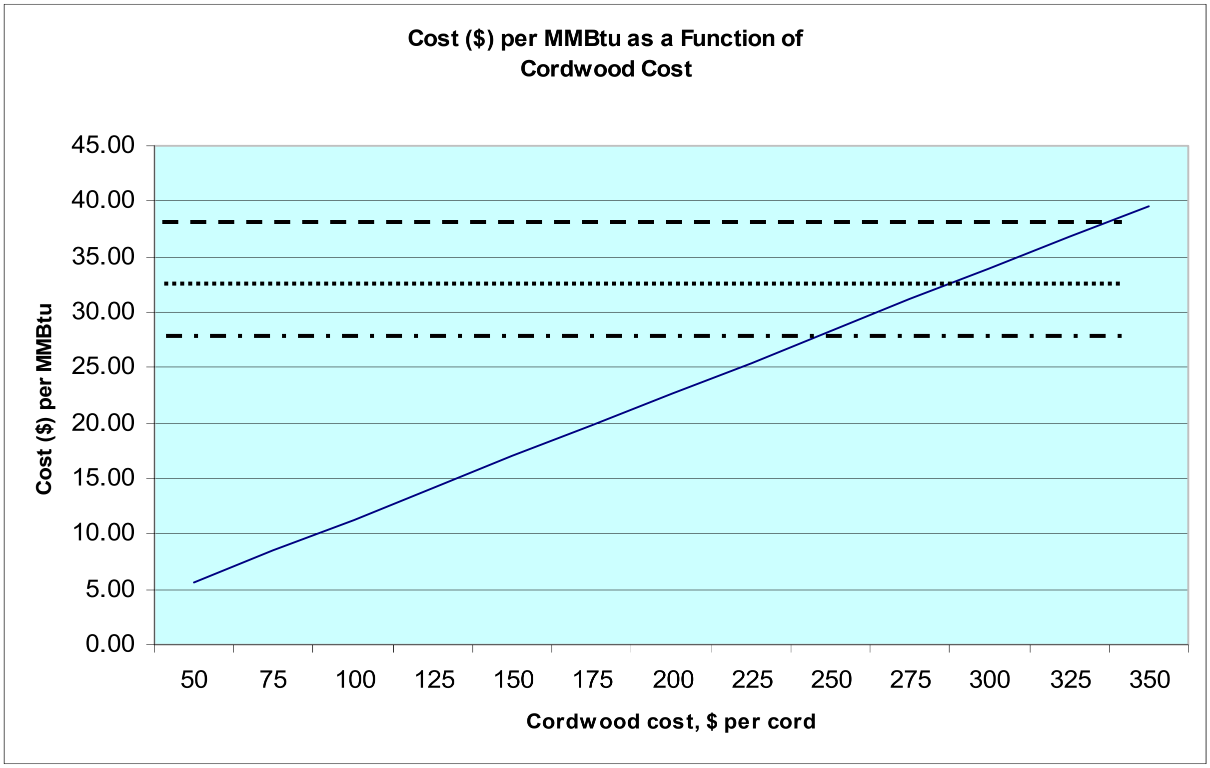
Table 5-1. Comparative Cost of Fuel Oil vs. Wood Fuels					
FUEL	RHV[a] (Btu)	Conversion Efficiency[a]	DHV[a] (Btu)	Price per unit ($)	Cost per MMBtu (delivered, ($))
Fuel oil, #1, 1 gallon	134,000	80%	107,200 per gallon	3.00/gal	27.99
				3.50	32.65
				4.00	37.31
White spruce, 1 cord, MC30	11,778,133	75%	8,833,600 per cord	100/cord	11.32
				125	14.15
				150	16.98

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 about $1.13. 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 $3.00, $3.50 and $4.00 per gallon ($27.99, $32.65 and $37.31 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $276.05 per cord is equal to the cost of oil at $3.35 per gallon, before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $100 per cord, a high-efficiency cordwood boiler will deliver heat at about 36% of the cost of #1 fuel oil at $3.35 per gallon ($11.32 versus $31.25 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 $4.00 per gallon
Fuel Oil at $3.50 per gallon
Fuel Oil at $3.00 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 amount of fuel oil consumed by the various public buildings in Gulkana (as reported for CY 2006)

Table 5-2. Reported Annual Fuel Oil Consumption, GVC Facilities		
Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $3.35/gallon*
Shop	1,122	3,759
Admin	620	2,077
Teen Center	1,202	4,027
New Office	2,398	8,033
Community Hall	779	2,610
Health Clinic	747	2,502
Duplexes	6,227	20,860
TOTAL	**13,095**	**43,868**

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 Gulkana Village public buildings 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.

