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

Prepared for:

Ernest Arnold
Tanacross Village Council

Prepared by:

Daniel Parrent,
Wood Utilization Specialist
Juneau Economic Development Council

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Key words: HELE, LEHE, bulk fuel, cordwood

ABSTRACT

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

Early in 2007, organizations were invited to submit a Statement of Interest (SOI) to the Alaska Wood Energy Development Task Group (AWEDTG). Task Group representatives reviewed all the SOIs and selected projects for further review based on selection criteria presented in Appendix A. AWEDTG representatives visited Tanacross during the summer of 2007 and information was obtained for the various facilities. Preliminary assessments were made and challenges identified. Potential wood energy systems were considered for the projects using AWEDTG, USDA and AEA objectives for energy efficiency and emissions. Preliminary findings are reported.

SECTION 1. EXECUTIVE SUMMARY

1.1 Goals and Objectives

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

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

- This project meets the AWEDTG objectives for petroleum fuel displacement, use of hazardous forest fuels or forest treatment/processing residues, sustainability of the wood supply, community support, and project implementation, operation and maintenance.

- Given annual fuel oil consumption estimates of 8,000 gallons (water plant), 10,000 gallons (Upper Tanana Regional Training Center), and 14,000 gallons (planned multi-purpose facility) these projects would be considered "medium" in terms of their relative sizes.

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

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

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

1.3 Assessment Summary and Recommended Actions

Three facilities are considered in this report:

1.3.1. Tanacross Water Plant

• Overview. It was reported that the Tanacross water plant heats very cold incoming well-water about 14 degrees before distributing the water to residences on the city water system. Currently that amounts to approximately 20,000 gallons of water per day, requiring approximately 2,337,000 net Btu. This heat is provided by three Weil-McLain Gold P-WGO-5 boilers, rated at 152,000 Btu/hr net (each), with a firing rate of 1.45 gallons per hour (each).

• Fuel Consumption. Assuming that the water plant heats 20,000 gallons per day by 14 degrees Fahrenheit, and operates 365 days per year, the annual fuel consumption would be approximately **8,000 gallons**.

• Potential Savings. At the projected price of about $5.00 per gallon, the Tanacross water plant spends approximately $40,000 per year for fuel oil. The HELE *cordwood* fuel equivalent of 8,000 gallons of #1 fuel oil is approximately **94 cords**, and at $125 per cord represents a potential **annual fuel cost savings of $28,250** (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the water at the Tanacross water plant is dependent on the amount of water to be heated per hour. The installed capacity at the plant is currently 456,000 Btu (the combined capacity of the three existing boilers). If the plant operates 10 hours per, and total daily production amounts to 20,000 gallons, then the minimum RBC would be approximately **234,000** Btu/hr.

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

• Recommended action regarding a bulk fuel wood system. Given the heating demand, lack of fuel supply, and the probable costs of such a project, a "bulk fuel" system is not cost-effective for the Tanacross water plant.

1.3.2. Upper Tanana Regional Training Center

• Overview. The Upper Tanana Regional Training Center (UTRTC) is being developed at the old Tok school building in Tok, AK. TVC has renovated a portion of the facility (the gymnasium and adjacent spaces) for use as a construction trades training center, a manufactured home facility and office space. This space occupies approximately 10,000 square feet. Heat is provided by two Weil-McLain series 78 boilers (model 778?) rated at 625,000 Btu/hr (net, each), with a maximum burner rate of 6.5 gallons per hour (each). Whether or not the remainder of the building gets renovated and utilized remains to be seen.

• Fuel Consumption. Fuel consumption at the UTRTC was not known. The estimated consumption of **10,000 gallons** per year is based on a projected average consumption of 1 gallon per square foot per year.

• Potential Savings. At the projected price of about $5.00 per gallon, the UTRTC spends approximately $50,000 per year for fuel oil (based on the assumed 10,000 gpy). The HELE *cordwood* fuel equivalent of 10,000 gallons of #1 fuel oil is approximately **117 cords**, and at $125 per cord represents a potential annual fuel cost savings of $35,375 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the UTRTC is approximately **345,793** Btu/hr during the coldest 24-hour period (based on the assumed 10,000 gpy).

