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

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Key words: HELE, LEHE, bulk fuel, cordwood

ABSTRACT

The potential for heating the Hoonah School in Hoonah, AK with high efficiency, low emission (HELE) wood-fired boilers is evaluated for the Hoonah School District, Hoonah, AK.

SECTION 1. EXECUTIVE SUMMARY

1.1 Goals and Objectives

- Inspect the Hoonah School and gym/pool facility and physical site in Hoonah 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 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 Alaska Wood Energy Development Task Group 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

- Using an estimate of 50,000 gallons per year, this project would be considered relatively large in terms of its scale.

- 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

- <u>Overview</u>. The Hoonah School heating system is housed in its own building directly behind and in reasonably close proximity (100 feet) to the school. It consists of two Kewanee oil-fired boilers rated at 2,050 MBH (net each). Currently, the installed nozzles (2 per boiler) operate at a maximum rate of 5.5 gph (each). These boilers were installed in 1992, and reportedly are in good operational condition. However, the manufacturer is no longer in business and repair parts, though still available, are becoming more difficult to obtain. Domestic hot water for the school is provided by separate oil-fired water heaters (number, manufacturer and specifications not noted).

The gym/pool boiler room is located within the gym/pool building, approximately 320 feet from the school boiler building. The heating system consists of two Weil McLain H-486-S-W oil fired boilers installed in 1982 (CP No. 775956). The boilers are IBR rated at 626.1 MBH (net, each). Although nearing the end of their service life expectancy, these boilers appear to be in reasonably good condition and may be sufficient to serve as back-up boilers to a wood-fired heating system. Domestic hot water is provided by a single 250 gallon, PVI Industries "Copperglas" 9.0-G-250-A-O (SN 118454216) oil-fired water heater rated at 1.2 MBH with a fuel oil input of 9.0 gph.

• Fuel Consumption. The Hoonah School building consumes approximately 30,000 gallons of #2 fuel oil per year, and the gym/pool consumes approximately 20,000 gallons of fuel oil per year.

• Potential Savings. With current fuel prices at $5.35 per gallon and total consumption of 50,000 gallons of fuel oil per year, the annual cost of fuel oil for the Hoonah School and gym/pool is roughly $267,500. The HELE *cordwood* fuel equivalent of 50,000 gallons of fuel oil is approximately **555 cords**, and at $175/cord represents a potential annual fuel cost savings of $170,375 (Debt service and OM&R costs notwithstanding). The *bulk fuel* equivalent of 50,000 gallons of fuel oil is approximately **1,405 tons**, and at $70/ton represents a potential annual fuel cost savings of $169,150 (Debt service and OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the Hoonah School and gym/pool during the coldest 24-hour period is undeterminable since a presumably significant portion of the fuel is used to maintain consistent water temperatures in the swimming pool. However, *if* all the fuel was used to provide space heat, the estimated required boiler capacity (RBC) would be approximately 1.6 million Btu/hr during the coldest 24-hour period.

• Recommended action regarding a cordwood system. The financial metrics of installing multiple large HELE cordwood boilers are strongly positive, with simple payback periods between 5 and 6 years. Net present values are strongly positive and the internal rates of return, at 20 years, range from about 12½ to 13½ percent. Formal consideration of a HELE cordwood system for the Hoonah School/gym/pool is warranted. See Section 6.

• Recommended action regarding a bulk fuel wood system. A "bulk fuel" system appears financially feasible for the Hoonah School/gym/pool, given a consistent and reasonably-priced fuel supply and average initial investment costs. Formal consideration of a bulk fuel system for the Hoonah School/gym/pool is warranted. See Section 7.

1.4 Power Generation and Waste Heat Capture

There are five diesel generators installed at the Hoonah School -- (2) 75 kW generators, (1) 100 kW generator, and (2) 150 kW generators. These generators are co-located with the school boilers and water heaters. Apparently, none of these generators, individually, is large enough to supply the school with all its electrical needs, and the electrical control system is insufficiently designed to handle multiple generator operation/inputs. Therefore, the system is not being used, except in emergencies. It is worth noting, however, that a waste-heat reclamation system, tied into the oil-fired boilers, is already in place.

All electricity in Hoonah is currently diesel-generated, and the cost of self-generated power would offer little or no savings over purchased power. However, given total electrical consumption of approximately 500,000 kilowatt-hours per year, the potential to offset heating costs with reclaimed waste heat is substantial. At $0.60 per kWh, the annual cost of electricity amounts to approximately $300,000. Given that the school, pool, and gym consume about 50,000 gallons of fuel oil per year for space heat, domestic hot water, and pool water heating (at an annual cost of $250,000 to $275,000), it appears that the potential savings could be significant. Anecdotally, this was demonstrated last winter during a one-day power outage when one of the large generators was brought online. Apparently, although 150 kW is less than the total amount of power required for optimal operation of the school, it was enough to "get by". Furthermore, the captured waste heat was more than sufficient to keep the school warm; enough so that boilers did not have to fire at all.

If the power production/management issue(s) can be sufficiently resolved, and a waste heat capture system utilized to its full capacity, any discussion of a wood-fired heating system large enough to supply both the school and the gym/pool may be moot. Further consideration by a qualified engineer is **strongly** recommended.

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 Hoonah School and gym/pool project meets 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, project implementation, operation and maintenance, and community support.

In the case of a cordwood boiler system, the combination of cordwood supplied from forest-derived resources and local sawmill residues appears adequate, although more efficient processing and production equipment would be desirable. The "bulk fuel" infrastructure is nearly non-existent; apparently there is some processing equipment in town, but it is not installed. To supply bulk fuel to the Hoonah School would entail developing that capability.

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 very clear which organization(s) would sponsor and/or implement a wood-burning project. (NOTE: This is not necessarily the case with the Hoonah School, but the issue should be addressed if germane.)

With manual systems, boiler stoking and/or maintenance is required for approximately 5-10 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. Though automated, bulk fuel systems also have a daily labor requirement. 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. Another option would be to hire a local vendor/contractor to provide such services.

The forest industry infrastructure in/around Hoonah is not large, but appears to be sufficient to supply the necessary wood requirements. Some local processing capabilities, whether for cordwood or bulk fuel, would need to be developed, but the basic infrastructure is in place.