Typically, installed oil-fired heating capacity at most sites is two to four times the demand for the coldest day. Given the dispersed nature of the heating appliances in use in the various building in Gulkana, the actual installed heating capacity is unknown.

Manual HELE cordwood boilers, equipped with special tanks for extra thermal storage, can supply heat at higher than their rated capacity for short periods. While rated at 425,000 Btu/hr (heat input) each, a pair of Garn WHS 2000 boilers can store (collectively) more than 2.5 million Btu, which would be enough to heat the Gulkana Village public buildings during the coldest 24-hour period for nearly 6 hours (2,544,000 ÷ 439,308).

Table 5-3. Estimate of Heat Required in Coldest 24 Hr 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]
Gulkana Village public buildings	13,100	14,004	100,280	-40	439,308	unknown

Table 3-7 Notes:

[a] From SOI and site visit; net 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

5.4 Summary of Findings

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 Gulkana Village district heating system. [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

Facility	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 ($)		
		3.00	*3.50*	*4.00*	White spruce, MC30, CE 75%	*100/cord*	*125/cord*	*150/cord*	*Low*	*Medium*	*High*
Gulkana Village public buildings	13,100	39,300	45,850	52,400	160 cords	16,000	20,000	24,000	15,300	25,850	36,400

NOTES:
a From Table 5-3; used the numerical average where a range was indicated
b From Table D-3, Fuel Oil Equivalents

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 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, two hypothetical 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 easily accomplished.

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 plumbing, heat exchangers 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 two cordwood boiler heating installation options in a medium heating demand situation.

Building(s) 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 cost of hard copper pipe normally used in Alaska now precludes its use in nearly all 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.

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

Table 6-1. Initial Investment Cost Scenarios for Hypothetical Cordwood Systems			
	Gulkana Village District Heating System		
Fuel oil consumption (gallons per year)	13,100		
Required boiler capacity (RBC), Btu/hr	439,308		
Cordwood boiler Model Rating - Btu/hr Btu stored	(1) Garn WHS 2000[e] 425,000 1,272,000	(2) Garn WHS 2000 850,000 combined 2,544,000 combined	(1) Garn WHS 3200 950,000 2,064,000
Building and Equipment (B&E) Costs (for discussion purposes only), $			
Fuel storage building[a] (fabric bldg, gravel pad, $20 per sf)	64,000 (160 cords; 3,200 sf)		
Boiler building @ $100 per sf (minimum footprint, concrete pad)[b]	12,800 (8' x 16')	22,400 (14' x 16')	20,000 (10' x 20')
Boilers Base price[c] Shipping[d]	 14,500 3,000	 29,000 5,000	 27,700 $6,000
Plumbing/connections[d]	35,000	35,000	35,000
Installation[d]	20,000	20,000	20,000
Subtotal - B&E Costs	**149,300**	**175,400**	**172,700**
Contingency (25%)[d]	**37,325**	**43,850**	**43,175**
Grand Total	**$186,625**	**$219,250**	**$215,875**

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, Dectra Corp, May 2006

[d] "guess-timate"; for illustrative purposes only

[e] A single Garn WHS 2000 would have to be fired nearly continuously 24 hours per day during the heating season in order to consume 160 cords of fuel, and could not meet the heating requirements on the coldest days. Therefore, it is the author's opinion that a single cordwood boiler installation is not a viable alternative for this application.