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

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

1.3.3. Tanacross Village Council, Multi-Purpose Facility (MPF)

• Overview. Tanacross Village Council is developing a 14,000 square foot Multi Purpose Community Services Center (MPF) that will host a mid-level community health center, Headstart center, social services offices and large meeting area. TVC has developed the facility site, installed a concrete foundation and piped/water services to the building foundation. TVC plans to complete the building in 2007/2008.

• Fuel Consumption. Since this is a new facility, fuel consumption at the TVC MPF is not known. The estimated consumption of **14,000 gallons** per year is based on a projected average consumption of 1 gallon per square foot per year..

• Potential Savings. At the projected price of about $5.00 per gallon, TVC MPF will spend approximately $70,000 per year for fuel oil. The HELE *cordwood* fuel equivalent of 14,000 gallons of #1 fuel oil is approximately **164 cords**, and at $125 per cord represents a potential annual fuel cost savings of $49,500 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the TVC MPF would be approximately 483,854 Btu/hr during the coldest 24-hour period, based on an annual consumption projection of 14,000 gallons.

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

• Recommended action regarding a bulk fuel wood system. Given the heating demand, lack of fuel supply, and the probable costs of such a project, a "bulk fuel" system is not cost-effective for the TVC MPF.

SECTION 2. EVALUATION CRITERIA, IMPLEMENTATION, WOOD HEATING SYSTEMS

The approach being taken by the Alaska Wood Energy Development Task Group (AWEDTG) regarding biomass energy heating projects follows the recommendations of the Biomass Energy

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

2.1 Evaluation Criteria

The AWEDTG selected projects for evaluation based on criteria listed in Appendix A. The Tanacross projects meet the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, use of local processing residues, sustainability of the wood supply, community support, and the ability to implement, operate and maintain the project. In the case of a cordwood boiler system, the potential to supply wood from local forests appears adequate and matches the application.

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

2.2 Successful Implementation

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

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

With manual systems, boiler stoking and/or maintenance is required for approximately 10 to 20 minutes per boiler several times a day (depending on the heating demand), and dedicating personnel for the operation is critical to realizing savings from wood fuel use. For this report, it is assumed that new personnel would be hired or existing qualified personnel would be assigned as necessary, and that "boiler duties" would be included in the responsibilities and/or job description of facility personnel.

The forest industry infrastructure in/around Tanacross and the upper Tanana Valley is fairly well-developed. For this report, it is assumed that wood supplies are sufficient to meet the demand.

2.3 Classes of Wood Heating Systems

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

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

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Currently, wood fuels in Tanacross will generally be in the form of cordwood and/or large unprocessed sawmill residues (slabs, edgings). Residential use of cordwood has increased significantly in the past 18 months due to sharply higher fuel oil costs. Given that higher demand, prices for firewood have gone up accordingly.

3.2 Heating Value of Wood

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

For this report, white spruce cordwood at 30 percent moisture content (MC30) calculated on the wet weight basis (also called green weight basis), is used as the benchmark. [It should be noted that other species are also present, including black spruce, white birch, cottonwood/poplar, willow and aspen. And although white spruce is used as the "benchmark", any species of wood can be burned in a cordwood system; the most critical factor being moisture content, not species.]

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

The RHV for white spruce *cordwood* (MC30) is calculated at 12.22 million Btu per **cord**, and the DHV, which is a function of boiler efficiency (assumed to be 75%), is 9.165 million Btu per cord. The delivered heating value of 1 **cord** of white spruce cordwood (MC30) equals the delivered heating value of **85.5** gallons of #1 fuel oil or **83.0** gallons of #2 fuel oil when the wood is burned at 75% conversion efficiency.

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

SECTION 4. WOOD-FUELED HEATING SYSTEMS

4.1 Low Efficiency High Emission (LEHE) Cordwood Boilers

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

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

In a news release dated January 29, 2007[12], the U.S. Environmental Protection Agency announced a new voluntary partnership agreement with 10 major OWB manufacturers to make cleaner-burning appliances. The new, Phase 1 standard calls for emissions not to exceed 0.60 pounds of particulate emissions per million Btu of heat **input**. The Phase 2 standard, which will follow 2 years after Phase 1, will limit emissions to 0.30 pounds per million Btus of heat **delivered**, thereby creating an efficiency standard as well.