2.3 Classes of Wood Energy Systems

There are, essentially, two classes of wood energy systems: manual cordwood systems and automated "bulk fuel" systems. Cordwood systems are generally appropriate for applications where the maximum heating demand ranges from 100,000 to 1,000,000 Btu per hour, although smaller and larger applications are possible. "Bulk fuel" systems are systems that burn wood chips, sawdust, bark/hog fuel, shavings, pellets, etc. They are generally applicable for situations where the heating demand exceeds 1 million Btu per hour, although local conditions, especially fuel availability and cost, 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 normally remain in place and be available for peak demand or backup in the event of downtime (scheduled or unscheduled) in the wood system.

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Currently, potential wood fuel supplies in Hoonah are fairly abundant. There is one fairly large, full-time sawmill operation (Icy Straits Lumber & Milling), a small, full-time sawmill operation (D&L Woodworks), and several part-time sawmill operations. Wood could come from a variety of land ownerships, including Huna Totem Corp., Sealaska Corp., and the USDA Forest Service. Wood fuels in Hoonah, currently, are most likely to be in the form of cordwood or large mill residues (slabs, edgings) since there is no demand for bulk fuels locally. However, bulk fuels could be produced if demand was sufficient to warrant the investment in the processing equipment.

3.2 Heating Value of Wood

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

For this report, hemlock cordwood at 30 percent moisture content (MC30) and hemlock bulk fuel at 50 percent moisture content (MC50), calculated on the green wet weight basis (also called wet weight basis), are used as benchmarks. NOTE: Drier wood will have greater heater value, and less of it would be required to deliver a given amount of heat.

The HHV of hemlock at 0% moisture content (MC0) is 8,515 Btu/lb[1]. The GHV at 30% moisture content (MC30) is 5,961 Btu/lb, and the GHV at 50% moisture content (MC50) is 4,258 Btu/lb.

The RHV for cordwood (MC30) is calculated at 13.26 million Btu per **cord**, and the DHV, which is a function of boiler efficiency (assumed to be 75%), is 9.945 million Btu per cord. The delivered heating value of 1 **cord** of hemlock cordwood (MC30) equals the delivered heating value of **90.08** gallons of #2 fuel oil when oil is burned at 80% efficiency and wood is burned at 75% efficiency.

The RHV for bulk fuel (MC50) is calculated at 5.61 million Btu per **ton**, and the DHV, which is a function of boiler efficiency (assumed to be 70%), is 3.927 million Btu per ton. The delivered heating value of 1 **ton** of hemlock bulk fuel (MC50) equals the delivered heating value of **35.57** gallons of #2 fuel oil when oil is burned at 80% efficiency and wood is burned at 70% efficiency.

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

SECTION 4. WOOD-FUELED HEATING SYSTEMS

4.1 Low Efficiency High Emission (LEHE) Cordwood Boilers

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

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

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

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

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

4.2 High Efficiency Low Emission (HELE) Cordwood Boilers

In contrast to low efficiency, high emission cordwood boilers there are a few units that can be considered high efficiency, low emission (HELE). These systems are designed to burn cordwood fuel cleanly and efficiently, mostly by incorporating some degree of gasification technology.

Table 4-1 lists three HELE boiler suppliers, all of which have units operating in Alaska. BioHeatUSA (formerly TarmUSA) and Greenwood and have a number of residential units operating in Alaska. A number of Garn boilers, manufactured by Dectra Corporation, have been installed in larger institutional applications in Dot Lake, Tanana and Kasilof; several others are in the planning stages.

Table 4-1. HELE Cordwood Boiler Suppliers

Supplier	Btu/hr ratings	Brands
Bio Heat USA www.bioheatusa.com	100,000 to 198,000	Tarm, Scandtec, Froling
Greenwood www.greenwoodusa.com	100,000 to 300,000	Greenwood
Dectra Corp. www.garn.com	350,000 to 950,000	Garn
Note: Listing of any manufacturer, distributor or service provider does not constitute an endorsement.		

Table 4-2 shows the test results for a high efficiency boiler (Garn WHS 1350) that was tested at 157,000 to 173,000 Btu per hour using standardized 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	

Other gasification-style wood boiler manufacturers and/or suppliers include Econoburn, Wood Gun, TurboBurn, and EKO-Line. (And there may be others.) However, there are no known operating units by these suppliers in Alaska, and it is unknown whether any of the appliances sold by these suppliers meet the efficiency or emission standards discussed in Section 4.1.

4.3 Bulk Fuel Boiler Systems

Commercial bulk fuel systems are generally efficient and meet typical federal and state air quality standards. They have been around for a long time and there is little new technological ground to break when installing one. Efficient bulk fuel boilers typically convert 70% of the energy in the wood fuel to hot water or low pressure steam when the fuel moisture is less than 40% moisture content (MC40, calculated on a wet basis). NOTE: It *is* possible to incorporate fuel dryers when dealing with wetter feedstocks.

Most vendors provide systems that can burn various bulk fuels (wood chips, sawdust, wood pellets, hog fuel, etc.), but each system, generally, has to be designed around the predominant fuel form. A system designed to burn clean sawmill chips will not necessarily operate well on a diet of hog fuel, for example. And most vendors will emphasize the need for good quality wood fuel as well as a consistent source, i.e., fuel of consistent size and moisture content from a common source is considerably more desirable than variations in chip size and/or moisture content from numerous suppliers. Table 4-3 presents a partial list of bulk fuel boiler system vendors.

Table 4-3. Bulk Fuel Boiler System Vendors

Decton Iron Works, Inc www.decton.com	New Horizon Corp. www.newhorizoncorp.com
Messersmith Manufacturing, Inc. www.burnchips.com	Precision Energy Services, Inc www.pes-world.com
Chiptec Wood Energy Systems www.chiptec.com	Bio-Fuel Technologies www.bio-fueltechnologies.com

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

Bulk fuel systems are available in a range of sizes between 300,000 and 60,000,000 Btu/hr. However, the majority of the institutional installations range from 1 MMBtu/hr to 20 MMBtu/hr. Larger energy consumers, consuming at least 35,000 gallons of fuel oil per year, have the best potential for installing bulk fuel boilers and may warrant detailed engineering analysis. Bulk fuel systems with their storage and automated fuel handling conveyances are generally not cost-effective for smaller applications.