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 will operate 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 (Garn Model)	(1) WHS 2000	(2) WHS 2000	(1) WHS 3200
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	351.75	351.75	281.9
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	150	150	150
Total Annual labor (hrs/yr)[b]	20	40	20
Total labor (hrs/yr)	521.75	541.75	451.9
Total annual labor cost ($/yr) (total hrs x $20)	**10,435**	**10,835**	**9,038**

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 year[4]. There is also the added cost of operating circulation pumps and/or blowers in those buildings that do not have pre-existing hydronic heating systems.

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			
	Cost/Allowance ($)		
	(1) WHS 2000	(2) WHS 2000	(1) WHS 3200
Labor	10,435	10,835	9,038
Electricity	100	200	150
Maintenance/Repairs	300	300	300
Total non-fuel OM&R ($)	**10,835**	**11,335**	**9,488**

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 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 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 HELE cordwood boiler installations.

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

	(1) WHS 2000	(2) WHS 2000	(1) WHS 3200
Fuel oil cost ($ per year @ $3.35 per gallon (1/17/08))	43,885		
Cordwood cost ($ per year @ $100 per cord)	16,000		
Gross annual fuel cost savings ($)	27,885		
Annual, non-fuel OM&R costs[a]	10,835	11,335	9,488
Net Annual Savings ($) (Annual Cash Flow)	17,050	16,550	18,397
Total Investment Costs ($)[b]	186,625	219,250	215,875
Simple Payback[c] (yrs)	6.69	7.86	7.74
Modified Payback[d] (yrs)	10.95	13.25	11.73

Notes:
a From Table 6-3
b From Table 6-1
c Total investment costs divided by Gross annual fuel cost savings
d Total investment costs divided by Net Annual Savings

6.6 Present Value (PV), Net Present Value (NPV) and Internal Rate or Return (IRR) Values for HELE Cordwood Boilers

Table 6-5 presents PV, NPV and IRR values for hypothetical small and large HELE cordwood boilers.

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

	(1) WHS 2000	(2) WHS 2000	(1) WHS 3200
Discount Rate[a]	3%		
Time, "t", (years)	20		
Initial Investment ($)[b]	186,625	219,250	215,875
Annual Cash Flow ($)[c]	17,050	16,550	18,397
Present Value (of expected cash flows, $ at "t" years)	253,661	246,222	273,701
Net Present Value ($ at "t" years)	67,036	26,972	57,826
Internal Rate of Return (% at "t" years)	6.58	4.29	5.72
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. A single Garn WHS 2000 would have to be fired nearly continuously 24 hours per day during the heating season in order to consume 160 cords of fuel, and could not meet the heating requirements on the coldest days. Therefore, it is the author's opinion that a single cordwood boiler installation is not a viable alternative for this application.

Note #2. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $246,222 today (PV), which is greater than the initial investment of $219,250. The resulting NPV of the project is $26,972, and the project achieves an internal rate of return of 4.29% at the end of 20 years.

Note #3. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $273,701 today (PV), which is greater than the initial investment of $215,875. The resulting NPV of the project is $57,826, and the project achieves an internal rate of return of 5.72% at the end of 20 years.

NOTE: In this hypothetical example, it appears that the labor savings associated with the single large boiler provides improved financial metrics over the more labor-intensive pair of smaller boilers. As a practical matter, having to fire the boiler 5 times per day versus 8 times per day could be significant

Given the assumptions and cost estimates for these examples, the project appears feasible. However, the cost estimates could be low. Areas where significant cost increases could be incurred include the fuel storage building, the boiler building, the plumbing and connections, and the contingency allowance. Consultation with qualified experts is strongly recommended.

6.7 Life Cycle Cost Analysis

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. While not applicable to the Gulkana Village project, Alaska Statute 14.11.013 directs the Department of Education and Early Development (EED) to review capital projects (at schools) 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 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 cost 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 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/femp/pdfs/ashb07.pdf). The DOE discount and inflation rates for 2007 are as follows:

Real rate (excluding general price inflation)	3.0%
Nominal rate (including general price inflation)	5.0%
Implied long term average rate of inflation	1.9%

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

6.8 Gulkana Village District Heating System LCCA

Alternative 1 represents the existing oil-fired furnaces, boilers and space heaters. The initial investment was assumed (arbitrarily) to be $50,000. The operation costs include 13,100 gallons of fuel oil at $3.35 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.

