Alaska Wood Energy Development Task Group

Feasibility Assessment for Wood Heating

Final Report

August 2006

Prepared by:
T. R. Miles Technical Consultants, Inc.
1470 SW Woodward Way, Portland, OR, 97225
Tel 503-292-0107 www.trmiles.com

Prepared for:
Alaska Wood Energy Development Task Group (AWEDTG)
Juneau Economic Development Council/Wood Products Development Service
204 Siginaka Way, Sitka, AK 99835

Legal Notice

Table of Contents

Appendices

List of Tables

List of Figures

1.0 Executive Summary

The potential for wood heat in several Alaskan communities was evaluated for the Alaska Wood Energy Development Task Group (AWEDTG). Organizations submitted a Statement of Interest (SOI) to AWEDTG. TR Miles visited the village of Venetie and Delta-Greely Schools with Dan Parrent of JEDC and Peter Crimp of the Alaskan Energy Authority and the Prince of Wales Island with Karen Petersen of the UAF Cooperative Extension Service in August 2005. Information was obtained for each facility. Preliminary feasibility assessments were made and challenges were identified. Potential wood energy systems were considered for each project using AWEDTG and AEA objectives for energy efficiency and emissions. Recommendations are made for each site.

1.1 Goals and Objectives

- Visit sites in Venetie, Delta Junction and Prince of Wales Island.
- Assess the suitability of the sites for wood heat.
- Assess availability of wood.
- Review Statements of Interest (SOI) for wood heating systems.
- Size and estimate the capital costs of suitable systems.
- Estimate the potential economic benefits from installing a wood heating system.

1.2 Evaluation Criteria, Energy Efficiency and Emissions

- All projects meet the AWEDTG objectives for fuel displacement, use of forest residues for public benefit, use of local residues, sustainability of the wood supply, project implementation and operation and maintenance.
- The large energy consumers – Delta Greely Schools (69,000-102,000 gallons of fuel oil per year), Thorne Bay School (11,500 gallons per year) and Craig Community Association (6,605 gallons per year) have the best potential for implementing wood energy and deserve detailed engineering analysis.
- City of Thorne Bay Maintenance Shop and Duplexes (3,050 gpy fuel oil) represent positive benefit but marginal savings. This site should be considered for demonstration of an energy efficient and low emissions system.

- Systems consuming less than 2,000 gallons per year represent little or small savings with efficient wood systems unless they can be enclosed in an existing or low cost structure, wood is low cost and labor is free.
- Low emission energy efficient boiler systems are too expensive for most of the small (600 gpy) applications proposed. These may be satisfied with domestic wood appliances, such as cord wood or pellet stoves.
- Efficiency and emissions standards for Outdoor Wood Boilers (OWB) will change beginning in October 2006 which will increase costs for small systems.
- Economic benefits depend on low cost buildings and piping systems.

1.3 Recommended Actions for Delta–Greely Schools (Section 5)

- Delta Greely schools can benefit from a 4.5 MMBtuh wood chip heating system at a cost of $800,000 to $1,000,000.
- At $2.50/ gallon fuel oil the district pays $173,000 or more for 69,000 gallons of fuel. New demand is estimated at a total of 102,000 gallons per year. The district will pay $255,000 per year at $2.50gal. A wood system represents savings of $171,175 per year.
- Conduct a detailed engineering study for a central heating plant for the Delta Greely Schools.
- Determine fuel supply sources and costs.

1.4 Recommended Actions for Thorne Bay School (Section 6)

- A 1 MMBtuh wood chip system is too expensive for Thorne Bay School but it could benefit from a 425,000 Btuh cordwood system at an estimated cost of $104,300, or $78,500 if it is housed in the existing covered area.
- At $2.50 per gallon and 11,501 gallons of fuel oil the school pays $28,750 per year for fuel. Wood systems represent savings of $19,940 for the wood chip system at $30/ton and $11,705 per year for the cordwood systems at $100/cord respectively.
- Conduct a detailed engineering study for the integration of energy efficient, low emission cordwood boiler(s) for the Thorne Bay school and gym.

1.5 Recommended Actions for Craig Community Association (Section 7)

- Craig Community Center can benefit from a 350,000 Btuh cordwood system for $37,000.
- The Center pays proximately $16,513 for fuel oil at $2.50/gal. Savings would be $7,163 per year.
- Conduct a detailed engineering study for the integration of an energy efficient, low mission cordwood boiler for the Craig Community Center if it does not receive heat from the City of Craig Aquatic Center project.
- Plan to install a cordwood boiler at the lower level along side the center.

1.6 Recommended Actions for City of Thorne Bay (Section 8)

- City of Thorne Bay could benefit from wood heat in the city Maintenance Garage. The Maintenance Garage and two adjacent city owned duplexes consume 3,050 gallons fuel oil per year at a cost of $7,625 per year.
- A $31,900 boiler could be installed at the garage to serve the garage and duplexes for a savings of $3,125 per year.
- Conduct a detailed engineering study for the integration of energy efficient, low emission cordwood boilers for the Maintenance garage and City owned Duplexes. Plan to install a cordwood boiler behind the Maintenance garage. Extend the piping to the Duplexes if feasible.
- Verify project costs for a cordwood boiler at the Solid Waste Facility (2,000 gpy) for space heating.
- Verify the system costs for installing a small cordwood boiler to serve the City Hall and VPSO (1250 gpy).
- The loads for the Emergency Services Building, City Shop, Water Treatment and Wastewater Treatment facilities are too small for a wood fired system unless a residential sized energy efficient low emission appliance is used.

1.7 Recommended Actions for Venetie Village (Section 9)

- Venetie Airport maintenance facility is the same size as the Thorne Bay City Hall with only slightly higher fuel consumption. Two 250,000 Btuh heaters consume 1,688 gallons per year at a cost of $7,090 at $4.20/gallon.

- Consider installing a $35,000, 350,000 Btuh boiler with heat storage for the maintenance facility and waiting room in an external building.
- Consider an energy efficient, low emission cordwood system for heating the facility (100,000 Btuh) if the delivered system cost is appropriate. An $18,000 boiler could be installed at the garage and terminal building for a savings of $3,900 per year with wood at $100/cord.

1.8 General Recommendations for AWEDTG

- Plan to install a few efficient low emission cordwood boiler systems.
- Develop and demonstrate low cost enclosures for wood boilers and low cost heat distribution systems for hot water applications since building costs and integration of heat distribution are the major costs for wood burning boilers.

2.0 Introduction

2.1 Background and Objectives

T. R. Miles, Technical Consultants, Inc. was retained by Juneau Economic Development Council (JEDC) on behalf of the Alaska Wood Energy Development Task Group (AWEDTG) to evaluate the potential for wood heat in Alaska communities. Each organization submitted a Statement of Interest (SOI) to JEDC. TR Miles visited the village of Venetie and the Delta-Greely Schools with Dan Parrent of JEDC and Peter Crimp of the Alaskan Energy Authority and the Prince of Wales Island projects with Karen Petersen of the UAF Cooperative Extension Service in August 2005. Information was obtained for each facility and wood supply. Preliminary assessments were made and challenges were identified. Potential wood energy systems were considered for each project with the AWEDTG and AEA objectives for energy efficiency and emissions.

2.2 Project Scope

This report describes wood heating alternatives based on discussions with system providers and economic analysis. After each site visit a boiler system was selected and cost estimates were prepared. An economic model was developed to determine operating and investment costs and potential financial benefits. Wood boiler suppliers were consulted to refine system selection and cost assumptions. Investment estimates were revised and the wood systems were compared with oil using a federal Life Cycle Cost Method.

2.3 Study Organization

Following this Introduction, this report is organized into the following sections:

- Section 3 –Evaluation Criteria, Energy Efficiency and Emissions
- Section 4 – Fuels and Heating System Overview
- Section 5 – Delta Greely Schools
- Section 6 – Thorne Bay School
- Section 7 – Craig Community Association
- Section 8 – Thorne Bay City
- Section 9 – Venetie Village

Abbreviations and acronyms used in this report are listed in Appendix A.

3.0 Evaluation Criteria, Energy Efficiency, Emissions

3.1 Evaluation Criteria

The AWEDTG selected projects for evaluation based on the criteria listed in Appendix B. All projects meet the AWEDTG criteria for fuel displacement, use of forest residues for public benefit, use of local residues, sustainability of the wood supply, project implementation and operation and maintenance. In all cases the wood supply from public forest fuels or local processing residues is adequate and matches the applications. Community support appeared to be present in most cases.

Two aspects of project implementation have been important to wood projects in the past: clear identification of a sponsoring agency and dedication of personnel. In situations like Venetie Village where several organizations are responsible for different services it must be clear which organization would sponsor or implement a wood burning project. Stoking fuel or boiler maintenance is only required for an hour once or twice a day for most systems but dedicating personnel for operation is important to realize savings from wood fuel. Also the cost of labor can absorb fuel costs savings. In Dot Lake, for example, the wood system was idle for a period when an employee could not be found to fuel and maintain the boiler. Since there are no full time personnel at the airport at Venetie, or dedicated to the boiler at the Craig Community Center, it was not clear who would be responsible for a wood boiler or whether there would be additional labor costs for a wood system. All other locations assumed that the personnel would fit into the responsibilities of existing facilities personnel.

3.2 Energy Efficiency and Emissions

An objective of the Alaska Energy Authority is to support projects that use energy efficient and clean burning wood heating systems. Wood chip systems that are built in schools are generally efficient and meet typical air pollution standards. Boilers convert 70% of the energy in the wood fuel to hot water when the fuel moisture is 35% MC to 45% MC (wet basis).

Outdoor Wood Boilers (OWB) for cordwood, like two that are now being used on Prince of Wales Island, are low cost and save fuel oil but have been criticized for low efficiency and smoky operation. The State of New York recently banned use of outdoor wood boilers.[1] Other states have also considered regulations.[2] OWB ratings are inconsistent and misleading. Some suppliers rate their boilers on fuel input. Others rate their boilers on hot water produced using dense, 20% MC, red oak fuel.[3] Standard procedures for evaluating wood boilers have not existed. Test data assembled by New York showed a wide range of efficiencies and emissions among outdoor wood boilers. Boiler efficiencies were low at 35% to 40%. Most emissions exceed acceptable standards for residential appliances or industrial boilers.

A committee was formed under the American Society for Testing and Materials (ASTM) to develop a standard test protocol for outdoor wood boilers.[4] The rules will include uniform testing for performance and emissions. The ASTM committee sponsored tests of three common outdoor wood boilers using the new procedures that showed efficiencies of 35% to 40% and emissions more than nine times the standard for industrial boilers. The new standard will require owner training by the dealer, certification that the owner received training, and consent by the owner that they will burn only wood fuels. The new standard is expected to be approved and promulgated in October 2006. After that date OWB manufacturers will have two years to test their boilers. States will use the test results to set emission limits. Consumers will only be allowed to buy boilers that meet state emissions limits.

Implementation of the new standard will improve air quality and boiler efficiency but increase costs as manufacturers modify their design, fabrication and marketing to adjust to the new standards. Some residential models, which are the scale of many of the AWEDTG proposals, will no longer be feasible.

Table 3-1 lists examples of two boilers with high efficiency and low emissions that are in use in Alaska. A Tarm boiler is being used to heat a 5,000 ft2 house in Palmer.[5] Tarm USA supplies boilers from 100,000 Btu/hr to 198,000 Btu/hr maximum heat output and claims fuel to hot water efficiencies of 80%. A Garn boiler by Dectra

[1] Smoke Gets in Your Lungs: Outdoor Wood Boilers in New York State, October 2005, New York State Attorney General http://www.oag.state.ny.us/press/2005/aug/August%202005.pdf

[2] Assessment of Outdoor Wood-Fired Boilers, Revised May 2006, NESCAUM, the Clean Air Association of the Northeast States http://www.nescaum.org/documents/assessment-of-outdoor-wood-fired-boilers

[3] Red Oak 20% MC 8,500 Btu/lb, 18.2 MMbtu/cord.

[4] WK5982 Standard Test Method for Measurement of Particulate Emissions and Heating Efficiency of Outdoor Wood-Fired Hydronic Heating Units, Committee E06.54 on Solid Fuel Burning Appliances American Society of Testing and Materials. www.astm.org

Corporation is used in Dot Lake for heating buildings to replace 7,000 gpy of fuel oil.[6] Table 3-2 shows the results for a Garn WHS 1350 boiler that was tested at 157,000 Btu/hr to 173,000 Btu/hr by the State of Michigan using the new procedures compared with EPA standards for wood stoves and boilers.[7] It is also important to remember that wood fired boilers are not always smokeless; all efficient boilers smoke for a few minutes on startup.

Table 3-1. Examples of Efficient Cordwood Boilers.

Model	MBtuh	Location	Supplier
Garn	900,000	Dot Lake, AK	Dectra
Tarm	140,000	Palmer, AK	Tarm USA

Table 3-2. Emissions from Wood Heating Appliances

Appliance	Emissions Gm/1000 Btu Delivered
EPA Certified Non Catalytic Stove	0.50
EPA Certified Catalytic Stove	0.25
EPA Industrial Boiler (many states)	0.225
GARN WHS 1350 Boiler*	0.179

Source: Intertek Testing Services, Michigan, March 2006.
Note:
*Average efficiency of 75.4% based upon the higher heating value of wood.