Although there are several options, bulk fuel is best delivered in 40-ft, self-unloading, tractor-trailer vans that hold about 22 tons of material. A facility such as the Hoonah School/gym/pool, replacing 50,000 gallons of fuel oil with hemlock bulk fuel (MC50), would use an estimated 1,405 tons per year, or about 2 tractor-trailer loads per week (on average) throughout the school year.

There are four known bulk fuel boilers in Alaska (Table 4-4), three of which are installed at sawmills. The most recent was installed in Craig in 2008 and consists of a 4 MMBtu/hr wood chip gasifier at the Craig Aquatic Center and School. It is designed to replace the equivalent of 36,000 gallons of fuel oil per year, and is similar in size to boilers recently installed in several Montana schools. Bulk fuel boilers are also being considered for school heating projects in Delta Junction, Tok and Haines. Bulk fuel systems are discussed in more detail in Section 7.

Table 4-4. Bulk Fuel Boilers in Alaska				
Installation	Boiler Horsepower*	MMBtu/hr	Heating Degree Days**	Supplier
Craig Aquatic Center Craig, AK	120	4	7,209[a]	Chiptek
Icy Straits Lumber & Milling Hoonah, AK	72	2.4	8,496[b]	Decton
Regal Enterprises Copper Center, AK	N/A	N/A	13,486[c]	Decton
Logging & Milling Associates Delta Junction, AK	N/A	2	12,897[d]	Decton

Table 4-4 Notes:

* Heat delivered as hot water or steam. 1 Boiler Horsepower = 33,475 Btu/hr or 34.5 pounds of water at a temperature of 100°C (212°F) into steam at 212°F

** assumes base temperature = 65° F

[a] NOAA, July 1, 2005 through June 30, 2006, Ketchikan data

[b] NOAA, July 1, 2005 through June 30, 2006, Average of Juneau and Yakutat data

[c] NOAA, July 1, 2005 through June 30, 2006, Gulkana data

[d] NOAA, July 1, 2005 through June 30, 2006, Big Delta data

ftp://ftp.cpc.ncep.noaa.gov/htdocs/products/analysis_monitoring/cdus/degree_days/archives/Heating%20degree%20Days/Monthly%20City/2006/jun%202006.txt

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

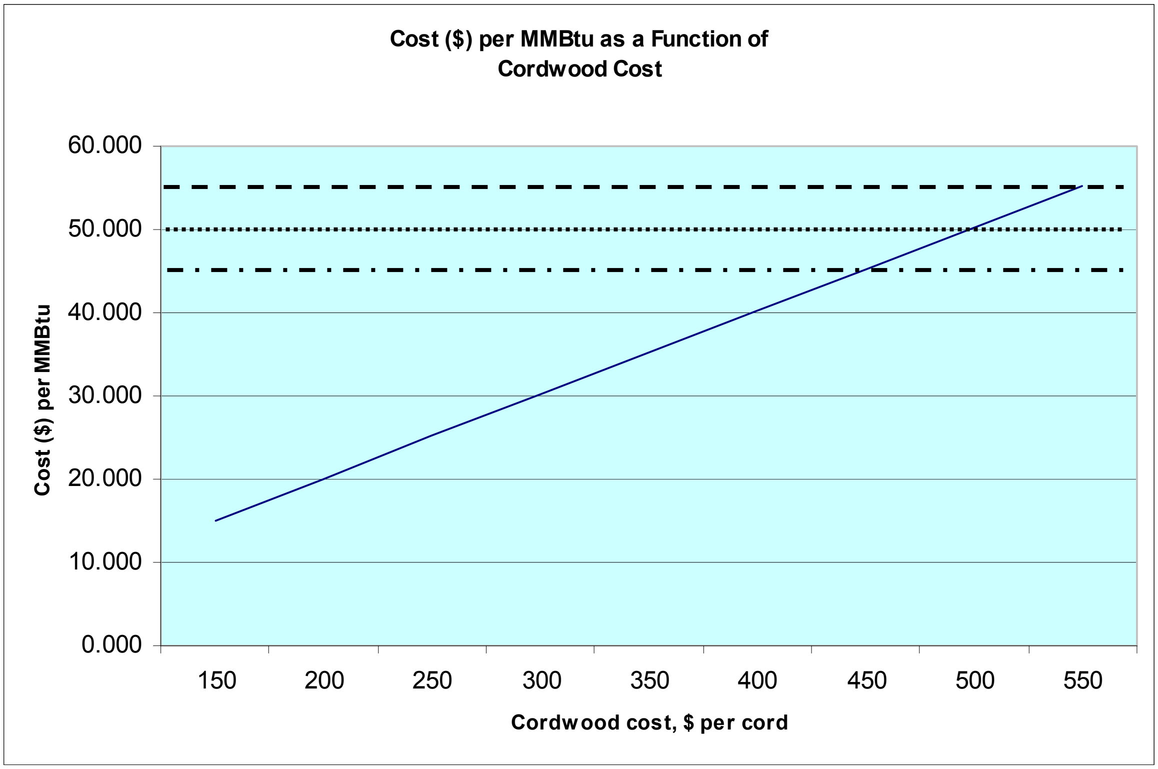
Table 5-1 (next page) compares the cost of #2 fuel oil to hemlock cordwood (MC30) and hemlock bulk fuel (MC50). In order to make reasonable comparisons, costs are provided on a "per million Btu" (MMBtu) basis.

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, #2, (per 1 gallon)	138,000	80%	110,400	5.00/gallon	45.29
				5.50	49.819
				6.00	54.348
Hemlock, (per 1 cord, MC30)	13.26 million	75%	9.945 million	175/cord	17.597
				200	20.111
				225	22.624
Hemlock (per 1 ton, MC50)	5.61 million	70%	3.927 million	70/ton	17.825
				80	20.372
				90	22.918
Notes: [a] from Appendix D					

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 (next page) illustrates the relationship between the price of hemlock cordwood (MC30) and the cost of delivered heat, (the slanted line). For each $25 per cord increase in the price of cordwood, the cost per million Btu increases by about $2.514. 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 fuel oil at $5.00, $5.50 and $6.00 per gallon ($45.29, $49.819 and $54.348 per million Btu respectively).