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

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

4.2 High Efficiency Low Emission (HELE) Cordwood Boilers

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

Table 4-1 lists four HELE cordwood boiler suppliers, two of which have units operating in Alaska. HS Tarm/Tarm USA has a number of residential units operating in Alaska, and a Garn boiler manufactured by Dectra Corporation is used in Dot Lake, AK to heat several homes and the washeteria, replacing 7,000 gallons per year (gpy) of #2 fuel oil.[14] Two Garn boilers were recently installed in Tanana, AK (on the Yukon River) to provide heat to the washeteria and water plant, and two were installed near Kasilof on the Kenai Peninsula.

Table 4-1. HELE Cordwood Boiler Suppliers

	Btu/hr ratings	Supplier
EKO-Line	85,000 to 275,000	New Horizon Corp www.newhorizoncorp.com
Tarm	100,000 to 198,000	HS Tarm/Tarm USA www.tarmusa.com/wood-gasification.asp
Greenwood	100,000 to 300,000	Greenwood www.GreenwoodFurnace.com
Garn	350,000 to 950,000	Dectra Corp. www.garn.com

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

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

Table 4-2. Emissions from Wood Heating Appliances

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

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

4.3 Bulk Fuel Boiler Systems

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

Section 5. Selecting the Appropriate System

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

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

5.1 Comparative Costs of Fuels

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

Table 5-1. Comparative Cost of Fuel Oil vs. Wood Fuels					
FUEL	RHV[a] (Btu)	Conversion Efficiency[a]	DHV[a] (Btu)	Price per unit ($)	Cost per MMBtu (delivered, ($))
Fuel oil, #1, (per 1 gallon)	134,000	80%	107,200 per gallon	4.50/gal	41.978
				5.00	46.642
				5.50	51.306
Fuel oil, #2, (per 1 gallon)	138,000	80%	110,400 per gallon	4.50/gal	40.761
				5.00	45.29
				5.50	49.819
White spruce, (per 1 cord, MC30)	12.22 million	75%	9.165 million	100/cord	10.911
				125	13.639
				150	16.367

Notes:
[a] from Appendix D

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 illustrates the relationship between the price of white spruce cordwood (MC30) and the cost of delivered heat, (the slanted line). For each $10 per *cord* increase in the price of cordwood, the cost per million Btu increases by $1.091. The chart assumes that the cordwood boiler delivers 75% of the RHV energy in the cordwood to useful heat and that oil is converted to heat at 80% efficiency. The dashed lines represent #1 fuel oil at $4.50, $5.00 and $5.50 per gallon ($41.978, $46.642 and $51.306 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $427.47 per cord is equal to the cost of #1 fuel oil at $5.00 per gallon (i.e., $46.642 per MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $125 per cord, a high-efficiency cordwood boiler will deliver heat at about 29% of the cost of #1 fuel oil at $5.00 per gallon ($13.639 versus $46.642 per MMBtu). Figure 5-1 indicates that, at a given efficiency, savings increase significantly with decreases in the delivered price of cordwood and/or with increases in the price of fuel oil.