Garn advertises efficiencies of 70% on cordwood for the WHS series from 350,000 Btuh to 950,000 Btuh heat output and heat storage capacities of 920,000 Btu to 2,135,000 Btu (120° F - 200° F). While other suppliers may develop models with similar performance these two units were used as a basis for the feasibility analysis.[8]

[5] http://www.tarmusa.com/ Tarm USA Inc. P.O. Box 285 Lyme, NH 03768 This is equal to 1600 gallons of fuel oil in the Southeast or 2500 gpy in the Interior.
[6] http://www.dectra.net/garn/ Dectra Corporation, Minneapolis, Minnesota. 612-781-3585
[7] Test of a Solid fuel Boiler for Emissions and Efficiency per Intertek's Proposed Protocol for Outdoor Boiler Efficiency and Emissions Testing. Intertek report No. 3087471 for State of Michigan, Air Quality Department. Intertek Testing Services NA Inc. 8431 Murphy Drive, Wisconsin 53562. March 2006.
[8] Keunzel, New Horizon and Alternate Heating Systems are sometimes recommended for high efficiency boilers; however they are not yet used in Alaska and no efficiency or emissions data was available for this study. www.newhorizoncorp.com/ www.kuenzel.de/English/indexE.htm www.alternateheatingsystems.com/Multi-Fuel_boilers.htm

In these analyses a non-pressurized cord wood boiler would supplement, not replace, an oil fired system. Glycol from the existing oil-fired boiler would be circulated through a heat exchanger at the wood boiler ahead of an existing oil boiler or a heat exchanger. The existing oil fired systems would be available for peak demand or backup in the event of a failure in the wood system. In wood chip systems the boiler would be integrated with the existing oil fired system.

4.0 Fuels and Heating Systems Overview

The projects reviewed for AWEDTG fall into three sizes: small institutions, schools and residential scale heating systems. Wood fuels and fuel oil replacement for typical systems are discussed below.

4.1 Wood Fuels and Recoverable Heat

Wood fuels on Prince of Wales Island and in Delta Junction are likely to be chips, sawdust or hogged fuel from larger sawmills and whole tree chipping operations or cordwood from forest cleanup and small sawmills. Sawdust and shavings are used at Icy Straits Milling in Hoonah and Regal Enterprises in Copper Center. Three boilers on Prince of Wales Island use cordwood: two from mill residues such as slabs, edgings, butt cuts and buck-outs and the other with purchased cordwood.

4.1.1 Wood Fuel Properties

Heating values for Alaskan woods are listed in Table 4-1. Oven dry (od) heating values are similar for most species on a weight basis. Cordwood is considered to be air dried to 20% moisture content (MC20), wet basis. Heating value of the cordwood as fired is 6,650-6,896 Btu/lb at 20% MC. Density varies from Western Red Cedar to Hemlock. Sitka Spruce has an intermediate density and is used here. The as-fired heating value of Sitka Spruce cordwood at MC20 is about 13.4 Million Btu (MMBTU) per cord (80 ft3). Many wood boilers are rated on northern Red Oak which contains 18.2 MMBtu per cord (1.4 tons per cord) at MC20. More cordwood will be required for the Alaskan wood compared with the northern and eastern hardwoods.

Wood chips are typically 45% to 50% moisture content, wet basis (MC50) and are sold either by weight (per ton) or volume (per Unit of 200 ft3). Since there are no pulp mills on Prince of Wales Island or near Delta Junction it is likely that the chips will be sold by weight. Sitka Spruce has a Gross Heating Value (GHV) of 4,100 Btu/lb at MC50.

Wet fuel may be a problem for wood chip boilers on Prince of Wales Island. Most small boilers operate well when wood chips are 35% to 45% MC and very poorly above that. Wood chips that are stored outside can absorb rainwater and reach moistures as high as 60% to 65%.[9] Schools in the Northeast using wood chips select suppliers carefully and often pay extra for clean chips below 40% MC.[10]

Table 4-1. Wood Fuel Properties.

Species	HHV Btu/lb od [a]	GHV Btu/lb MC20 [a]	Lb/Cord [b, c]	Ton/Cord [b, c]	MMBtu/ cord [c]	GHV Btu/lb MC50 [a]
Western Red Cedar	8,620	6,896	1,860	0.93	12.8	4,310
Hemlock	8,338	6,670	2,512	1.26	13.9	4,169
Sitka Spruce	8,200	6,650	2,040	1.02	13.4	4,100
White (Englemann) Spruce	8,401	6,721	2,040	1.02	13.7	4,201

Source: Juneau Economic Development Council
Notes:
[a] Higher Heating Value (HHV) and Gross Heating Value (GHV) from JEDC. GHV = HHV (1-MCwb/100)
[b] Specific Gravity: Cedar 0.31, Hemlock 0.42, Spruce 0.34
[c] 80 ft^3 per cord

4.1.2 Recoverable Heat and Fuel Oil Replacement

Wood boilers are more expensive to install, own and operate than oil boilers. Fuel savings must pay for these higher costs. The amount of fuel oil replaced depends on the heating value of the fuel and the efficiency of the wood boiler. Table 4-2 shows the amount of fuel oil displaced at typical efficiencies by wood with the heating values in Table 4-1. Boiler conversion efficiency (CE) can be expected to vary from 35% to 70% of the energy in the fuel. Recovered heat is calculated using the equation Recovered Heating Value (RHV) = Gross Heating Value (GHV) x % Conversion Efficiency (CE).[11] Fuel oil replacement based on Sitka Spruce is calculated at 49 gallons for a ton of green wood chips at 70% conversion efficiency. Fuel oil replacement for an efficient cordwood boiler at 66 gallons of fuel oil saves twice as much as an inefficient boiler at 33 gallons per cord.

[9] Wood with moisture greater than about 63% MC will not support combustion.
[10] Interviews with schools in Massachusetts and Vermont. 2005.
[11] Briggs, David, 1994. Forest Products Measurements and Conversion factors: with Special Emphasis on the U.S. Pacific Northwest, University of Washington Institute of Forest Resources, AR-10, Seattle, Washington 98195 Chapter 8.

Table 4-2. Fuel Oil Replaced by Wood Boilers				
Fuel, boiler	Conversion Efficiency CE	Energy in Fuel HHV	Btu Delivered RHV	Gal Fuel Oil
Fuel Oil, Btu/gal	85%	138,500	117,300	1
[a] Wood chip boiler, 50% MC, MMBtu/ton, gal/ton	70%	8.2	5.8	49
[b] Efficient Cordwood Boiler 20% MC, MMBtu/cd, gal/cord	70%	11.1	7.8	66
[c] Low efficiency wood boiler, 20% MC, MMBtu/cd, gal/cord	35%	11.1	3.9	33

Notes:

[a] Typical conversion efficiency 70%. Recovered Heating Value (RHV) = Gross Heating Value (GHV) x % Conversion Efficiency (CE).

[b] Based on references cited in Section 3.0

[c] Typical efficiency 35% to 40%

4.2 Wood Heating Systems

The Delta Greely Schools are suited to a chipped wood boiler. Most other systems are better suited for cordwood. The sources and supply of wood must be verified. On Prince of Wales Island both wood chips and cordwood are available. In the Interior cordwood is probably more available now but chips will be available if there is a demand.

4.2.1 Wood Chip Systems

Wood chip boilers are generally used for commercial, institutional or light industrial applications. The larger energy consumers, like Delta Greely Schools (69,000-102,000 gallons of fuel oil per year) have the best potential for installing wood chip boilers and deserve detailed engineering analysis. Chip handling systems are generally too expensive for small boilers.

Wood chips are delivered in self-unloading trailers that hold about 24 tons of green chips. A school replacing 60,000 gallons of oil might use 35 tons per week or about 1 1/2 trailers.[12]

There are at least three wood chip boilers in Alaska. Table 4-3. The most recent was installed in Hoonah in 2006. A 4 MMBtuh chip boiler will be installed at the Craig Aquatic Center to replace 36,000 gals of fuel oil per year. It is similar in size to boilers recently installed in Montana schools as shown in Table 4-4.

Table 4-3. Wood Chip Boilers in Alaska.

Location	Boiler Horsepower	MMBtuh	Heating Degree Days	Supplier
Craig Aquatic Center, Craig, AK	120	4	7,487	Chiptek
Icy Straits Lumber & Milling, Hoonah, AK	72	2.4	8,217	Decton
Regal Enterprises, Copper Center, AK	N/A	N/A	13,797	Messersmith (Fuel bin only)

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

The cost of these systems ranges from $0.5 to $2 million with about $350,000 to $900,000 in equipment. Fuel handling and boiler equipment for an 8 MMBtuh (300 BHP) system was recently quoted to a school in the Northeast for $900,000. Boiler and fuel handling equipment for the 3 to 4 MMBtuh systems is about $350-$500,000. A 2.4 MMBtuh system in Hoonah was installed at a saw mill for $250,000. Fuel and boiler equipment for a 1 MMBtuh system is estimated at $250,000 to $280,000. At Hoonah an existing building was used and there were economies in fuel preparation and handling. Several schools in New England have been able to use existing buildings or boiler rooms. The Montana projects are all in new buildings. Schools in Montana and New England save about half the total cost of fuel oil consumed at 60,000 gallons per year.

[12] Athol Royalston High School, Massachusetts, a 3 MMBtuh boiler replaces 60,000 gpy fuel oil, installed 1998.

Table 4-4. Wood Chip Boilers in Montana Schools.

Table Header	Phillipsburg Public Schools	Darby Public Schools	Thompson Falls Public Schools	Victor Public Schools
Location	Phillipsburg, MT	Darby, MT	Thompson Falls, MT	Victor, MT
Heating Degree Days***	8,734	7,041	6,496	7,494
Project Cost *	$650,000	$650,000	$455,000	$628,991
Square Footage **	99,000	82,000	60,474	47,000
Peak Output Btu/hr	3.87 million	3 million	1.6 million	4.9 million
Annual wood fuel Use	400 tons	750 tons	400 tons	500 tons
Fuel Replaced	Natural Gas	Fuel Oil	Fuel Oil	Natural Gas
Estimated Fuel Use	NA	50,000 gal	24,000 gal	NA
Estimated Annual fuel Savings	$67,558 ($11 dkt)	$100,000 ($2.50/gal)	$60,000 ($2.50/gal)	$31,898 ($13.82/MM Btu)
Supplier***	N/A	Messersmith	Chiptek	Messersmith
Date Operational	01/05	11/03	10/05	09/04

Source: Montana Department of Natural Resource Conservation, http://dnrc.mt.gov
Notes:
* Darby cost excludes $268,000 in repairs to existing heat distribution system.
** Victor boiler sized to heat an additional 16,000 sq. ft. in future.
*** Additional data not supplied by Montana DNRC

Table 4-5 shows costs from the Darby project at $1,001,000 including $268,000 for repairs to the existing system. Integration to any school will 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 puts the total cost at Darby between $716,000 and $766,000 for the 3 million Btuh 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 as low as 10-15% to as high as 25%. A new budget price for the Darby system might be $800,000 without repairs to the existing system. The Craig Aquatic Center project has been estimated at $1 million to replace propane and fuel oil equal to 36,000 gallons of fuel oil. Building and system integration costs for the pool and two schools increased the project costs.

Table 4-5. Darby Public Schools Wood Chip Boiler Costs.	
Boiler Capacity	3 MMBtuh
Fuel Oil Displaced	47,000
Heating Degree Days	7,186
System Costs	
Building, Fuel Handling	$ 230,500
Boiler and Stack	$ 285,500
Boiler system	$ 516,000
Piping, integration	$ 95,000
Other repairs, improvements	$ 268,000
Total direct Costs	$ 885,000
Engineering, permits, indirect	$ 116,000
Total Cost	$1,001,000

Source: Biomass Energy Resource Center, 2005.

4.2.2 Cordwood Boilers

Cordwood boilers best suit applications from 100,000 Btuh to 900,000 Btuh. There are a few examples of the high efficiency, low emission boilers in Alaska. Two are listed in Table 3-1. At Dot Lake the $66,000 project replaces 7,000 gpy of fuel oil for a fuel savings of $16,000 per year.

Fuel quality has a large impact on the performance of cordwood boilers. It is assumed for this study that cordwood has been seasoned and dried to 20% MC.

4.2.3 Wood Heat System Capacity

Wood boilers are often sized to displace only a portion of the heating load since the oil system will remain in place for peak demand. Fuel oil consumption for each site was compared with heating demand based on heating degree days to determine the boiler capacity required for heating only on the coldest 24 hour day. Table 4-6. This method matches well with woodchip boilers installed in schools across the country. While there are many reasons for sizing heating systems it is clear that in all cases in this study a wood system of reduced size could replace a substantial quantity of fuel oil.

The calculation shows that installed oil capacity at most sites is three to four times the demand for the coldest day. Excess capacity may be necessary in the interior. Wood boilers with hot water tanks for thermal storage can also supply heat at higher than their rated capacity for short periods. The 4,000 gallon tank at Dot Lake, for example, can store more than 2 million Btu which would be enough to heat the Thorne Bay School on the coldest day for five hours.