At high efficiency, heat from hemlock cordwood (MC30) at $481.93 per cord is equal to the current cost of oil at $5.35 per gallon ($48.46/MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $175 per cord, a high-efficiency cordwood boiler will deliver heat at about 36.3% of the current cost of fuel oil ($17.597 versus $48.46 per MMBtu respectively). Figure 5-1 indicates that, at a given efficiency, savings increase significantly with decreases in the delivered price of cordwood and/or with increases in the price of fuel oil.



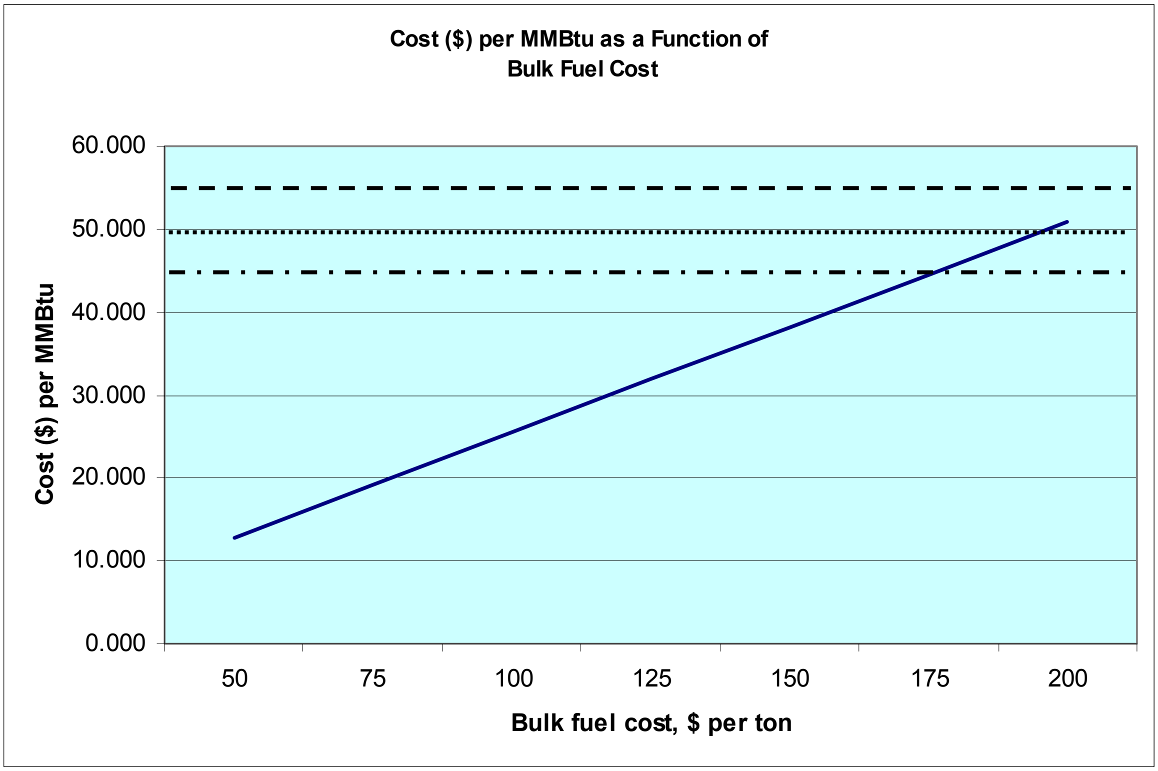
Fuel Oil at $6.00 per gallon
Fuel Oil at $5.50 per gallon
Fuel Oil at $5.00 per gallon

Figure 5-1. Effect of Hemlock Cordwood (MC30) Price on Cost of Delivered Heat

5.2(b) Cost per MMBtu Sensitivity – Bulk Fuels

Figure 5-2 (next page) illustrates the relationship between the price of hemlock bulk fuel (MC50) and the cost of delivered heat, (the slanted line). For each $10 per ton increase in the price of bulk fuel, the cost per million Btu increases by about $2.55. The chart assumes that the bulk fuel boiler converts 70% of the RHV energy in the wood to useful heat and that fuel oil is converted to heat at 80% efficiency. The dashed lines represent fuel oil at $5.00, $5.50 and $6.00 per gallon ($45.29, $49.819 and $54.348 per million Btu respectively).

At standard efficiency, heat from hemlock bulk fuel (MC50) at $190.30 per ton is equal to the current cost of oil at $5.35 per gallon ($48.46/MMBtu), before considering the investment and OM&R costs. At 70% efficiency and $70/ton, a bulk fuel boiler will deliver heat at about 36.8% of the cost of fuel oil at $5.35 per gallon ($17.825 versus $48.46 per MMBtu respectively). Figure 5-2 shows that, at a given efficiency, savings increase significantly with decreases in the delivered price of bulk fuel and/or with increases in the price of fuel oil.



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

Figure 5-2. Effect of Hemlock Bulk Fuel (MC50) Price on Cost of Delivered Heat

5.3 Determining Demand

Table 5-2 shows the reported approximate amount of fuel oil used by the Hoonah School, gym and pool.

Table 5-2. Reported Annual Fuel Oil Consumption, Hoonah School and Gym/pool

Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $5.35/gallon*
Gym/pool	20,000	107,000
Hoonah School	30,000	160,500
Total	**50,000**	**267,500**

Wood boilers, especially cordwood boilers, are often sized to displace only a portion of the heating load since the oil system typically remains in place, in standby mode, for “shoulder seasons” and peak demand. Fuel oil consumption for the Hoonah School and gym/pool 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.

NOTE: In the gym/pool building, much of the heat is used to maintain the pool water temperature, not for space heating. However, the calculations in Table 5-3 were made as if all the fuel oil was used for space heating.

Typically, installed oil-fired heating capacity at most sites is two to four times the demand for the coldest day. The installed capacity at the school is slightly greater than four times the estimated RBC and the installed capacity at the pool/gym is about 1.9 times the estimated RBC.

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 trio of Garn® WHS 3200 boilers can store more than 6 million Btu, which would be enough to heat the Hoonah School during the coldest 24-hour period for more than 6 hours (6,192,000 ÷ 970,396).