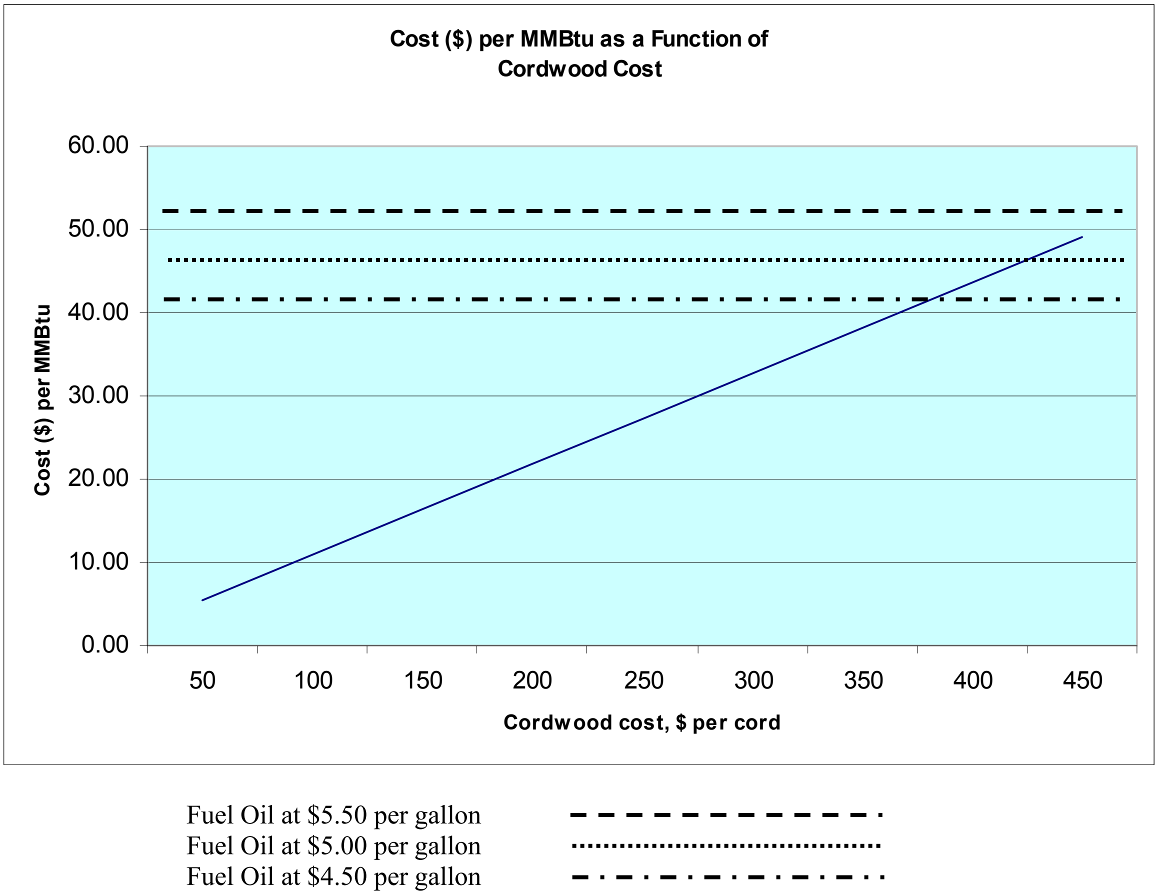

Figure 5-1. Effect of White Spruce Cordwood Price on Cost of Delivered Heat

5.2(b) Cost per MMBtu Sensitivity – Bulk Fuels

Not included in this report

5.3 Determining Demand

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

Table 5-2. Reported Annual Fuel Oil Consumption, Tanacross, AK		
Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $5.00/gallon*
Water plant	8,000	40,000
UTRTC	10,000	50,000
TVC MPF	14,000	70,000
TOTAL	**32,000**	**160,000**

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

Typically, installed oil-fired heating capacity at most sites is two-to-four times the demand for the coldest day. It appears that the Tanacross facilities fall within this range, although the heating capacity of the of the heating system ay the TVC MPF is unknown (non-existent; new construction).

Manual HELE cordwood boilers equipped with special tanks for extra thermal storage can supply heat at higher than their rated capacity for short periods. For example, while rated at 950,000 Btu/hr (heat into storage), a Garn WHS 4400 can store nearly three million Btu, which, theoretically, would be enough to heat for the UTRTC during the coldest 24-hour period for about 8½ hours (2,932,000 ÷ 345,793).

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

Facility	Fuel Oil Used gal/year[a]	Heating Degree Days[d]	Btu/DD[c]	Design Temp[d] F	RBC[e] Btu/hr	Installed Btu/hr[a]
Water plant	8,000		NA		234,000 (estimated)	525,000 (gross) 456,000 (net)
UTRTC	10,000	15,400 (Gulkana data)	69,610	-54	345,793	1,250,000
TVC MPF	14,000		208,831		483,854	unknown

Table 5-3 Footnotes:

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

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

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

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

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

According to these calculations (Table 5-3), it appears that the Tanacross facilities could each, technically, supply 100% of their heating needs with one or more high efficiency low emission cordwood boilers. Consultation with a qualified engineer is justified and strongly recommended.