Alternative 2 represents the existing oil-fired furnaces, which would remain in place, *plus* the installation of two Garn WHS 2000 wood fired boilers. The initial investment was assumed to be $269,250, which includes the value of the existing oil-fired furnaces (valued at $50,000, as above) plus the initial investment cost of the Garn boilers ($219,250, as per Table 6-1). The operation costs include 160 cords of fuelwood at $100 per cord and 541.75 hours of labor per year at $20 per hour. The annual maintenance and repairs costs were assumed to be $500 and no allowances were made for replacement costs or residual value.

Alternative 3 represents the existing oil-fired furnaces, which would remain in place, *plus* the installation of a single Garn WHS 3200 wood fired boiler. The initial investment was assumed to be $265,875, which includes the value of the existing oil-fired furnaces (valued at $50,000 as above) plus the initial investment cost of the Garn boiler ($215,875, as per Table 6-1). The operation costs include 160 cords of fuelwood at $100 per cord and 451.9 hours of labor per year at $20 per hour. The annual maintenance and repairs costs were assumed to be $450 and no allowances were made for replacement costs or residual value.

The EED LCCA results for the GVC District Heating Project are presented in Table 6-6.

Table 6-6. Life Cycle Costs of GVC District Heating Project Alternatives			
	Alternative #1	**Alternative #2**	**Alternative #3**
Initial Investment Costs	**$50,000**	**$269,250**	**$265,875**
Operation Costs	**$664,800**	**$399,237**	**$372,502**
Maintenance & Repair Costs	**$14,877**	**$7,439**	**$6,695**
Replacement Costs	**$0**	**$0**	**$0**
Residual Values	**$0**	**$0**	**$0**
Total Life Cycle Cost	**$729,677**	**$675,926**	**$645,072**

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

Not included in this report

SECTION 8. CONCLUSIONS

This report discusses conditions found "on the ground" in Gulkana in south-central Alaska, and attempts to demonstrate, by use of realistic, though hypothetical, examples, the feasibility of installing high efficiency low emission cordwood boilers for a local district heating system.

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 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.

Gulkana Public Buildings

The Gulkana Village Council owns, operates and manages several public buildings in the village of Gulkana, AK. These buildings consist of a vehicle/equipment maintenance garage, fitness center, teen center, community hall, administrative office, health clinic, new office building, and four residential duplexes. These buildings are in relatively close proximity to one another, and each has its own heating system.

The individual fuel oil consumption for each of these buildings is known, and taken all together; these buildings consume a reported 13,100 gallons of fuel oil per year. It may be possible that these buildings could be served by one large cordwood boiler, but the cost of plumbing might dictate two separate, smaller boiler installations. Several of these buildings do not have pre-existing have hydronic heating systems, so some additional expenses will have to be incurred to retrofit the systems.

In the hypothetical examples presented in Section 6, the gross annual fuel cost savings would amount to $27,885. Two scenarios were then presented:

1. With a pair of medium boilers (Garn WHS 2000) being fired approximately 8 times per day, the simple payback period would be 7.86 years (given a cordwood boiler installation costing an estimated $219,250). However, when annual OM&R costs are considered, modified simple payback period is 13.25 years. The present value, net present value and internal rate of return after 20 years, assuming a real discount rate of 3%, are $246,222, $26,972 and 4.29% respectively. The total life cycle cost was nearly $54,000 *less* than the existing situation.

2. With a single large boiler (Garn WHS 3200) being fired approximately 5 times per day, the simple payback period would be 7.74 years (given a cordwood boiler installation costing an estimated $215,875). However, when annual OM&R costs are considered, modified simple payback becomes 11.73 years. The present value, net present value and internal rate of return after 20 years, assuming a discount rate of 3%, are $273,701, $57,826 and 5.72% respectively. The total life cycle cost was about $84,600 *less* than the existing situation.

Both of these scenarios presents a fairly positive outcome given the stated assumptions and cost estimates. The financial metrics appear to favor scenario 2, with the single large boiler and the labor savings associated with fewer firings per day, however conditions on the ground may dictate a different scenario. Closer scrutiny of this project by qualified professionals would be justified.