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]
Gym/pool	20,000	9,105 (Juneau data)	242,504	1 (Juneau data)	647,057	1,252,200
Hoonah School	30,000		363,756		970,396	4,100,000
Total	**50,000**		**606,260**		**1,617,073**	**5,352,200**

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

* Btu/hr into storage is fuel dependent. The data provided for Garn boilers by Dectra Corp. is 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

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 Hoonah School and gym/pool. [Note: potential gross annual fuel cost savings <u>do not</u> 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

HOONAH SCHOOL and GYM/POOL	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	*5.50*	*6.00*							
Cordwood system	50,000	250,000	275.000	300,000	W. Hemlock, MC30, CE 75%	*175/cord*	*200/cord*	*225/cord*	*Low*	*Medium*	*High*
					555 cords	97,125	111,000	124,875	125,125	164,000	202,875
Bulk fuel system					W. Hemlock, MC50, CE 70%	*70/ton*	*80/ton*	*90/ton*	*Low*	*Medium*	*High*
					1,405 tons	98,350	112,400	126,450	123,550	162,600	201,650

NOTES:
[a] From Table 5-2
[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/or 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 systems 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 readily 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 several cordwood systems in a large heating demand situation. Three alternatives are presented.

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 high cost of hard copper and/or iron 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.

Allowances 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 <u>estimates</u>.

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.

c. These examples are based on the assumption that all current fuel oil use is used for space heating, which is NOT the actual case. Some of the fuel oil is used to heat pool water or domestic hot water, which may require a different set of calculations that are beyond the scope of this report. Consultation with a qualified engineer is required.

Table 6-1. Initial Investment Cost Scenarios for Hypothetical Cordwood Systems			
Fuel oil consumption (gallons per year)	20,000 (Gym/pool only)	30,000 (School only)	50,000 (Gym/pool + School)
Required boiler capacity (RBC), Btu/hr	647,057[f]	970,396	1,617,073[f]
Cordwood boiler Garn model Btu/hr[e]	(2) WHS 3200 1,900,000	(3) WHS 3200 2,850,000	(5) WHS 3200 4,750,000
	Building and Equipment (B&E) Costs (for discussion purposes only)		
Fuel storage building[a] (fabric bldg, gravel pad, $20 per sf)	$88,800 (222 cords; 4,440 sq ft)	$133,200 (333 cords; 6,660 sq ft)	$222,000 (555 cords; 11,100 sq ft)
Boiler building @ $150 per sf (minimum footprint w/concrete pad)[b]	$60,000 (20' x 20')	$90,000 (30' x 20')	$150,000 (50' x 20')
Boilers			
Base price[c]	$70,000	$105,000	$175,000
Shipping[d]	$8,000	$12,000	$20,000
Plumbing/connections[d]	$60,000	$70,000	$130,000
Installation[d]	$30,000	$35,000	$65,000
Subtotal - B&E Costs	**316,800**	**445,200**	**762,000**
Contingency (25%)[d]	**79,200**	**111,300**	**190,500**
Grand Total	**396,000**	**556,500**	**952,500**

Notes:
[a] A cord occupies 128 cubic feet. If the wood is stacked 6½ feet high, the area required to store the wood is 20 square feet per cord.
[b] Does not allow for any fuel storage within the boiler building
[c] List price, Alaskan Heat Technologies
[d] "guess-timate"; for illustrative purposes only
[e] Btu/hr into storage is extremely fuel dependent. The data provided for Garn boilers by Dectra Corp. are based on the ASTM standard of split, 16-inch oak with 20 percent moisture content and reloading once an hour.
[f] Assumes all fuel oil used is used to provide space heat, which is NOT the actual case; a significant though undetermined portion is used to maintain pool water temperatures and some is used for domestic hot water

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 210 days (30 weeks) per year between mid-September and mid-April.

Table 6-2 (next page) 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			
Facility	Hoonah School and Gym/Pool		
System (Garn Model)	(2) WHS 3200 (Gym/pool only)	(3) WHS 3200 (School only)	(5) WHS 3200 (Gym/pool + School)
Total Daily labor (hrs/yr) (hrs/day X 210 days/yr)	248.06	385.11	659.23
Total Periodic labor (hrs/yr) (hrs/wk X 30 wks/yr)	222	333	555
Total Annual labor (hrs/yr)	40	60	100
Total labor (hrs/yr)	510.06	778.11	1,314.23
Total annual labor cost ($/yr) (total hrs x $20)	**$10,201.20**	**$15,562.20**	**$26,284.60**
Source: Appendix F, Tables F-2 and F-3			

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

Lastly, there is the cost of maintenance and repair items, such as fire brick, door gaskets, water treatment chemicals, etc. For this exercise, a flat rate of $1,000 per boiler per year is used. The non-fuel OM&R cost estimates are summarized in Table 6-3.

Table 6-3. Summary of Total Annual Non-Fuel OM&R Cost Estimates			
Item	Cost/Allowance ($)		
	(2) WHS 3200 (Gym/pool only)	(3) WHS 3200 (School only)	(5) WHS 3200 (Gym/pool + School)
Labor	10,201	15,562	26,285
Electricity	1,187	1,781	2,986
Maintenance/Repairs	2,000	3,000	5,000
Total non-fuel OM&R ($)	**$13,388**	**$20,343**	**$34,271**

Notes for Table 6-3:
[a] From Table 6-2
[b] Electrical cost based on a formula of horsepower x kWh rate x operating time. Assumed kWh rate = $0.60

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 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)

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 Multiple 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

	(2) WHS 3200 (Gym/pool only)	(3) WHS 3200 (School only)	(5) WHS 3200 (Gym/pool + School)
Fuel oil cost ($ per year @ $5.35 per gallon)	107,000 (20,000 gal)	160,500 (30,000 gal)	267,500 (50,000 gal)
Cordwood cost ($ per year @ $175 per cord)	38,850 (222 cds)	58,275 (333 cds)	97,125 (555 cds)
Annual Fuel Cost Savings ($)	68,150	102,225	170,375
Total Investment Costs ($)[b]	396,000	556,500	952,500
Simple Payback (yrs)[c]	**5.81**	**5.44**	**5.59**

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 Multiple HELE Cordwood Boilers

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

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

	(2) WHS 3200 (Gym/pool only)	(3) WHS 3200 (School only)	(5) WHS 3200 (Gym/pool + School)
Discount Rate[a] (%)		3	
Time, "t", (years)		20	
Initial Investment ($)[b]	396,000	556,500	952,500
Annual Cash Flow ($)[c]	54,762	81,882	136,104
Present Value (of expected cash flows, $ at "t" years)	814,720	1,218,197	2,024,884
Net Present Value ($ at "t" years)	418,720	661,697	1,072,384
Internal Rate of Return (% at "t" years)	12.52	13.56	13.06
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 $814,720 today (PV), which is greater than the initial investment of $396,000. The resulting NPV of the project is $418,720 and the project achieves an internal rate of return of 12.52% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears to be economically and operationally feasible.