5.4 Summary of Findings and Potential Savings

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

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

	Fuel Oil Used gal/year[a]	Annual Fuel Oil Cost (@ $ ___ /gal)			Approximate Wood Requirement[b]	Annual Wood Cost (@ $ ___ /unit)			Potential Gross Annual Fuel Cost Savings ($)		
CORDWOOD SYSTEMS		*4.50/gal*	*5.00/gal*	*5.50/gal*	W. spruce, MC30, CE 75%	*100/cord*	125/cord	*150/cord*	*Low*	*Medium*	*High*
Water plant	8,000	36,000	40,000	44,000	**94 cds**	9,400	11,750	14,100	21,900	28,250	34,600
UTRTC	10,000	45,000	50,000	55,000	**117 cds**	11,700	14,625	17,550	27,450	35,375	43,300
TVC MPF	14,000	63,000	70,000	77,000	**164 cds**	16,400	20,500	24,600	38,400	49,500	60,600
Total	32,000	144,000	160,000	176,000	**375 cds**	37,500	46,875	56,250	87,750	113,125	138,500

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

SECTION 6. ECONOMIC FEASIBILITY OF CORDWOOD SYSTEMS

6.1 Initial Investment Cost Estimates

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

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

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

Table 6-1 (next page) presents hypothetical scenarios of initial investment costs for cordwood systems in medium-sized heating demand situations. One scenario is presented for each facility. It should be noted, however, that these scenarios are strictly hypothetical. The solutions presented here are not necessarily the best or correct or only choices; consultation with qualified professionals is strongly recommended.

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

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

NOTES:

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

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

Table 6-1. Initial Investment Cost Scenarios for Hypothetical HELE Cordwood Systems				
Fuel oil consumption, gallons per year		8,000 (water plant)	10,000 (UTRTC)	14,000 (TVC MPF)
Required boiler capacity (RBC), Btu/hr		234,000 (?)	345,793	483,854
Cordwood boiler	Garn model	(2) Garn WHS 2000	(1) WHS 4400	(2) WHS 3200
	Rating -Btu/hr [e]	850,000	950,000	1,900,000
	Btu stored	2,544,000	2,932,000	4,128,000
		Building and Equipment (B&E) Costs, **$** (for discussion purposes only)		
Fuel storage building[a] (fabric bldg, gravel pad, $20 per sf)		37,600 (94 cds @ 20 sf/cd)	46,800 (117 cds @ 20 sf/cd)	65,600 (164 cds @ 20 sf/cd)
Boiler building @ $125 per sf (minimum footprint w/concrete pad)[b]		32,000 (16'x16')	27,500 (10'x22')	50,000 (20'x20')
Boilers				
Base price[c]		29,800	40,000[f]	65,800
Shipping[d]		5,000	4,500	8,000
Bush delivery [d]		NA	NA	NA
Plumbing and electrical[d]		15,000	15,000	15,000
Installation[d]		10,000	10,000	10,000
Subtotal - B&E Costs		**129,400**	**143,800**	**214,400**
Contingency (25%)[d]		**32,350**	**35,950**	**53,600**
Grand Total		**161,750**	**179,750**	**268,000**

Notes:

[a] A cord occupies 128 cubic feet. If the wood is stacked 6½ feet high, the area required to store the wood is 20 square feet per cord.

[b] Does not allow for any fuel storage within the boiler building

[c] List price, Alaskan Heat Technologies, April 2008

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

[e] Btu/hr into storage is extremely fuel dependent. The data provided for Garn boilers by Dectra Corp. are based on the ASTM standard of split, 16-inch oak with 20 percent moisture content and reloading once an hour.

[f] Published list price not available; this represents the current list price for WHS 3200 + $7,100

6.2 Operating Parameters of HELE Cordwood Boilers

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

6.3 Hypothetical OM&R Cost Estimates

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

Table 6-2. Labor/Cost Estimates for HELE Cordwood Systems			
System	(2) WHS 2000 (combined capacity) (94 cds/yr)	(1) WHS 4400 (117 cds/yr)	(2) WHS 3200 (combined capacity) (164 cds/yr)
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	317.27	229.53	273.61
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	47.0	58.5	82.0
Total Annual labor (hrs/yr)[c]	40	20	40
Total labor (hrs/yr)	404.27	308.03	395.61
Total annual labor cost ($/yr) (total hrs x $20)	**8,085.40**	**6,160.60**	**7,912.20**
Notes: a Appendix F, Table F-2 b Appendix F, Table F-3 c Appendix F			