The two groups of buildings at the Delta Greely schools each have an installed capacity of about twice the estimated demand of 3.988 MMBtuh. This suggests that a 4.5 MMBtuh boiler could replace all the oil used at the schools. The two centers are more than 1000 feet apart which increases piping costs but since they are at the same elevation it is feasible to distribute to them from a single boiler. The smaller buildings at Delta Greely - VoTech center, Career Advancement and Cyber Center - were each estimated at approximately 400,000 Btuh.

According to this calculation the Thorne Bay school could supply 100% of its heating needs of 347,000 Btuh with a 425,000 Btuh wood fired boiler. The Craig Community Center could use a 350,000 Btuh system to meet its demand of 207,000 Btuh. All of the other buildings evaluated require capacities less than 100,000 Btuh.

Table 4-6. Estimate of Heat Required in Coldest 24 Hr Period.

Facility	Fuel Oil Used gal/year [a]	Heating Degree Days [b]	Btu/DD [c]	Design Temp [b] F	Capacity MMBtuh [c]	Installed MMBtuh [a]
Delta-Greely Schools (Estimated)	102,000	13,549	866,261	-43	3.988	~10.000
2004 Fuel Oil	69,000	13,549	599,529		2.698	4.200
High School and Admin(former elementary)	33,000 [d]		286,731		1.290	4.200
VoTec, Career Advancement and Cyber Center, (est ea)	9,300 [d]		80,806		0.363	~.500
New Elementary	33,000 [d]		286,731		1.290	4.500
Thorne Bay School	11,501	7,802	173,540	17	0.347	1.800
Craig Community Assn	6,605	7,487	103,857	17	0.207	0.704
City of Thorne Bay						
Maintenance Garage and Duplexes	3,050	7,802	46,022	17	0.092	
Maintenance Garage	1,800		18,861	17	0.054	0.140
City Duplexes	1,250					
Solid Waste Building	2,000		30,178		0.060	0.080
City Hall, VPSO	1,250		18,861		0.038	0.190
Emergency Services, Water Treatment	600		9,053		0.018	0.080
Wastewater Treatment	600		9,053		0.018	0.120
Venetie Airport Maintenance	1,688	16,465	12,069	-57	0.061	0.500

Notes:

[a] From SOI and site visits

[b] 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.

[c] Btu/DD= Btu/year x oil furnace Efficiency (0.85) /Degree Days; Boiler capacity Required for the coldest Day, Btu/hr= Btu/DD x (65 F-Design Temp=DD)/24 hrs

[d] Estimated from total fuel oil consumption and building area.

4.3 Cost Estimates

The selection of a wood heating system has an impact on fuel economy. Wood system costs include the fuel cost and the cost of owning the heating system. After each site visit a boiler system was selected and cost estimates were prepared. An economic model was developed to determine the operating and investment costs and potential financial benefits for the system. The breakeven for each system was determined which became a target cost. Wood system suppliers were consulted to refine system selection and cost assumptions. Investment estimates were revised and the wood systems were compared with oil using a Life Cycle Cost Method to calculate savings compared with the existing oil systems. The general results of these assessments are discussed below.

4.3.1 Fuel Cost

The major advantage of wood compared with fuel oil is the cost of the fuel. Wood burning boilers are usually first installed where chips, pallets or cordwood are free. Two wood boilers on Prince of Wales Island use cordwood that is essentially free. At Thorne Bay Wood Products [in Thorne Bay] and W.R. Jones & Son Lumber Co. [in Craig], slabs, edgings, butt cuts and buck-outs are burned in cordwood boilers to heat a process building and dry kilns. Planer shavings and sawdust are used at Icy Straits Lumber in Hoonah and at Logging and Milling Associates at Dry Creek in the Interior. Chips and cordwood can also be free at the mill site. Hog fuel, composed of unscreened bark and sawdust, can be available from Viking Mill in Klawock for slightly more than the cost of delivery, or about $10-15/ton ($20-$30/odt). For comparison typical delivered chip costs at schools in New England are $30-$40/ton at 40% MC ($58/odt) which is equal to $30/ton at 50% MC.

The price of chipped wood usually has a low impact on the cost of heat. Figure 4-1. The chart assumes that the wood chip boiler converts 70% of the energy in the chips to useful heat and that oil is converted to heat at 85% efficiency. Fuel at $30/ton is equal to $5/MMBtu compared with fuel oil ($2.50/gallon) at $21.31/MMBtu. Chip prices of $15/ton and $30/ton were used for Thorne Bay and Delta-Greely. When fuel supplies are identified for Delta-Greely chips may cost $30/ton or more.

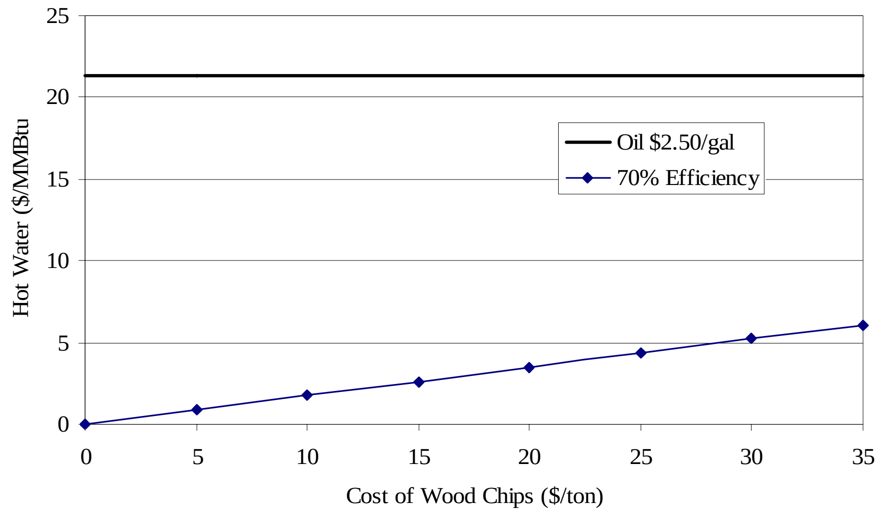


Figure 4-1. Effect of Wood Chip Costs on Cost of Delivered Heat.

Figure 4-2 shows that the price of cordwood can have a large impact on the cost of heat. If cordwood at 20% MC, like the slabs and edging used on POW, could be delivered to a low efficiency boiler for $25/cord the cost of heat would be $5/MMBtu, which is equal to $30/ton of green chips. Figure 4-1 Cordwood prices in southeast Alaska vary from $75 to $160 per cord, with $100 to $125 per cord being typical on Prince of Wales Island. Figure 4-2 shows that at 35% efficiency heat from wood at $100/cord is equal to the cost of oil at $2.50/gallon, before considering the cost of the boiler, however, at high (70%) efficiency, heat from wood at $200/cord is equal to the cost of oil at $2.50 per gallon, before considering the cost of the boiler. Given fuel oil at $2.50 per gallon, most low efficiency boiler projects would not be feasible with cordwood prices at or above $100 per cord. At 70% efficiency and $100/cord a boiler will deliver heat at half the cost of fuel oil. Figure 4-2 shows that at a given efficiency project savings increase significantly with decreases in the delivered price of cord wood.

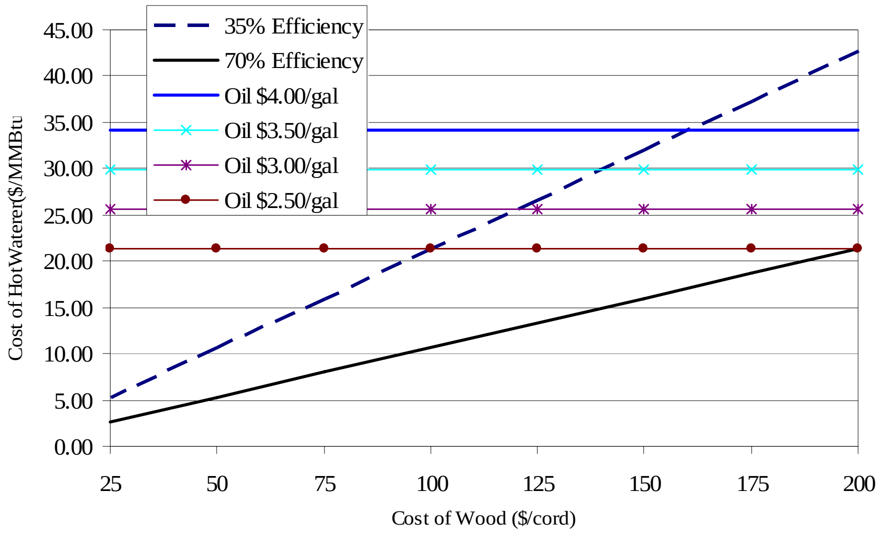


Figure 4-2. Effect of Cordwood Cost on Cost of Delivered Heat.

4.3.2 Heating System Costs: Chips

Wood heating systems include the cost of the fuel delivery and storage, boiler equipment, piping, heat exchangers, electrical service to integrate with existing distribution systems, installation, and for larger and institutional projects: allowance for engineering and contingency. Table 4-7 summarizes cost estimates for two wood chip boiler systems. The total system cost is two to three times the cost of the boiler. Building and piping cost are the most significant costs besides the boiler. Building costs deserve more site specific investigation to reduce system costs.

Table 4-7. Cost Estimates for Wood Chip Boiler Systems.

Facility	Delta Greely Schools*	Thorne Bay School**
Capacity, Btuh	4,500,000	1,000,000
Fuel Oil Replaced, gallons per year	102,000***	11,501
Estimated costs		
Buildings	$ 228,000	$ 158,000
Boilers, Fuel System, Stack	$ 397,000	$ 280,000
Piping, Integration	$ 231,000	$ 52,500
Other Installation	$ 80,000	$ 48,100
Total Direct Costs	$ 936,000	$ 538,600
Engineering, permits	$ 120,000	$ 70,000
Contingency 15%	$ 158,000	$ 91,000
Total	$ 1,214,000	$ 699,000

Notes:
* Section 5 Table 5-1
** Section 6 Table 6-1
*** 69,000 gpy at old school plus estimated 33,000 gpy at new elementary= 102,000 gpy

Assumptions in Table 4-9 were used for economic analysis to assess the feasibility of the wood fired systems.

Table 4-8. Assumptions for Economic Analysis.

Component	Factor	Units
Cost of Power	$0.17, $0.25	/kWh
Cost of Fuel Oil	$ 2.50	/gal
Cost of Chips, MC50	$15, $30	/ton
Cost of Cordwood	$60-$100	/cord
Operating and Maintenance as % of Capital	3% 2%	Chips Cordwood
Loan Interest or Capital Recovery	6%	Interest rate
Loan Term	20, 10, 5	Years
Discount rate (for constant dollar PV calculation)	3%	
Inflation	3%	
Power price escalator	3%	
Tax rate	None	
Grant financing	None	
Debt	None	

Figure 4-3 illustrates the effect of capital and non-fuel costs on the cost of heat for a 4,500,000 Btuh wood chip system to replace 102,000 gallons of fuel oil per year. At this annual fuel consumption the 70% efficient system would be used at a full load equivalent of 2,660 hours per year or about 30.4% capacity factor (2,660 hours/8760 hours at 45 MMBtuh). The cost to recover a $1.2 million investment would be about $11/MMBtu for 10 years, or $6.24/MMBtu for 20 years.

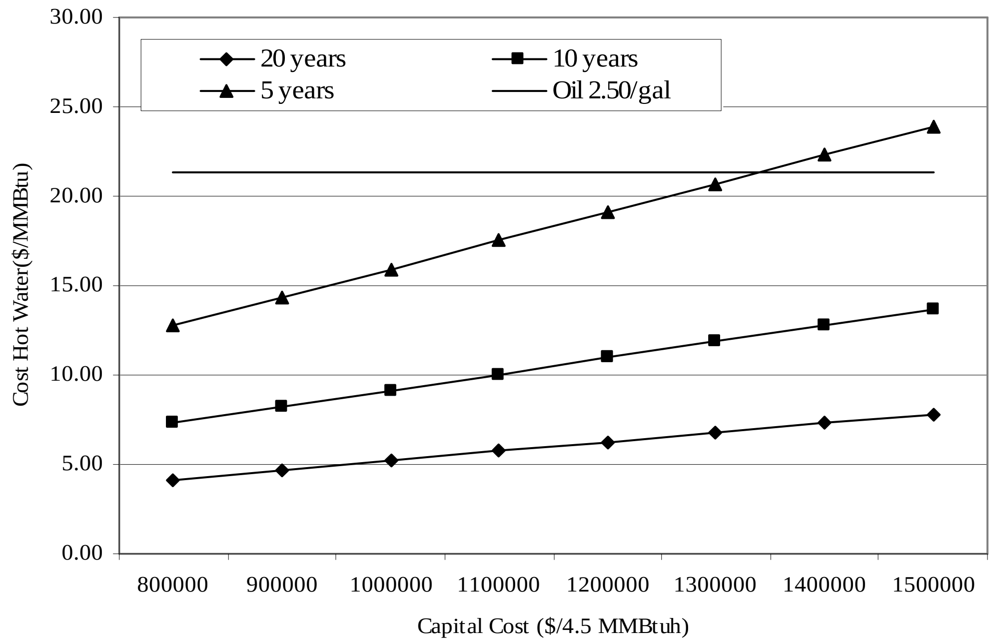


Figure 4-3. Impact of Capital and Non Fuel Cost on Cost of Heat for a 4.5 MMBtuh Boiler to replace 102,000 Gallons of Fuel Oil Per Year. Does not include wood cost.