Note #2. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $1,218,197 today (PV), which is greater than the initial investment of $556,500. The resulting NPV of the project is $661,697 and the project achieves an internal rate of return of 13.56% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears to be economically 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 $2,024,884 today (PV), which is greater than the initial investment of $952,500. The resulting NPV of the project is $1,072,384 and the project achieves an internal rate of return of 13.06% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears to be economically and operationally feasible.

6.7 The Case for Fuel Purchase Planning and Fuel Storage

Too often, a fuel storage building is omitted from a project in order to save the initial investment cost and improve the cost-effectiveness of the project. This is FALSE ECONOMY. The importance of a fuel storage building cannot be stressed enough, especially in southeast Alaska. With good planning, fuel could be purchased a year or more in advance and be given sufficient time to dry, while incurring no additional cost. And a fuel storage building can pay for itself in less time than the boiler!

Protected from the elements and provided with good air circulation, it is not unreasonable to expect split and well-stacked cordwood to achieve moisture contents in the neighborhood of fiber saturation point (approximately 23% on the wet weight basis) or less. The difference in heating value between hemlock cordwood at MC30 (partially air-dried) and hemlock cordwood at MC23 (well air-dried) is notable – about 13 percent more recoverable heat value (RHV) in the drier wood, which amounts to about 1,700,000 Btu per cord. And instead of a cord replacing 90.05 gallons of #2 fuel oil, a cord could now replace 101.5 gallons.

For the Hoonah school, gym and pool, this would mean that instead of having to buy 555 cords per year, that fuel requirement becomes 493 cords, a savings of 62 cords and $10,850 per year (at $175 per cord). NOTE: There are also operational cost *savings* that can be realized due to fewer boiler stokings, less ash removal/disposal, and less fuel handling.

The opposite is also true. Cordwood left exposed to the elements in southeast Alaska will not dry much at all and may, in fact, gain moisture. The difference in total RHV Btu value between a cord of hemlock at MC30 (partially air-dried) and a cord of hemlock at MC50 ("green") is more than 4.84 million Btu. The wetter wood has roughly 63.5% of the heating value of the drier wood. In terms of its #2 fuel oil equivalence, the value is 57.16 gallons per cord at MC50 compared to 90.05 gallons per cord at MC30.

For the Hoonah school, gym and pool, this would mean that instead of having to buy 555 cords (MC30) per year, that cordwood equivalent becomes 875 cords ("dead green"), an increase of 320 cords and $56,000 per year (at $175 per cord). NOTE: There are also operational cost *increases* that would have to be incurred due to more frequent boiler stokings, more ash removal/disposal, and additional fuel handling.

In summary:

875 cords of green wood per year at $175 = $153,125 versus 493 cords of well air-dried wood per year at $175 = $86,275. The savings between green wood and well dried wood would be $66,850/year. Given a fuel storage building costing $277,500 ($220,000 plus 25% contingency as shown in Table 6-1), the simple payback would be about 4.15 years.

6.8 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. 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 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 $100,000. The operation costs included 50,000 gallons of #2 fuel oil at $5.35 per gallon and 40 hours of labor per year at $20 per hour. The annual maintenance and repairs costs were assumed to be $2,000 and no allowances were made for replacement costs or residual value.

NOTE: The value of the existing boiler system ($100,000), the amount and cost of labor (40 hours, $800), and maintenance and repair costs ($2,000) 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 **five Garn WHS 3200** wood fired boilers. The initial investment was assumed to be $1,052,500, which includes the hypothetical value of the existing oil-fired boilers (valued at $100,000 as per Alternative 1) plus the initial investment cost of the Garn boiler system ($952,500, as per Table 6-1). The operation costs include 555 cords of fuelwood at $175 per cord and 1,314.23 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 $7,986 (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 Hoonah School/gym/pool 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	$100,000	$1,002,500
Operations Cost	$3,991,627	$1,836,023
Maintenance & Repair Cost	$29,755	$118,812
Replacement Cost	$0	$0
Residual Value	$0	$0
Total Life Cycle Cost	$4,121,381	$2,957,335

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

A typical bulk fuel boiler system includes bulk fuel storage, boiler building, wood-fuel handling systems, combustion chamber, boiler, ash removal, cyclone, exhaust stack and electronic controls. The variables in this list of system components include the use of silos or bunkers of various sizes for wood fuel storage, chip storage areas of various sizes, boiler buildings of various configurations, automated versus manual ash removal and cyclones for particulate removal (if necessary).[17]

7.1 Capital Cost Components

As indicated, bulk fuel systems are larger, more complex and often more costly to install and integrate with existing boiler and distribution systems. Before a true economic analysis can be performed, *all* of the costs (capital, non-capital and OM&R) must be identified, and this is where the services of architects and civil and mechanical engineers are necessary.

Table 7-1 outlines the various general components for a hypothetical, small bulk fuel system; however it is beyond the scope of this report to offer estimates of actual costs for those components. As an alternative, a range of likely total costs is presented and analyzed for comparative purposes.