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

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

Table 6-3. Summary of Total Annual Non-Fuel OM&R Cost Estimates			
Item	Cost/Allowance ($)		
	(2) WHS 2000 (combined capacity) (94 cds/yr)	(1) WHS 4400 (117 cds/yr)	(2) WHS 3200 (combined capacity) (164 cds/yr)
Labor[a]	8,085.40	6,160.60	7,912.20
Electricity[b]	836.89	333.40	467.78
Maintenance/Repairs	2,000.00	1,000.00	2,000.00
Total non-fuel OM&R ($)	**10,922.29**	**7,494.00**	**10,379.98**
Notes: a From Table 6-2 b Electrical cost based on a formula of horsepower x kWh rate x operating time. Assumed kWh rate = $0.32			

6.4 Calculation of Financial Metrics

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

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

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

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

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

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

6.5 Simple Payback Period for HELE Cordwood Boilers

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

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

	(2) WHS 2000 (combined capacity) (94 cds/yr)	(1) WHS 4400 (117 cds/yr)	(2) WHS 3200 (combined capacity) (164 cds/yr)
Fuel oil cost, $ per year @ $5.00 per gallon	40,000 (8,000 gal)	50,000 (10,000 gal)	70,000 (14,000 gal)
Cordwood cost $ per year @ $125 per cord	11,750 (94 cds)	14,625 (117 cds)	20,500 (164 cds)
Annual Fuel Cost Savings, $/yr	28,250	35,375	49,500
Total Investment Costs [b], $	161,750	179,750	268,000
Simple Payback[c], yrs	**5.73**	**5.08**	**5.41**
Annual, Non-fuel OM&R costs[a]	10,922	7,494	10,380
Net Annual Savings ($) (Annual Cash Flow)	17,328	27,881	39,120

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

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

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

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

	(2) WHS 2000 (combined capacity) (94 cds/yr)	(1) WHS 4400 (117 cds/yr)	(2) WHS 3200 (combined capacity) (164 cds/yr)
Discount Rate[a] (%)	3		
Time, "t", (years)	20		
Initial Investment ($)[b]	161,750	179,750	268,000
Annual Cash Flow($)[c] (Net Annual Savings)	17,328	27,881	39,120
Present Value (of expected cash flows, $ at "t" years)	257,797	414,799	582,007
Net Present Value ($ at "t" years)	96,047	235,049	314,007
Internal Rate of Return (% at "t" years)	8.69	14.47	13.42
See Note #_ below	1	2	3

Notes:

[a] real discount (excluding general price inflation) as set forth by US Department of Energy, as found in NIST publication NISTIR 85-3273-22 (Rev 5/08), Energy Price Indices and Discount Factors for Life Cycle Cost Analysis, April 2008

[b] From Table 6-1

[c] Equals annual cost of fuel oil minus annual cost of wood minus annual non-fuel OM&R costs (i.e., Net Annual Savings)

Note #1. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $257,797 today (PV), which is greater than the initial investment of $161,750. The resulting NPV of the project is $96,047 and the project achieves an internal rate of return of 8.69% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears financially 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 $414,799 today (PV), which is greater than the initial investment of $179,750. The resulting NPV of the project is $235,049 and the project achieves an internal rate of return of 14.47% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears financially and operationally feasible.

Note #3. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $582,007 today (PV), which is greater than the initial investment of $286,000. The resulting NPV of the project is $314,007 and the project achieves an internal rate of return of 13.42% at the end of 20 years. Given the assumptions and cost estimates, this alternative appears financially and operationally feasible.

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

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

SECTION 8. CONCLUSIONS

This report discusses conditions found "on the ground" at various facilities in Tanacross, Alaska, and attempts to demonstrate, by use of realistic, though hypothetical, examples the feasibility of installing high efficiency, low emission cordwood boilers to heat these facilities.

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

1. Tanacross water plant
2. Upper Tanana Regional Training Center (UTRTC) at the old Tok school building
3. Tanacross Village Council Multi-Purpose Facility (new, planned, partly constructed)

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

Each of the facilities under consideration could be heated with a HELE cordwood boiler system; none of the facilities appears too small and none appears too large.

Typically, the greater the fuel oil replacement the better the cost-effectiveness, but all of the proposed projects in Tanacross show strong financial metrics. However, all of these metrics are predicated on two assumptions: 1) that sufficient volumes of wood can be provided at a reasonable cost and 2) that someone will tend the boilers. Failure on either count will compromise the success of the project(s).