Figure 4-4 illustrates the effect of capital and non-fuel costs on the cost of heat for a 1,000,000 Btuh wood chip system to replace 11,500 gallons of fuel oil per year. At this annual fuel consumption the 70% efficient system would be used at a full load equivalent of 1,349 hours per year or about 15.4% capacity factor (1,349 hours/8760 hours at 1 MMBtuh). The cost to recover a $699,000 investment would be about $50.34/MMBtu for 10 years, or $32.30/MMBtu for 20 years. Figure 4-4 suggests that when fuel oil costs $2.50/gallon a chip system to replace 11,500 gallons should cost less than $300,000.

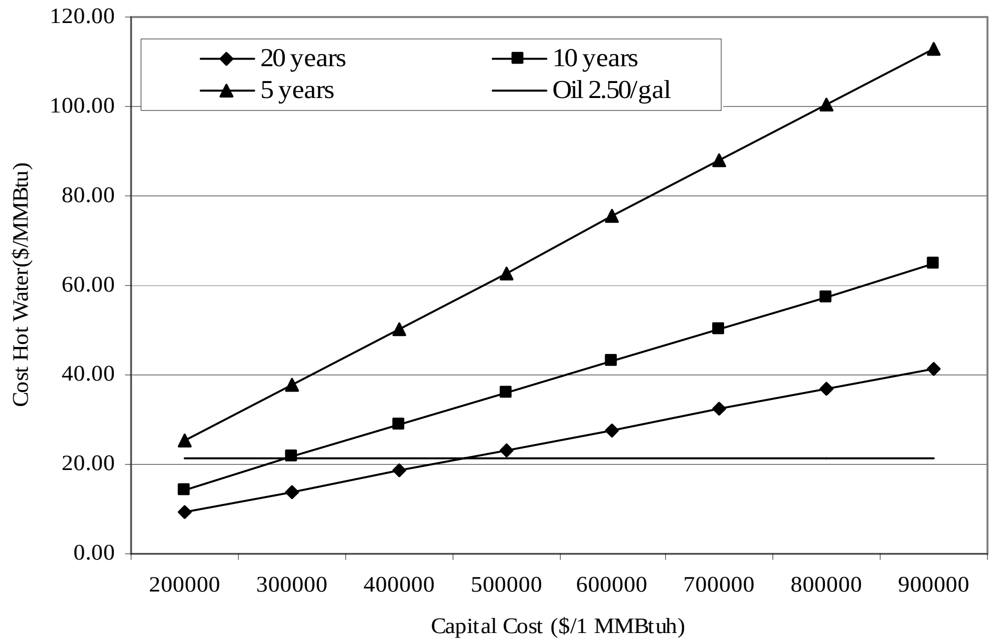


Figure 4-4. Impact of Capital and Non Fuel Cost on Cost of Heat for a 1 MMBtuh Boiler to replace 11,500 Gallons of Fuel Oil Per Year. Does not include wood cost.

Figure 4-5 shows the total cost of heat for a 4.5 MMBtuh system saving 102,000 gallons of fuel oil per year at 20 year cost recovery with an interest rate of 6% and an annual maintenance cost of 2%). Operating and maintenance costs include labor since fuel handling would be included in the normal duties of maintenance personnel. From this calculation for an investment of $1.2 million fuel chips at $30/ton would generate heat at a total cost of $11.53/MMBtu compared with fuel oil at $21.21/MMBtu ($2.50/gallon). This is the sum of fuel costs (Figure 4-1) of $5.23/MMBtu at $30/ton and non-fuel costs (Figure 4-3) of approximately $6.30/MMBtu.

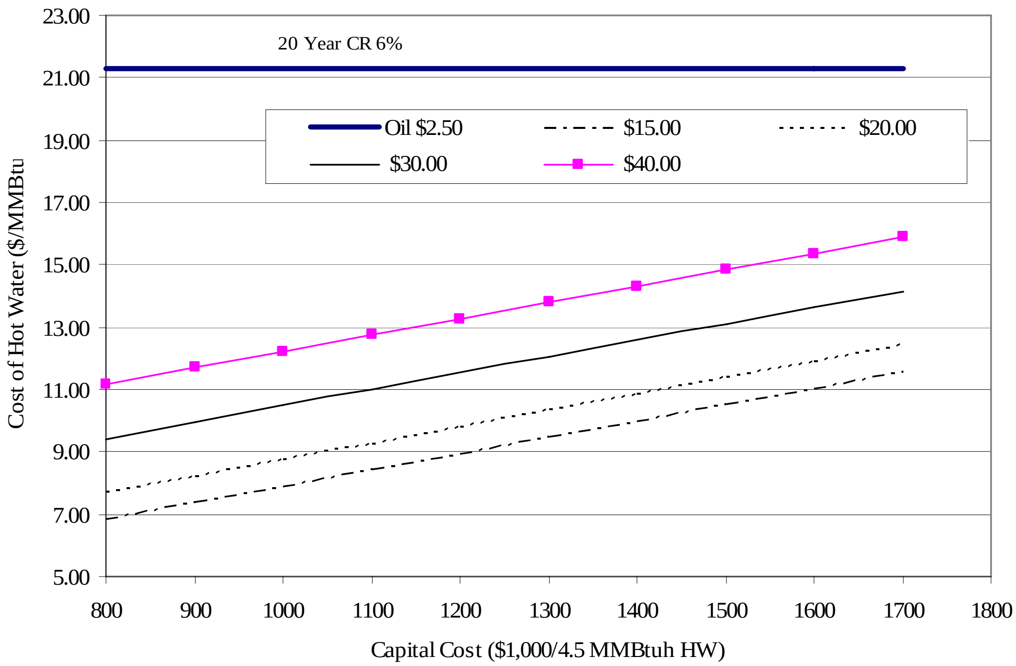


Figure 4-5. Total Cost of Heat to Replace 102,000 Gallons at Various Wood Chip Costs ($/ton).

Figure 4-6 shows the total cost of heat for a 1 MMBtuh system saving 11,500 gallons of fuel oil per year at 20 year cost recovery with an interest rate of 6% and an annual maintenance cost of 3%. Operating and maintenance costs include labor since fuel handling would be included in the normal duties of maintenance personnel. From this calculation for an investment of $699,000 with fuel chips at $30/ton would generate heat at a total cost of $37.84/MMBtu compared with fuel oil at $21.21/MMBtu ($2.50/gallon). This is the sum of fuel costs (Figure 4-1) of $5.23/MMBtu at $30/ton and non-fuel costs (Figure 4-3) of approximately $32.30/MMBtu.

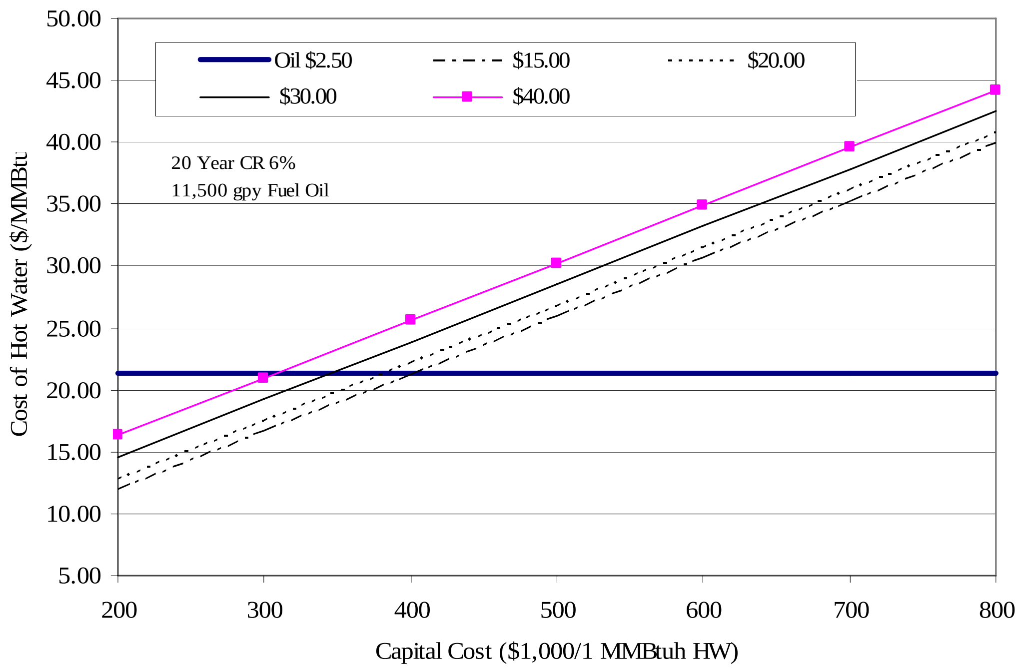


Figure 4-6. Total Cost of Heat to Replace 11,500 Gallons At Various Wood Chip Costs ($/ton).

4.3.3 Heating System Costs: Cordwood

Table 4-9 summarizes cost estimates for four cordwood systems. The total cost is often two to three times the cost of the boiler.

Table 4-9. Cost Estimates for Cordwood Systems.

Facility	Thorne Bay School	Craig Community Center	Thorne Bay Shop + Duplexes	Thorne Bay Solid Waste
Fuel Oil, gallons per year	11,501	6,605	3,050	2,000
Calculated required capacity*	347,000	207,000	90,000	60,000
Wood Boiler, Btuh	425,000	350,000	350,000	100,000
Building and Equipment Costs				
Building	$ 21,600	$ 14,500	$ 6,500	$ 1,900
Boilers	$ 19,500	$ 15,540	$ 15,540	$ 9,200
Piping	$ 38,300	$ 3,500	$ 8,000	$ 3,200
Installation	$ 3,500	$ 1,200	$ 1,300	$ 2,100
Total Direct Costs	$ 81,700	$ 34,700	$ 31,340	$ 16,400
Engineering +Contingency**	$ 22,000	$ 2,000	$ 560	$ 600
Total	$ 104,300	$ 37,000	$ 31,900	$ 17,000

Notes:
* Table 4-6 Estimate of heat required in Coldest 24 Hr period.
** This larger project may require more allowance for indirect costs such as engineering, approvals, etc.

Building and piping are the most significant costs besides the boiler. Building costs deserve more site specific investigation. A variety of prefabricated buildings were considered to enclose the boiler and wood supply. A quote was obtained from one supplier to deliver a pre-assembled boiler in a shipping container. Since the boiler enclosure had to meet special codes the cost of a containerized boiler was higher than in a separate building.

Piping from the wood-fired boiler is another area of potential cost saving. The impact of piping costs can be seen in the costs estimates for Craig Community Center compared with the Thorne Bay school. Long piping runs and additional heat exchanger substantially increase project costs. The hard pipe normally used in Alaska costs $70/foot. If plastic or PEX piping is used the cost is reduced to about $40/foot.

Allowance for indirect costs such as engineering and contingency are most important for larger systems that involve extensive permitting and budget approval by public agencies. This can increase the cost of a project by 25% to 50%.

Figure 4-7 illustrates the effect of capital and non-fuel costs on the cost of heat for a 425,000 Btuh cordwood system to replace 11,500 gallons of fuel oil per year at different terms of cost recovery. This is the reported use at the Thorne Bay School. A 70% efficient boiler system would be used at a full load equivalent of 3,175 hours per year or about 36% capacity. The cost to recover a $104,300 investment would be about $13.23/MMBtu for 5 years, $7.57/MMBtu for 10 years or $4.86 for 20 years. Boilers in this example have been in use for more than 20 years. No labor is included in this calculation since most sites indicated that stoking the wood boilers would be included in responsibilities of existing personnel.

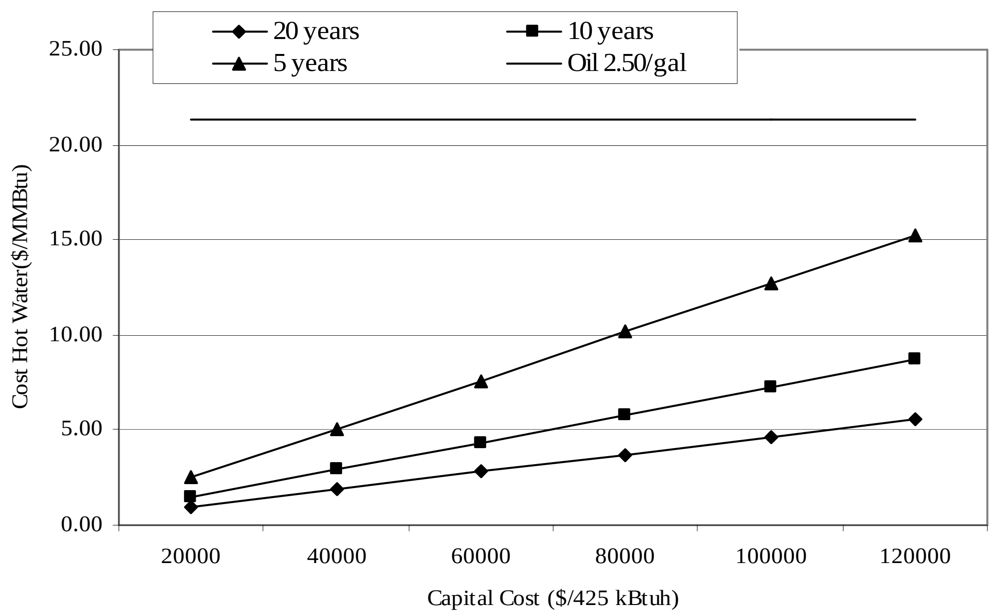


Figure 4-7. Impact of Capital and Non Fuel Cost on Cost of Heat for a 425,000 Btuh Cordwood Boiler to Replace 11,500 gpy Fuel Oil. Does not include wood cost.