Table 7-1. Initial Investment Cost Components for Bulk Fuel Systems	
Facility	Hoonah school, gym and pool (50,000 gallons/year; 1,405 tons/year, (MC50))
	Capital Costs: Building and Equipment (B&E)
Fuel storage building	?
Material handling system	?
Boiler building	?
Boiler: base price shipping	?
Plumbing/connections	?
Electrical systems	?
Installation	?
	Non-capital Costs
Engineering , Permitting, Contingency, etc.	?
Initial Investment Total ($)	**$1,000,000 to $2,000,000**

The investment cost of bulk fuel systems installed in institutional settings can range from $500,000 to over $2 million, with about $350,000 to $900,000 in equipment costs. Fuel handling and boiler equipment for an 8 MMBtu/hr (300 BHP) system was recently quoted to a school in the northeast USA for $900,000. The cost of a boiler and fuel handling equipment for a 3 to 4 MMBtu/hr system is about $350,000 to $500,000. The 2.4 MMBtu/hr system in Hoonah was installed at a sawmill for around $250,000, but an existing building was used and there were significant economies in fuel preparation and fuel handling that would be unacceptable in a non-industrial, setting. Fuel and boiler equipment for a 1 MMBtu per hour system is estimated at $250,000 to $300,000 (buildings are extra). Several schools in New England have been able to use existing buildings or boiler rooms to house new equipment and realize substantial savings, but recent school projects in Montana were all installed in new buildings.[4]

The cost of a bulk fuel heating system at the Craig School and Aquatic Center in Craig, AK was originally estimated at less than $1 million, designed to replace propane and fuel oil equivalent to 36,000 gallons of fuel oil. But the results of a January 2007 bid opening brought the cost to $1.85 million. The fuel storage and boiler building, fuel dryer, and system integration costs for the pool and two schools increased the project costs. *NOTE: The City of Craig undertook construction of the project using a "force account" and brought the final cost down to about $1.5 million.*

Table 7-2 shows the total costs (in 2005) for the Darby School (Darby, MT) project at $1,001,000 including $268,000 for repairs and upgrades to the pre-existing heating system. Integration with any pre-existing system will likely require repairs and rework that must be included in the wood system cost. Adding the indirect costs of engineering, permits, etc. to the equipment cost put the total cost at Darby between $716,000 and $766,000 for the 3 million Btu/hr system to replace 47,000 gallons of fuel oil per year. Since the boiler was installed at Darby, building and equipment costs have increased from 10% to 25% (as of 2007). A new budget price for the Darby system might be closer to $800,000 excluding the cost of repairs to the existing system.[4]

Table 7-2. Darby, MT Public School Wood Chip Boiler Costs [a]	
Boiler Capacity	3 MMBtu/hr
Fuel Oil Displaced	47,000 gallons
Heating Degree Days	7,186
System Costs:	
Building, Fuel Handling	$ 230,500
Boiler and Stack	$ 285,500
Boiler system subtotal	$ 516,000
Piping, integration	$ 95,000
Other repairs, improvements	$ 268,000
Total, Direct Costs	$ 879,000
Engineering, permits, indirect	$ 122,000
Total Cost	**$1,001,000**
[a] Biomass Energy Resource Center, 2005 [4]	

The following is an excerpt from the Montana *Biomass Boiler Market Assessment*[17]:

> "To date, CTA [*CTA Architects and Engineers, Billings, MT*] has evaluated more than 200 buildings throughout the northwestern United States and designed 13 biomass boiler projects, six of which are now operational. Selected characteristics of these projects, including total project cost, are presented in Table 1 [*7-3*]. As can be seen from Table 1 [*7-3*], total costs for these projects do not correlate directly with boiler size. The least expensive biomass projects completed to date cost $455,000 (not including additional equipment and site improvements made by the school district) for a wood chip system in Thompson Falls, Montana. The least expensive wood pellet system is projected to cost $269,000 in Burns, Oregon. The general breakdown of costs for these two projects is presented in Tables 2 [*7-4*] and 3."
>
> *NOTE: Information related to wood pellet systems was not included in this report as wood pellets are not readily available as a fuel in southeast Alaska.*

Table 7-3. Characteristics of Biomass Boiler Projects[17]					
Facility Name	**Location**	**Boiler Size** (MMBtu/hr output)	**Project Type**	**Wood Fuel Type**	**Total Project Cost**
Thompson Falls School District	Thompson Falls, MT	1.6 MMBtu	Stand-alone boiler building tied to existing steam system	Chips	$ 455,000
Glacier High School	Kalispell, MT	7 MMBtu	New facility with integrated wood chip and natural gas hot water system	Chips	$ 480,000
Victor School District	Victor, MT	2.6 MMBtu	Stand-alone boiler building tied to existing steam system	Chips	$ 615,000
Philipsburg School District	Philipsburg, MT	3.87 MMBtu	Stand-alone boiler building tied to existing hot water system	Chips	$ 684,000
Darby School District	Darby, MT	3 MMBtu	Stand-alone boiler building tied to existing steam & hot water system	Chips	$1,001,000
City of Craig	Craig, AK	4 MMBtu	Stand-alone boiler building tied to existing hot water systems	Chips	$1,500,000
Univ. MT Western	Dillon, MT	14 MMBtu	Addition to existing steam system	Chips	$1,400,000

Table 7-4. Cost Breakdown for the Least Expensive Wood Chip Boiler System Installed in a New Free-Standing Building [17]		
System Component	**Cost**	**% of Total**
Wood Boiler System Equipment	$136,000	30%
Building	$170,000	38%
Mechanical/Electrical	$100,000	22%
Mechanical Integration	$15,000	3%
Fees, Permits, Printing, Etc.	$34,000	7%
Total*	**$455,000***	100%

* not including additional equipment and site improvements made by the school district

7.2 Generic OM&R Cost Allowances

The primary operating cost is fuel. The estimated bulk fuel cost for the Hoonah school, gym and pool is **$98,350** (1,405 tons @ $70/ton). Other O&M costs would include labor, electricity, and maintenance and repair costs. For purposes of this analysis, it is assumed that the boiler will operate daily, 210 days (30 weeks) per year, from mid-September through mid-April.

Daily labor would consist of monitoring the system and performing daily inspections as prescribed by the system manufacturer. It is assumed that the average daily labor requirement is ½ hour. An additional **2** hours per week is allocated to perform routine maintenance tasks. Therefore, the total annual labor requirement estimate is (210 x 0.5) + 60 = **165 hours per year**. At $20 per hour, the annual labor cost would be **$3,300**.

There is also an electrical cost component to the boiler operation. Typically, electrically-powered conveyors of various sorts are used to move fuel from its place of storage to a metering bin and into the boiler. There are also numerous other electrical systems that operate various pumps, fans, etc. The Darby High School system in Darby, MT, which burned 755 tons of bulk fuel in 2005, used electricity in the amount of $2,035,[18] however the actual kWh or cost per kWh were not reported. Another report[17] proffered an average electricity cost for Montana of $0.086 per kWh. If that rate is true for Darby, then the electrical consumption would have been about 23,663 kWh. The Hoonah school, gym and pool system is projected to use 1,405 tons of bulk fuel (1.86 times the amount used at Darby). If it is valid to apportion the electrical usage based on bulk fuel consumption, then the Hoonah school, gym and pool system would use about 44,013 kWh per year. At $0.60 per kWh, the annual electric bill would be **$26,408.**

Lastly, there is the cost of maintenance and repair. Bulk fuel systems with their conveyors, fans, bearings, motors, etc. have more wear parts. An arbitrary allowance of **$5,000** is made to cover these costs.