Figure 4-8 illustrates the effect of capital and non-fuel costs on the cost of heat for a 425,000 Btuh cordwood system to replace 6,605 gallons of fuel oil per year at different terms of cost recovery. This is the reported use at the Craig Community Center. A 70% efficient boiler system would be used at a full load equivalent of 1,823 hours per year or about 21% capacity. The cost to recover a $40,000 investment would be about $8.84/MMBtu for 5 years, $5.06/MMBtu for 10 years or $3.25 for 20 years. Boilers in this example have been in use for more than 20 years. No labor is included in this calculation since most sites indicated that stoking the wood boilers would be included in responsibilities of existing personnel.

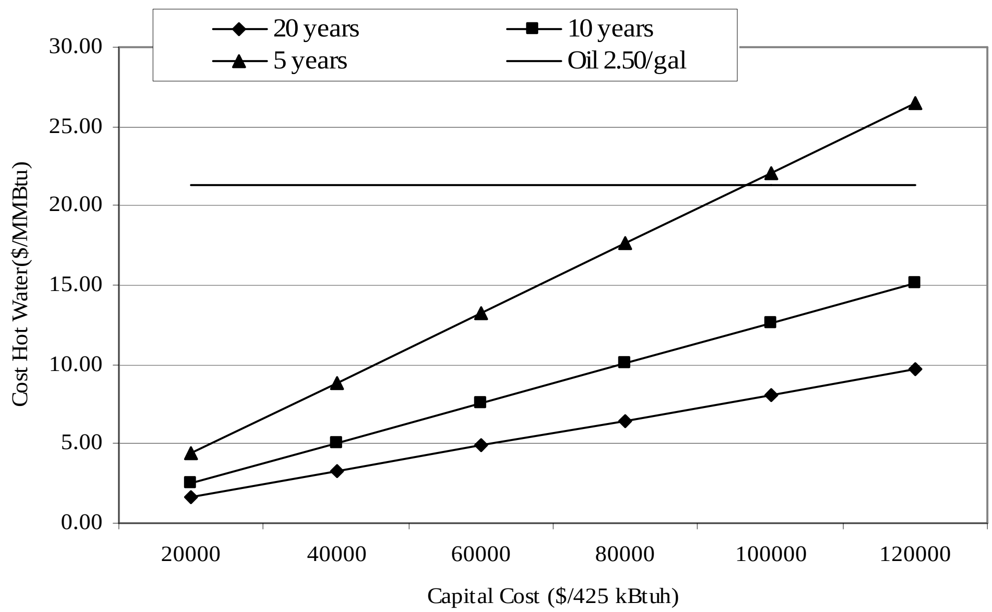


Figure 4-8. Impact of Capital and Non Fuel Cost on Cost of Heat for a 425,000 Btuh Cordwood Boiler to Replace 6,600 gpy Fuel Oil. Does not include wood cost.

Figure 4-9 shows the total cost of heat including the wood and capital cost for a 425,000 Btuh system saving 11,501 gallons of fuel oil per year at 20 year capital cost recovery with an interest rate of 6% and an annual maintenance cost of 3% ($1,200). Operating and maintenance costs do not include labor since each institution indicated that fuel handling would be included in the normal duties of maintenance personnel. From this figure $160/cord would be the maximum price for fuel when fuel oil is $2.50/gallon ($21.31/MMBtu). This example would fit a single boiler at Thorne Bay school to recover all of the fuel oil consumed.

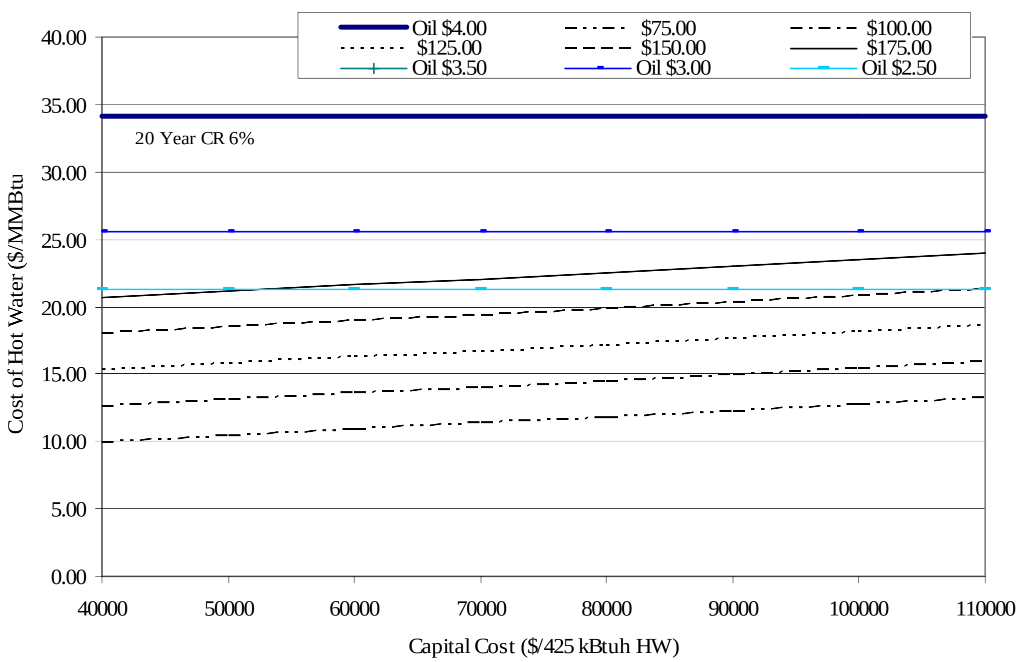


Figure 4-9. Total Cost of Heat to Replace 11,500 gpy Fuel Oil At Various Wood Costs ($/Cord).

Figure 4-10 shows the total cost of heat including the wood and capital cost for a 425,000 Btuh system saving 6,605 gallons of fuel oil per year at 20 year capital cost recovery with an interest rate of 6% and an annual maintenance cost of 3%. Operating and maintenance costs do not include labor since each institution indicated that fuel handling would be included in the normal duties of maintenance personnel. From this figure $160/cord would be the maximum price for fuel when fuel oil is $2.50/gallon ($21.31/MMBtu). This example would fit the Craig Community Center. If the $66,000 Dot Lake system were built again today it could afford to pay about $140/cord to be equal to oil at $2.50/gal.

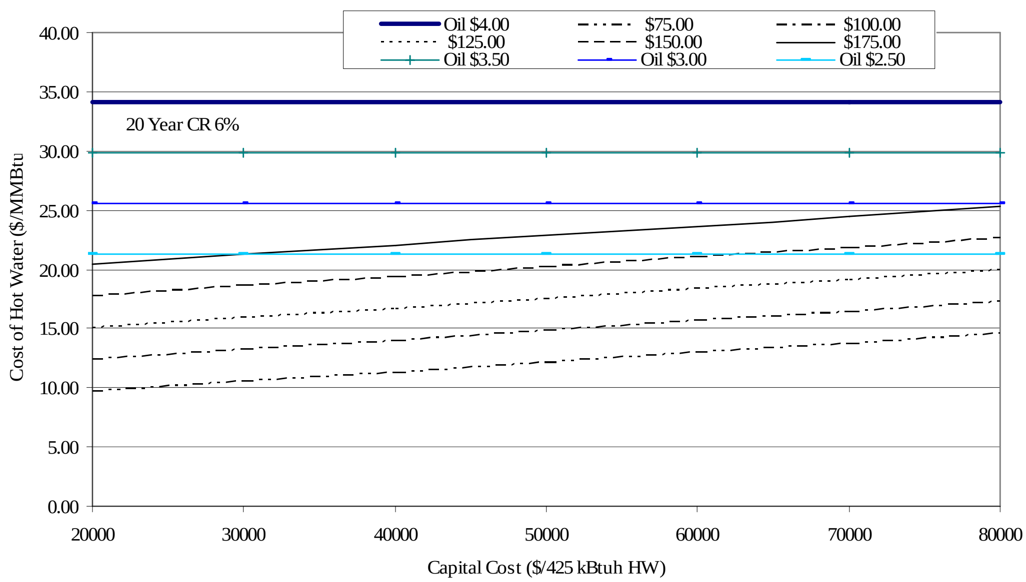


Figure 4-10. Total Cost of Heat to replace 6,605 gal Fuel Oil at Various Wood Costs ($/Cord).

4.3.4 Conclusions:

- This analysis suggests that a chip system would be feasible at Delta Greely Schools but a low cost system ($300,000) would be necessary for the Thorne Bay School.
- Cordwood systems may be appropriate at Thorne Bay School and Craig Community Center or similar applications saving 6,600 to 11,500 gpy fuel oil.

- Chip fuel cost has a low impact on wood boiler systems at a high level of oil replacement (102,000 gpy).
- Capital costs have a high impact at low levels of oil replacement (11,500 gpy).
- Cordwood fuel costs have a high impact on small and large systems.
- Capital costs have a high impact at low levels of oil replacement.
- Building and piping or integration costs must be kept low for wood boilers to be feasible.

5.0 Delta Greely Schools

5.1 Overview

Delta Greely Schools consumed 69,000 gallons of fuel oil in 2004.[13] Fuel oil consumption at the new school was estimated 33,000 gallons based on the area of the facility. Total consumption for both complexes was estimated at 102,000 gallons per year. Installed capacity for the combined schools and auxiliary buildings is about 10 MMBtuh. (Table 4-6) The system is divided into two complexes with capacities of 4.5 MMBtuh for the new elementary and about 5.5 MMBtuh for the old campus. The total capacity required for the coldest day for both complexes is calculated to be 4 MMBtuh (Table 4-6). This is a typical size for chip-fired boilers in schools.

School officials want to reduce fuel costs. They recognize that the boilers in the older school building will eventually need replacement. And they would like to take advantage of wood available from land clearing, forest cleanup and community recycling.

In this assessment a single boiler is sized for 4.5 MMBtuh which would cover 100% of the current demand at both complexes. Detailed engineering will be required to determine if the calculation of capacity required for the coldest day (Table 4-6) is accurate or if a larger boiler is needed.

Fuel would be delivered as chips in self unloading trailers to a fuel storage bin where it would be automatically metered to the boiler on demand. At peak demand (4 MMBtuh) the boiler would consume 19 ton per day or 133 tons per week. This is equal to about 5.5 trailers per week. The boiler would normally consume an average of 50 tons per week or about two trailer loads. New systems of this size are normally supplied with storage for 80 tons or about three trailer loads.

The amount of fuel available from local sawmills or clearing operations has not been determined. Chipped or milled pallets and urban wood waste may be available from the solid waste facility. Whole tree chips from forest salvage must also be identified. Supply sources will determine feasibility. For this analysis we have used $15-$30/green ton for chipped wood delivered to the school compared with oil at $2.50/gallon.

[13] 60,000 gallons per year has been considered to be the minimum fuel oil consumption for considering wood fuel in New England. At this consumption a wood system can save about half of what is spent on oil. Biomass Energy Resource Center, 2005.

The fuel handling and boiler system is large enough that it could be supplied by several companies. Each supplier has a slightly different approach to receiving and burning wood. In most cases they buy components from other suppliers and install an integrated system at the site. The boiler building would house the fuel receiving and metering bin, boiler, water treatment and pumps, and cyclones for gas cleanup. A stack for a boiler of this size may be integrated within the building or built as a separate stack. In this case we have assumed that the stack would be separate.

Integration with the existing heating systems will be a significant cost. Delta-Greely has two centers of operation: the old campus containing the main high school, old elementary (now administration), Vocational Technology Center, Career Advancement Center, Cyber Center and several modular classrooms which consume 69,000 gpy fuel oil; and a new elementary. The old campus is an appropriate location for a central heating plant. The plant must be sited so that stack exhaust does not create fog on a busy local access road. Pipe routing must be designed between the buildings. The boiler would connect to the new elementary building which is 1,000 feet from the old campus. Since they are at the same elevation the two clusters can be serviced by a single boiler house.[14]

5.2 Estimated System Costs and Benefits

Capital costs and savings for two alternatives are shown in tables 5-1 and 5-2. In the first case (A) a 4.5 MMBtuh system is sized just for the old campus that has been consuming 69,000 gallons of fuel oil per year. In this case the boiler house would be located to serve the existing buildings. Total estimated cost is $1,034,000. The calculated Present Value (PV) of the savings from wood compared with oil at $2.50/gal is positive so the wood chip boiler project is viable at fuel prices of $15/ton and $30/ton.[15]

In the second case (B) the same boiler would supply heat to both the old campus and the new elementary school to displace 102,000 gallons per year of fuel oil. Additional capital costs are included for piping and integration of the new school. The

[14] Messersmith. 2006.

[15] Present Value (PV) of the savings from wood compared with oil is used to assess the financial viability of a project. A project is viable when the present value of the savings is greater than zero for a given discount rate. The capital investment for the wood heating system is estimated. Then the net annual cash flow is estimated for each year up to the end of the useful life of the system. A heating system has no direct annual revenues. Cash requirements are reduced by savings from using wood instead of fuel oil. BLCC5.3-6, Building Life Cycle Cost, from the USDOE Federal Energy Management Program was used to calculate savings from the wood fuel alternatives. Assumptions are listed in table 4-9.

total estimated cost is $1,214,000. Present Value (PV) of the savings from wood compared with oil is positive so the wood chip boiler project is viable at fuel prices of $15/ton and $30/ton. Estimated savings after fuel, electricity and labor are $171,175 per year which would imply a simple payback of about 7 years.

Table 5-1. Estimated Wood Boiler Costs for Delta-Greely Schools.

Facility	A 4.5 MM Btuh Old School	B* 4.5 MMBtuh New+ Old	Difference
Fuel Oil Replaced, gallons per year	69,000	102,000	33,000
Building, 50 x 40	$ 228,000	$ 228,000	
Boilers, Fuel System	$ 397,000	$ 397,000	
Piping, Integration	$ 106,000	$ 231,000	$ 125,000
Other Installation	$ 66,000	$ 80,000	$ 14,000
Total Direct Costs	$ 797,000	$ 936,000	$ 139,000
Indirect Costs: Engineering, Permits	$ 102,000	$ 120,000	$ 18,000
Contingency, unlisted items 15%	$ 135,000	$ 158,000	$ 23,000
Total	$1,034,000	$ 1,214,000	$ 180,000
Savings Compared With Fuel Oil**			
PV Wood at $15/ton	$ 580,000	$ 1,236,800	
PV Wood at $30/ton	$ 265,000	$ 770,400	

Notes:
* Wood system sized to supply actual consumption from schools. Table 4-6.
** Present Value Life Cycle Cost, 20 Year, 3% discount rate, constant dollars

Table 5-2. Savings from Wood Fuel at Delta Greely Schools

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons	$2.50/gal	102,000		$ 255,000
Wood chips used, tons green*	$30/ton	2,084	$ 62,520	
Electricity, kWh	$0.17/kWh	66,500	$ 11,305	
Labor, hr	$20/hr	500	$ 10,000	
				$ 83,825
Gross Savings from Wood**				$ 171,175

Notes:
* 66 gallons of fuel oil per tons of wood chips Table 4-2
** Does not include maintenance, financing or other costs not listed above

Building, piping and integration costs are the largest areas of uncertainty in these estimates. A detailed engineering study will be required to estimate these more accurately and to reduce piping and integration costs.

Heating the main schools at Delta Greely should prove feasible, especially since most of the heating equipment is old and some probably due for replacement. Replacement costs were not considered in this preliminary analysis.

5.3 Recommended Actions for Delta Greely Schools

- Conduct a detailed engineering study for a central heating plant for the Delta Greely Schools.

Several alternatives must be considered to supply all or part of the Delta Greely Schools with wood heat. This must be done in a more detailed engineering analysis which can evaluate the condition of the existing oil boilers and furnaces and the costs of integrating them with a central wood heat system or systems.

- Determine fuel supply sources and costs.

There is still uncertainty about the sources and cost of 2,084 tons of wood chips required to supply the Delta-Greely schools. There is no existing infrastructure for delivering wood chips as fuel. It is not likely that it would all be supplied from a single sawmill like Logging and Milling Associates at Dry Creek. Substantial savings could be made if mill residues were available at $15/ton but it is more likely that there will be a variety of fuel sources at higher costs. Whole tree chips from forest fuel reduction or land clearing may cost $30/ton or more.

6.0 Thorne Bay School

6.1 Overview

Fuel oil consumption at Thorne Bay School is 11,500 gallons per year. There are two boiler rooms in the school: one for the upper school and one for the lower building including the gymnasium. The installed fuel oil heating capacity is 1.8 MMBtuh for the two buildings. The calculated demand from Table 4-6 is only 347,000 Btuh so that a wood system producing 425,000 Btuh could replace all of the fuel oil now used. Both chip and cordwood systems are considered below.

Thorne Bay School is interested in reducing fuel costs and providing educational opportunities with a wood system for their students.

6.2 Wood Chip Boiler

A wood chip boiler would consist of a receiving bin, boiler, cyclone and separate stack. The bin would be 50 x 18 ft x 8 ft tall which would hold approximately 60 tons or two truckloads of woodchips. The bin would be filled by self unloading trailers. At the rate of use the bin would be filled about once every two to four weeks. There is not much room for an automated chip system near the school. The smallest chip system would be about 1 MMBtuh. It would require a 50 ft x 30 ft building.

Chips are available at the Viking mill in Klawock or a chipper could be installed at one of the mills at the Goose Creek industrial park.

The components and estimated costs of a chip system are listed in Table 6-1. Chips would be metered on demand into a boiler burning fuel directly on a grate (Messersmith, Decton) or to a separate gasifier (Chiptek). Hot gas exhausting from the boiler would be cleaned in a cyclone and exit from a separate stack. The separate stack is a significant cost but may be necessary for emissions control at this location.

Hot water from the boiler would be integrated directly into the existing heating system. The two systems in the Thorne Bay school are separated by about 600 feet. A significant cost may be for the plumbing to supply both buildings

6.3 **Cordwood Boiler**

A single cordwood boiler burning 147 cords per year could replace all of the fuel oil used. A cordwood boiler was based on a preassembled Garn WHS 2000 (425,000 Btuh) boiler with integral heat exchangers and a small horizontal stack. It has minimal installation and power requirements. A building could be built with one boiler installed to supply the upper building which is a short piping run from the boiler, or both the upper and lower buildings. A second boiler and piping could be installed later if it was found that the first boiler has excess capacity and if piping to the lower building can be completed economically. A 20 ft x 30 ft, building could house up to two 425,000 Btuh cordwood boilers which could supply 850,000 Btuh. Cordwood would be stored in the building or under cover adjacent to the boiler. The boiler would be filled approximately twice a day for a 2 hour burn. Operation during the daytime would also fill thermal storage incorporated into each boiler that is equal to 1,300,000 Btu. This may be sufficient to handle large heat demands for short periods. School personnel would stoke the boilers at no extra labor cost. An alternative arrangement would be to install a boiler under the existing cover which would avoid building a separate building. This would reduce the project cost.

The boiler could burn dry pallet waste or seasoned cordwood. Cordwood is available from small lumber processors in the Goose Creek Industrial area or in bulk from the small log processor at Viking lumber. For the purposes of this study cordwood has been priced at $60/cord and $100/cord.

6.4 **Estimated System Costs and Benefits**

Costs for the chip and cordwood systems are estimated in Table 6-1. The base price of the chip boiler includes a separate stack which is 10%-15% of the total cost. The total direct costs estimated here for the chip system are similar to other projects. Savings for the wood chip system of $19,940 result in a payback of 35 years. The present value of the chip savings compared with oil is negative at both $30/ton and $15/ton. This illustrates that a small wood chip system must displace a much higher oil consumption than the 11,500 gallons per year currently used at the school. With fuel at $15/ton a boiler system would have to cost $250,000. With fuel at $30/ton a boiler would have to cost $135,000 or less to be feasible. Adjacent buildings such as the city maintenance shop do not add much to the load. It has also been suggested that the Ranger station and school combine as a co-op but the ranger station must have a significantly higher demand to justify a combined system.

A similar size but lower cost chip system was recently installed at a mill in Hoonah but the equipment used may not be acceptable in a school environment.

Table 4-6 showed that one 425,000 Btuh boiler could offset the fuel oil consumed by the school. The capital costs are estimated here at $104,300. Savings of $14,150 would result in a simple payback of 8 years. Tables 6-1, 6-3. The project is feasible with one boiler as shown by the positive present value of savings from wood in Table 6-1 when cordwood is available for $60/cord or $100/cord.

Capital costs could be reduced if a boiler can be placed under the existing covered area near the utility entrance to the school. Savings from the wood boiler are positive at both $60/cord and $100/cord and the project is viable.

Annual savings would be $11,705 on an investment of $104,300 for a nine year payback using wood at $100/cord. Payback would be seven years without a building.

Table 6-1. Estimated Wood Boiler Costs for Thorne Bay School.

Facility	Wood Chips	Cordwood (1) boiler*	Cordwood (1) boiler**
Capacity, Btuh	1,000,000	425,000	425,000
Fuel Oil, gallons per year	11,500	11,500	11,500
Buildings, 1500 ft2; 600 ft2	$ 158,000	$ 21,600	**
Boilers, Fuel System, Stack	$ 280,000	$ 19,500	$ 19,500
Pumps, Piping, Integration	$ 52,500	$ 38,300	$ 38,300
Other Installation, Electrical	$ 48,100	$ 2,300	$ 3,500
Total Direct Costs	$ 538,600	$ 81,700	$ 61,260
Engineering +Contingency	$ 161,000	$ 22,600	$ 17,20
Total	$ 699,000	$ 104,300	$ 78,500
NPV $ 15/ton, $60/cord	($455,000)	$ 93,700	$ 119,500
NPV $30/ton, $100/cord	($510,400)	$ 6,000	$ 31,800

Notes:

* Building sufficient for two boilers. Install one (Garn WHS 2000) since estimated load is less than 425,000 Btuh. Table 4-6.

** Install boiler under existing building cover.

Table 6-2. Savings from Wood Chips at Thorne Bay School.

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons [a]	$2.50/gal	11,500		$ 28,750
Wood chips used, tons green [b]	$30/ton	236	$ 7,080	
Electricity	$0.17/kWh	10,170	$ 1,730	
Labor	Inc	Inc	-	
				$ 8,810
Gross Savings from Wood				$ 19,940

Notes:
[a] 2004 11,500 gal at $2.00/gal
[b] 49 gallons of fuel oil/ton wood chips, Table 4-2.

Table 6-3. Savings from Cordwood at Thorne Bay School.

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons [a]	$2.50/gal	11,500		$ 28,750
Cordwood [b c]	$100/cord	147	$ 14,700	
Electricity	$0.17/kWh	13794	$ 2,345	
Labor[d]	Inc.	Inc		
				$ 17,045
Annual Savings from Wood				$ 11,705

Notes:
[a] 2004 11,500 gal at $2.00/gal
[b] 66 gallons fuel oil per cord at 70% efficiency, Table 4-2.
[c] Slabs and edgings available from Goose Creek or Klawock
[d] Labor by school personnel

6.5 Recommended Actions for Thorne Bay School

Thorne Bay School provides a good opportunity for an efficient, low emission cordwood system. There is interest and enthusiasm for the project. Capital costs should be kept to less than $104,300. Integration and piping costs may be greater than expected.

Conduct a detailed engineering study for the integration of energy efficient, low mission cordwood boilers for the Throne Bay School and gym.

Plan to demonstrate wood heat with one boiler for half the load and a second in the future if feasible.

7.0 Craig Community Center

7.1 Overview

Community Center consumes 6,605 gallons of fuel oil per year. They are concerned about fuel cost increases. They expect fuel use to increase as the new Tribal Hall and Tech Center are used more. They would need to hire personnel to supply wood or maintain a wood boiler. A boiler can not be located in their 200 vehicle parking which is already at capacity for special functions.

Fuel use at the center could be replaced by approximately 52 cords of wood. A two hour burn during the day should supply the center's needs. The boiler could burn dry pallet waste or seasoned cordwood. Cordwood is available from sawmills in the Craig vicinity as slabs and edgings or off cuts from small log processing.

There is a location behind the center that would be suitable for a 14 x 20 building and fuel storage for a Garn WHS 1500 (350,000 Btuh 920,000 Btu storage). An internal glycol heat exchanger in the Garn would heat glycol circulated from the existing heating loop to the existing boiler. Dectra can supply a pre-engineered package which will require just attaching pipes to the heat exchanger on the Garn. The system would require two low power circuits.

If Craig Community Center participates in the Craig Aquatic Center boiler project hot water would be piped across the street to the center.

7.2 Estimated System Costs and Benefits

Cordwood system costs are estimated in Table 7.1. The principal cost is the boiler. Piping from the existing system would be connected to a heat exchanger built into the cordwood boiler. At a capital cost of $37,000 the savings at current fuel use is $7,163 for a payback of about 5 years. Present value savings from wood are positive at $60/cord and $100/cord.

Labor is an important consideration at the Community Center since there is no one currently available to stoke a wood boiler. Labor costs are included in the facilities maintenance personnel. However this may be a cost that needs to be added. If 500 hours per year (1 hour per day) is added at $20/hour then any savings from wood is offset by the labor cost.

Table 7-1. Estimated Wood Boiler Costs for Craig Community Center.