Total annual operating, maintenance and repair cost estimates for a bulk fuel boiler at the Hoonah school, gym and pool are summarized in Table 7-5

Table 7-5. Total OM&R Cost Allowances for a Bulk Fuel System

Item	Cost/Allowance
Non-Fuel OM&R	
Labor ($)	*3,300*
Electricity ($)	*26,408*
Maintenance ($)	*5,000*
Total, non-fuel OM&R	34,708
Wood fuel ($)	98,350
Total OM&R ($)	**133,058**

7.3 Calculation of Financial Metrics

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

7.4 Simple Payback Period for Generic Bulk Fuel Boilers

Table 7-6 (next page) presents Simple Payback Period analysis for a range of initial investment cost estimates for generic bulk fuel boiler systems.

Table 7-6. Simple Payback Period Analysis for Bulk Fuel Heating Systems						
	Hoonah school, gym and pool (50,000 gpy; 1,405 tons/yr)					
Fuel oil cost ($ per year @ $5.35 per gallon	267,500					
Bulk wood fuel ($ per year @ $70 per ton)	98,350					
Annual Fuel Cost Savings ($)	169,150					
Total Investment Costs ($)	750,000	1,000,000	1,250,000	1,500,000	1,750,000	2,000,000
Simple Payback (yrs)[a]	**4.43**	**5.91**	**7.39**	**8.87**	**10.34**	**11.82**

[a] Simple Payback equals Total Investment Costs divided by Annual Fuel Cost Savings

While simple payback has its limitations in terms of project evaluations, one of the conclusions of the Montana *Biomass Boiler Market Assessment* was that viable projects had simple payback periods of 10 years or less.[17]

7.5 Present Value (PV), Net Present Value (NPV) and Internal Rate of Return (IRR) Values for a Hypothetical Bulk Fuel Boiler Installed at the Hoonah school/gym/pool

Table 7-7 presents PV, NPV and IRR values for hypothetical bulk fuel boilers.

Table 7-7. PV, NPV and IRR Values for Bulk Fuel Systems						
Discount Rate	3					
Time, "t", (years)	20					
Initial Investment ($)[a]	750,000	1,000,000	1,250,000	1,500,000	1,750,000	2,000,000
Annual Cash Flow ($)[b]	134,442					
Present Value (of expected cash flows), ($ at "t" years)	2,000,157					
Net Present Value ($ at "t" years)	1,250,157	1,000,157	750,157	500,157	250,157	157
Internal Rate of Return (%)	17.17	12.07	8.74	6.34	4.49	3.00

Notes:
a from Table 7-6
b Equals annual cost of fuel oil minus annual cost of wood minus annual non-fuel OM&R costs

SECTION 8. CONCLUSIONS

This report discusses conditions found "on the ground" at the Hoonah school, gym and pool in Hoonah, Alaska, and attempts to demonstrate, by use of realistic, though hypothetical examples, the feasibility of installing high efficiency low emission cordwood and/or bulk fuel wood boilers for heating 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/or 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.

The Hoonah school, gym and pool, taken together, can be considered "large" in terms of their total fuel oil consumption (50,000 gpy). It appears possible to heat these buildings (and pool), separately or together, with a cordwood heating system. Taken as a single project, it may be large enough to justify the installation of a bulk fuel wood heating system if investment costs can be controlled and a reliable consistent fuel supply identified.

The topography around the school, gym and pool is hilly, but there is a level area behind the school (currently serving as a ball field and playground) that would be suitable for either a cordwood or bulk fuel biomass heating system. Delivery trucks can access the site, perhaps with some slight difficulty, and the proximity of the site to the buildings to be heated is reasonable. It may even be possible/feasible to tie-in the police department building and fire hall, which are up the street.

8.1 Cordwood Systems

To replace 50,000 gallons of #2 fuel oil per year would require approximately 555 cords of reasonably dry (MC30) hemlock cordwood or large sawmill residues.

Examples of installing and operating multiple, large cordwood boilers are presented in Section 6. In order to supply enough heat for both the school and the gym/pool, a total of five large HELE boilers would have to be installed. And in order to consume 555 cords of wood per year those boilers would require an average of 3.7 firings per day (See Appendix F). If provisions are made to capture waste heat from the diesel generators to heat the school, a cordwood boiler system consisting of two large boilers would be necessary to provide heat to the gym/pool. And even though this would be a much smaller system, this option still appears quite cost-effective.

Initial investment costs for the installation of multiple cordwood boilers ranged from about $396,000 (for the gym/pool alone) to $952,000 (for the combined school + gym/pool), with the cost of the fuel storage building being the single most costly item ($111,000 to $278,000). However, each boiler installation scenario returned positive financial metrics with simple payback periods ranging from 5.44 to 5.81 years, and internal rates of return ranging from 12.52 to 13.56 percent.

8.2 Bulk Fuel System

To replace 50,000 gallons of fuel oil per year would require approximately 1,405 tons (approximately sixty-four 40-foot tractor trailer loads) of bulk fuel (chips, sawdust, bark, shavings, etc.), assuming such fuel runs 50% moisture content (MC50).

Although it is beyond the scope of this assessment to delve into the detailed costs associated with the installation of bulk fuel systems, it is not unrealistic to say that, at 50,000 gallons of fuel oil per year, it appears quite likely that a bulk fuel system could be cost-effective for the Hoonah school/gym/pool **IF**:

1. a reliable, consistent source of fuel can be identified
2. fuel can be delivered at a reasonable cost
3. total investment costs can be held to less than $2,000,000

If provisions are made to capture waste heat from the diesel generators to heat the school, then a bulk fuel boiler system would probably not be cost-effective for heating the gym/pool given the considerably smaller heating load (i.e., 20,000 gpy). A cordwood system would then be the better option.