Facility	Cordwood
Capacity, Btuh	350,000
Fuel Oil, gallons per year	6,605
Buildings, 20ft x 14ft, 280 ft2	$ 14,500
Boilers, Fuel System, Stack Garn WHS 1500	$ 15,500
Pumps, Piping, Integration	$ 3,500
Other Installation, Electrical	$ 1,200
Total Direct Costs	$ 34,700
Engineering +Contingency	$ 2,300
Total	$ 37,000
Present Value Savings compared with Fuel Oil, 20 year	
Wood $60/cord	$ 90,800
Wood $100/cord	$ 40,400

Table 7-2. Savings from Wood at Craig Community Center.

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons [a]	$2.50/gal	6,605		$16,513
Wood chips used, tons green [b]	$100/cord	89	$8,900	
Electricity	$0.17/kWh	2,347	$ 450	
Labor	Inc	Inc	-	
				$ 9,350
Gross Savings from Wood				$ 7,163

Notes:
[a] 2004 6,605 gal at $2.45/gal, 10,000 ft2 in use
[b] 66 gallons of fuel oil/cord, Table 4-2.

7.3 Recommended Actions for Craig Community Center

Conduct a detailed engineering study for the integration of energy efficient, low emission cordwood boilers for the Craig Community Center. The wood system can be easily located at the ground floor alongside the building accessible from the rear. Detailed specifications for the piping and civil work and cost estimates should be obtained so that a true cost of the project can be determined.

Identify who will operate the boiler and supply the fuel.

8.0 City of Thorne Bay

8.1 Overview

City of Thorne Bay facilities are listed in Table 8-1 with the fuel oil consumption and potential savings from wood. All of the facilities are small. Oil consumption is significantly less than installed capacity, as shown in Table 4-6. The buildings are dispersed and there are few opportunities for combining loads. The City Hall, VPSO and Emergency Services which are in the same location are too small and too far apart to make use of combined loads. The City Maintenance facility may be large enough to support a cordwood boiler, especially if the load is combined with the adjacent duplexes. Fuel consumption at the solid waste building is similar.

Table 8-1. Potential Savings from Wood at City of Thorne Bay Facilities.

Facility	Oil Gal/yr [a]	Wood Cord/yr [b]	Oil $/yr [c]	Wood $/yr [d]	Potential Savings $/yr
City Shop and Duplexes	3,050	46	$ 7,625	$ 4,600	$ 3,025
City shop	1,800	27	$ 4,500	$ 2,700	$ 1,800
City Owned Duplexes	1,250	19	$ 3,125	$ 1,900	$ 1,225
Solid Waste Building	2,000	30	$ 5,000	$ 3,000	$ 2,000
City Hall + VPSO	600	9	$ 1,500	900	$ 600
Emergency Services	600	9	$ 1,500	900	$ 600
Water Treatment	600	9	$ 1,500	900	$ 600
Wastewater Treatment	600	9	$ 1,500	900	$ 600

Notes:
[a] 2004 use from SOI
[b] 66 gallons per cord Table 4-2
[c] $2.50/gal
[d] $100/cord

8.2 Maintenance Shop and Duplexes

City of Thorne Bay Maintenance Shop consumes 1,800 gpy of fuel oil. Adjacent to the shop are two city owned duplexes that consume 1250 gpy. Together they consume 3,050 gallons per year. The duplexes would add load without adding significant cost.

The City of Thorne Bay Maintenance Shop and Bus Garage is the former high school gym. It is heated primarily by oil fired furnaces that consume 1800 gpy. There is a location behind the center that would be suitable for a 14 x 20 building and fuel storage for a Garn WHS 1500 (350,000 Btuh. 920,000 Btu storage). This would provide heat at approximately the same rate as the installed fuel oil capacity. An internal glycol heat exchanger in the Garn would heat glycol circulated from the existing heating loop to the existing boiler. The cost of this system is estimated in Table 8-2 at $31,900. Savings from wood are approximately $3,125/year which would result in a payback of 10 years. The present values (PV) of the savings from wood are positive at $60/cord and negative at $100/cord.

Demand on the coldest day for both the maintenance facility and duplexes was estimated in Table 4-6 at less than 100,000 Btuh. Costs for a boiler of this size based on TarmUSA and Alternative Heating systems are shown in Table 8-2. In this case payback at $3,125 per year would be six years. The Present Values of the savings of wood compared with fuel oil for this arrangement are positive for wood at both $60/cord and $100/cord. If the same boiler is used for just the duplexes or for the City Hall and VPSO then savings are positive at $60/cord but negative at $100/cord. The costs shown in Table 8-2 are the lowest obtained for boilers in this size.

Table 8-2. Estimated Wood Boiler Costs for Thorne Bay Maintenance Facility.

Facility	Full Capacity	Smaller Boiler	Duplex, or City Hall and VPSO
Capacity, Btuh	350,000	100,000	100,000
Fuel Oil, gallons per year	3,050	3,050	1,250
Buildings, 20ft x 14ft, 160 ft2	$ 6,500	$ 1,900	$ 1,900
Boilers, Fuel System, Stack	$15,500	$ 9,200	$ 9,200
Pumps, Piping, Integration	$8,000	$ 3,200	$ 3,200
Other Installation, Electrical	$1,300	$ 2,100	$ 1,100
Total Direct Costs	$31,300	$16,400	$15,400
Engineering +Contingency	$600	$ 600	$ 600
Total	$31,900	$17,000	$16,000
Present Value of Savings from Wood compared with Fuel Oil, 20 year			
Wood $60/cord	$21,000	$ 40,800	$ 6,400
Wood $100/cord	($ 2,300)	$ 17,500	($ 3,200)

Notes:
[*] Garn WHS 1500 350,00 Btuh
[**] Alternate Heating Systems or Tarm 100,000 Btuh

Table 8-3. Savings from Cordwood at Thorne Bay Maintenance and Duplexes.

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons [a]	$2.50/gal	3,050		$ 7,625
Cordwood [b]	$100/cord	46	$ 4,600	
Electricity	$0.17/kWh	3,520	600	
Labor [c]	Incl.	Incl.		
				$ 4,500
Annual Savings from Wood				$ 3,125

Notes:
[a] 2004 Maintenance 1800 gal, Duplexes, 1250 gal at $2.00/gal
[b] 66 gallons fuel oil per cord at 70% efficiency, Table 4-2.
[c] Labor by school personnel

8.3 Solid Waste Facility

City of Thorne Bay Solid Waste Facility bales municipal refuse. It is heated with an oil fired air heater that consumes 2,000 gpy of fuel oil. The building is inefficient since the garage doors are often open during operation. Consumption was estimated at 60,000 Btuh in Table 4-2. A 100,000 Btuh boiler could be installed as shown in Table 8-4 at a cost of $17,000. Potential savings are $2,000/year at $100 cord. Present values of the savings from wood compared with oil are positive at $60/cord and $100/cord.

Table 8-4. Estimated Wood Boiler Costs for Thorne Bay Solid Waste Facility

Facility	Solid Waste Facility
Capacity, Btuh	100,000
Fuel Oil, gallons per year	2,000
Buildings, 50 ft2	$ 1,900
Boiler	$ 9,200
Pumps, Piping, Integration	$ 3,200
Other Installation, Electrical	$ 2,100
Total Direct Costs	$16,400
Engineering +Contingency	$ 600
Total	$17,000
Present Value Savings compared with Fuel Oil, 20 year	
Wood $60/cord	$ 19,600
Wood $100/cord	$ 4,300

8.4 City Hall and VPSO

Evaluation of other systems include the Thorne Bay City Hall and VPSO (1250 gpy). These systems represent a $3000 to $4,000/year fuel savings on investments of $16,000 to $18,000. They represent a positive net savings with a longer payback.

Thorne Bay City Hall and VPSO is central to the community and a good visible demonstration site. It is located at the end of a cluster of buildings that include the City Hall, VPSO, emergency services and in future will include a new City Hall and other public buildings. The site was evaluated for a central heating system with hot water distributed to the small buildings. However piping the hot water to the adjacent buildings is too costly for such low loads of about 600 gpy each. A Tarm residential system was evaluate for the City Hall and VPSO and shows savings of $3100 per year on an investment of $16,000 for a six year payback and net positive savings.

Low emission energy efficient boiler systems are too expensive for most small (600 gpy) applications proposed. These may be satisfied with domestic wood appliances.

Small buildings at Thorne Bay are heated with small efficient oil heaters supplied by Monitor or Toyo. These 40,000 Btuh units are efficient and difficult to replace with anything but a small wood appliance.

8.5 Recommended Actions for City of Thorne Bay

Conduct a detailed engineering study for the integration of energy efficiency, low emission cordwood boilers for the City of Thorne Bay Maintenance garage with the addition of the duplexes.

Installation at the Maintenance garage would replace old furnaces by putting a heat exchanger in the ducting. Those requirements and costs must be determined.

Plan to install a cordwood boiler behind the Maintenance garage. Extend the piping to the Duplexes if feasible.

By locating a boiler behind the garage glycol from a heat exchanger can be pumped to the city owned duplexes. Piping and heat exchangers must be specified and costs estimated to determine if this is feasible.

Verify project costs to duplicate the cordwood boiler for sites like the Maintenance garage or the Solid Waste Facility (2000 gpy) for space heating.

As discussed above, the Solid waste facility may be a difficult place to heat or to save money with wood heat. The Garn WHS 1500 could be used to heat the facility as a duplicate to the Maintenance garage.

Verify the system costs for installing a small cordwood boiler to serve the City Hall and VPSO (1250 gpy).

Installation costs for a Tarm boiler have not thoroughly been investigated here. The City Hall application is similar to a wood boiler in a residence. The boiler would be located a short distance from the City Hall or on the end of the City Hall building. Glycol from the boiler system would be piped through a heat exchanger on the wood boiler.

The loads for the Emergency Services Building, City Shop, Water Treatment and Wastewater Treatment facilities are too small for a wood fired system unless a residential sized energy efficient low emission appliance is used.

9.0 Venetie Airport Maintenance

9.1 Overview

Venetie Village presented several proposals for wood heating. Most were for future buildings that were not yet in the planning or design phase. The airport at the village has a maintenance garage and waiting area. The maintenance garage is heated with two oil-fired unit heaters and with waste heat from a diesel generator. The principal concerns at the village are: 1) the high cost of fuel, since all the fuel must be flown in; 2) availability of fuel when there is no winter delivery or failure of the engine, which occurred in 2004-2005; 3) keeping the snow removal equipment in the maintenance garage warm; and 4) heating the waiting room (16 x 24 ft).

Heat is supplied to the maintenance facility by two 250,000 Btuh oil-fired unit heaters. This total capacity of 500,000 Btuh may be necessary to heat the facility in the severe cold; however actual consumption suggests that the heat required on the coldest day is less than 100,000 Btuh. Table 4-6. Two wood systems were considered: a 350,000 Btuh boiler with 920,000 Btuh storage capacity located in an adjacent building; and a smaller 100,000 Btuh boiler that might be located in the maintenance facility itself. Table 9-1.

9.2 Estimated System Costs and Benefits

Table 9-1 shows that the savings from the wood system could be installed for $35,000 for the 350,00 Btuh system or $18,000 for the 100,000 Btuh system. Table 9-2 shows that Venetie Village could save approximately $3,900/year from wood at $100/cord compared with fuel oil at $4.20/gallon. Payback would be nine years on a 350,000 Btuh boiler or five years on a 100,000 Btuh boiler. The present values for savings from wood are positive in both cases.

Table 9-1. Estimated Wood Boiler Costs for Venetie Airport Maintenance Facility.

Facility	Excess Capacity	Small Boiler
Capacity, Btuh	350,000	100,000
Fuel Oil, gallons per year	1,688	1,688
Buildings, 20ft x 14ft, 160 ft2	$ 10,100	
Boilers, Fuel System, Stack	$14,000	$ 9,200
Pumps, Piping, Integration	$4,000	$ 2,300
Other Installation, Electrical, Freight	$6,300	$ 4,200
Total Direct Costs	$34,400	$15,700
Engineering +Contingency	$600	$ 2,300
Total	$35,000	$18,000
Present Value of Savings from Wood compared with Fuel Oil, 20 year		
Wood $60/cord	$ 26,800	$ 46,700
Wood $100/cord	$ 13,900	$ 33,800

Notes:
[*] Garn WHS 1500 350,000 Btuh
[**] Alternate Heating Systems or Tarm 100,000 Btuh

Table 9-2. Savings from Wood at Venetie Airport Maintenance Facility

Table Header	Cost	Quantity	$	Total
Fuel Oil Used, gallons [a]	$4.20/gal	1,688		$ 7,090
Wood chips used, tons green [b]	$100/cord	26	$2,600	
Electricity	$0.25/kWh	2,347	$ 590	
Labor	Inc	Inc	-	
				$ 3,190
Gross Savings from Wood				$ 3,900

Notes:
[a] 2004 1688 gal at $4.20/gal
[b] 66 gallons of fuel oil/cord, Table 4-2.

9.3 Recommended Actions for Venetie Village

Venetie Airport Maintenance Facility is the same size as the Thorne Bay City Hall with only slightly higher fuel consumption. Consider an energy efficient, low emission cordwood system for heating the facility if the delivered system cost is appropriate. Select the higher capacity system with the built-in heat storage capacity and the potential for heating the waiting room and other buildings as appropriate.

10.0 General Recommendations

Plan to install five or six energy efficient low emission cordwood boiler systems. There may be several cordwood systems which can be selected for demonstration. Transportation costs can be improved if several boilers from the same supplier are delivered on the same load.

Develop and demonstrate low cost buildings and heat distribution systems for hot water applications.

Assessments of energy system were initially made using the steel pipe construction common in Alaska. Lower cost systems using the PEX piping should be evaluated. These are being used effectively in the OWB applications in Alaska and have been used for many years in the Northern US.

Appendix A. List of Abbreviations and Acronyms

AEA Alaska Energy Authority
AWEDTG Alaska Wood Energy Development Task Group
BDT Bone Dry Ton
BTU British Thermal Unit (MBtu, thousand Btu ; MMBtu, million Btu)
CE Conversion Efficiency (fuel to heat)
CHP Combined Heat and Power
CO Carbon Monoxide
Cord 80 ft3 of solid wood
CR Cost Recovery; years to recover investment at indicated interest rate
DB Dry Basis (wet weight –dry weight/dry weight)
DD Degree Days (Heating Degree Days)
EPA U.S. Environmental Protection Agency
GHV Gross Heating Value (also Higher Heating Value)
Gm Gram
Gpy Gallons per year
HHV Higher Heating Value
JEDC Juneau Economic Development Council
KBtu Thousand Btu
KWe Kilowatts, electric
KWt Kilowatts, thermal
MC Moisture Content (e.g. MC20 20 % moisture)
MBtu Thousand Btu (also kBtu)
MMBtu Million Btu
NHV Net Heating Value
NPV Net Present Value
OD Oven Dry (weight)
ODT Oven Dry Ton
O&M Operating and Maintenance
OWB Outdoor Wood Boiler
POW Prince of Wales Island
PV Present Value
RHV Recovered Heating Value
Unit A shipping volume of 200 ft3
WB Wet basis (wet weight-dry weight/wet weight)

Appendix B. AWEDTG Evaluation Criteria

The following criteria were used to evaluate and recommend projects for feasibility assessments:

1. The opportunity for displacing fuel oil, natural gas, propane or diesel-generated electricity used by targeted facilities for heating needs (i.e., current fuel type, gallons of fuel per year, annual cost per year);
2. Local presence of high-hazard forest fuels and potential for utilizing these fuels for heating schools, other public facilities, and buildings owned and operated by not-for-profit organizations;
3. Availability of local wood processing residues (e.g., sawdust, planer shavings, and slabs);
4. Project cost versus yearly savings (cost-effectiveness);
5. Sustainability of the wood fuel supply;
6. Community support and project advocacy;
7. Ability to implement the project;
8. Ability to operate and maintain the project.

Appendix C. Wood Boiler Suppliers

Wood boiler suppliers contacted in this study.

Alternative Heating Systems, Inc.
Chiptek
Dectra/Garn
Decton Inc.
Messersmith
Precision Energy Systems
TarmUSA

1. Tarm USA, House in Palmer, AK

2. Alternate Heating Systems 100,000 Btuh -230,000 Btuh

3. Garn 350,000 Btuh WHS 1500 Ready to Ship

4. Dectra, Garn WHS 3200 Dot Lake,AK

	
1. 3 MMBtuh Boiler with Gasifier, MA	2. 3 MMBtuh Chiptek Gasifier, Athol, MA
	
3. 4.9 MMBtuh Boiler Building Victor, MT	4. Fuel Bin With Chip Reclaim Auger, Victor MT
	
5. Fuel Bin, Chip Reclaim and Boiler, Victor, MT	6. Low Fire, Victor MT

Appendix D. Delta Greely

Project: Delta Greely Schools
Location: Delta Junction, Fairbanks 64.035 N 145.725 W


1.Delta Elementary School, Now Admin


2. Delta Junction School

3. Delta Junction School


4. Delta High School


5. Shop Area of High School

6. Existing Stacks and Vents

7. Typical Oil Boiler

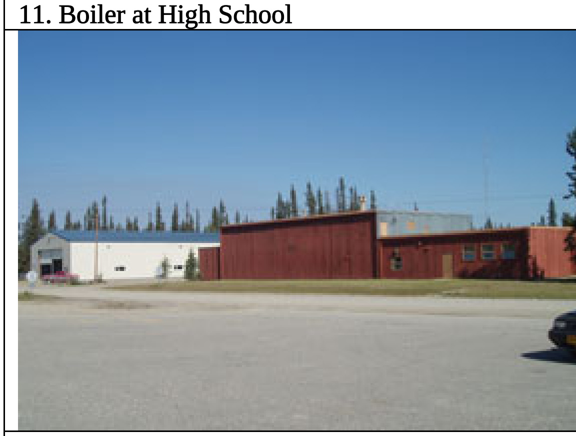
8. Typical Hot Water Air Heater

9. Hot Water Heater

10. Oil fired Air Heater

11. Boiler at High School

12. Boiler at High School



13. Vocational Tech and Buildings

14. Separately Heated Votech Building

15. Modular Classrooms

16. Front of New Elementary

17. View New Elementary to Old Campus

18. Front Entry New Elementary

19. Side of New Elementary

20. New Elementary Fuel Tank

21. New Elementary Boiler Room

22. 4 MMBtuh (3 Boilers)+ Hot Water

Appendix E. Thorne Bay School

Project:	Thorne Bay School, Southeast Island School District
Location:	Thorne Bay, Prince of Wales Island 55.67 N 132.49 W

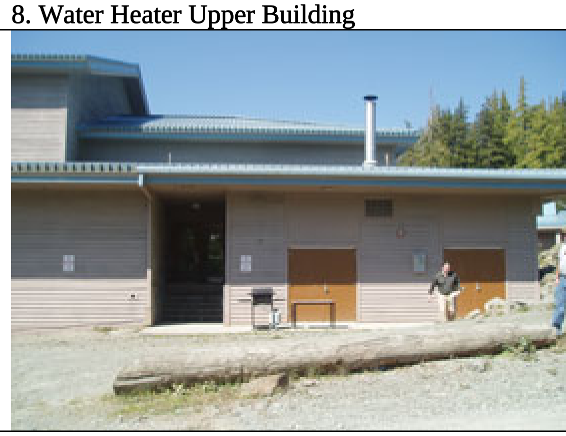
.

	
1.Thorne Bay High School Entry approach	2. TB School Upper and Lower Buildings
	
3. TB School Upper Entry	4. TB School Utility Entry
	
5. Possible Location for Wood Boiler	6. Back Wall to Upper Boiler Room

7. Boilers in Upper Building

8. Water Heater Upper Building

9. Upper and Lower Building



10. Boiler Room Lower Building

11. Road Past Lower Building

12. Lower Building Water Heater and Boilers

	
13. Duct Heat Exchanger	14. Duct Exchanger and Unit Heater

Appendix F. Craig Community Center

Project: Craig Community Association
Location: Craig, Prince of Wales Island 55.48 N 133.14 W

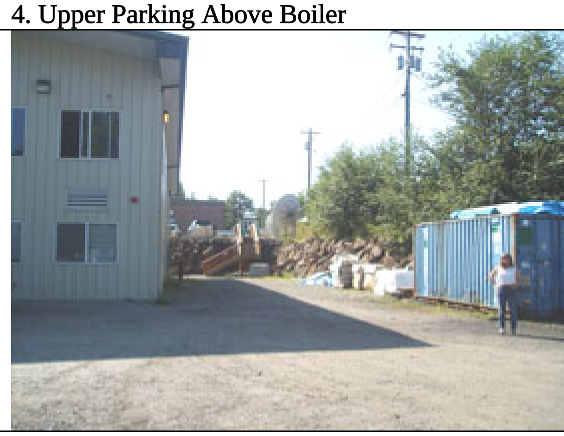

1. Craig Community Center Parking Area


2. Upper Level Meeting Hall


3. Lower Side-road Access Left


4. Upper Parking Above Boiler


5. Rear Used For Playground


6. Road Access Possible Boiler Location

	
7. Bridge Entry. Fuel Oil Tank Near Boiler	8. West Side Fence Line
	
9. Boiler	10. Hot Water

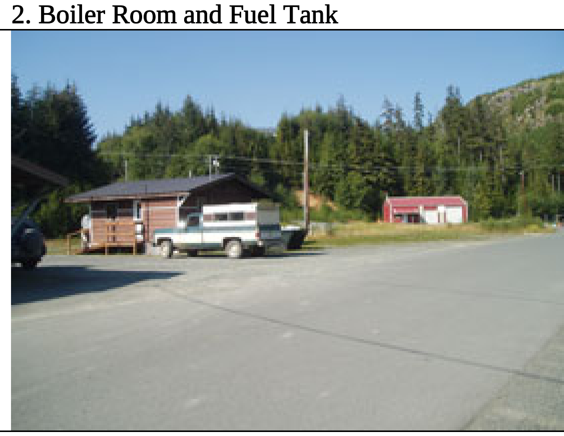
Appendix G. City of Thorne Bay

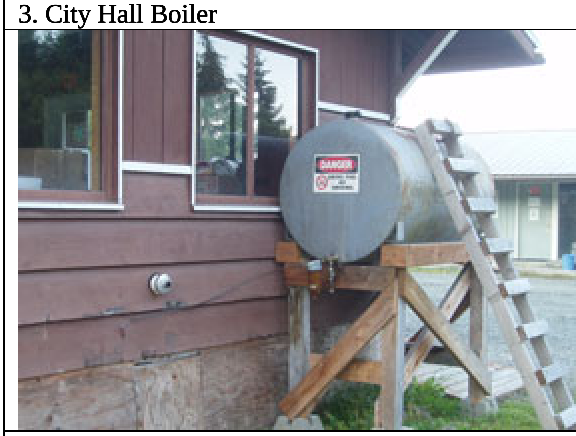
Project: City of Thorne Bay
Location: Thorne Bay, Prince of Wales Island 55.68 N 132.52 W


1. Thorne Bay City Hall


2. Boiler Room and Fuel Tank


3. City Hall Boiler


4. VPSO and Emergency Service Buildings



5. VPSO Heater Fuel Tank

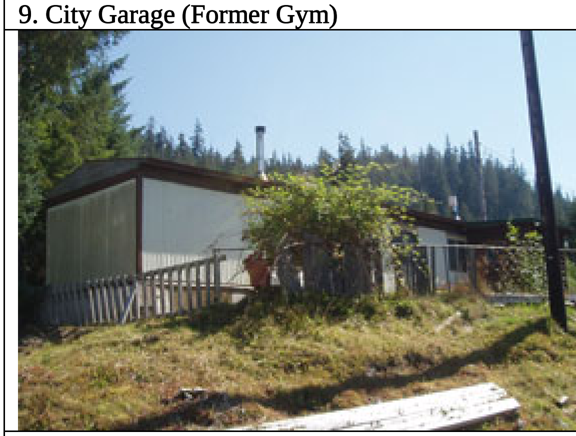

6. Emergency Services Building

7. Fuel and Exhaust Emergency Services

8. Air Heater Exhaust Emergency Services

9. City Garage (Former Gym)

10. Air Heated Garage



11. Adjacent City Duplexes for Teachers

12. Access to Garage Air heater

13. Fuel Oil Tank Near Heater

14. Air Heater

15. Maintenance Shop

16. Water Treatment

17. Water Treatment South Heater

18. Typical Heater

19. Sanitary Plant

20. Sanitary Boiler

21. Air Heater in Sanitary Plant

22. Municipal Waste Building

23. Fuel Tank Municipal Waste

24. Waste Baler and Office

Appendix H. Venetie Airport Maintenance

Project: Venetie Village
Location: Venetie, Yukon-Koyukuk 67.01895 N 146.40012 W

1.Venetie Village, School Washeria to Left

2. Lance Whitell and Council President

3. Hauling Firewood

4. Airport Garage and Waiting Room

5. Unit Heater Stack, Rear Side

6. Diesel Fuel and Engine Exhaust

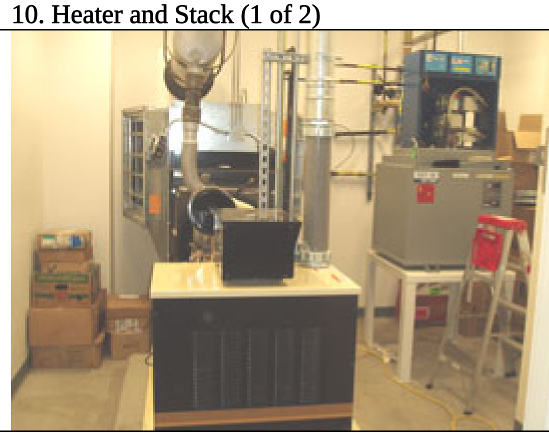
7. Diesel storage, Engine Exhaust


8. Heat Vent and Engine Exhaust


9. Oil Unit Heater (45,000 Btuh)


10. Heater and Stack (1 of 2)


11. Heated Equipment Room


12. Generator Room

13. Engine Exhaust, Radiator and Vent

14. Waiting Room

15. Waiting Room

16. Washeteria

17. Washing Machines

18. Showers


19. Dryers


20. Hot Water From Generator Exhaust


21. Fuel Oil, Hot Water, Water Supply


22. Shop: Converted Water Tank


23. Community School


24. Community School