Biomass Energy
Native Village of Anvik

Preliminary Feasibility Assessment

This preliminary feasibility assessment considers the potential for heating municipal buildings in Anvik with wood.

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Dalson Energy

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Project Summary

Dalson Energy was contracted by the Interior Regional Housing Authority (IRHA) and Tanana Chiefs Conference (TCC) to do a Pre-Feasibility Study (Pre-FS) for a Biomass Heating System for the Native Village of Anvik.

The IRHA/TCC Scope of Work stated that a study should be done to assess the pre-feasibility biomass heating for candidate facilities.

Dalson Energy biomass specialists Thomas Deerfield and Jason Hoke visited the community on September 20, 2011 for the initial assessment. Deerfield and Hoke made their assessment based on available data, interviews with local stakeholders and authorities, observations, and research and review of previous studies done in Anvik.

This report was prepared by Thomas Deerfield, Wynne Auld, Jason Hoke, Louise Deerfield, Tom Miles and Clare Doig.

Contact and interviews with the following individuals in Anvik assisted in some of the information gathering. Their contact information is as follows:

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Tribe: Anvik Village, federally-recognized
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Anvik Tribal Council Environmental Office
Contact: Nathan Elswick, Environmental Coordinator
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Email: atc.environmental@hotmail.com

Summary of Findings

Currently, many of Anvik's municipal buildings are excellent prospects for biomass heating. Containerized HELE (high-efficiency low-emission) cordwood boilers are suggested as an expedient way to develop biomass heating plants in Anvik. The two identified projects are (1) the Blackwell School, and (2) a small District heating system with the Washateria as its hub, also serving the City Building, Clinic, and Tribal Hall.

If both the School and District heating projects move forward, joint investment in chip harvesting and handling equipment may be warranted. A wood chip boiler or multi-fuel chip/ cordwood boiler could serve both projects.

The project's success is *critically dependent* on a Biomass Harvest Plan and an Operations Plan. These two project plans are discussed in this Pre-Feasibility Analysis. The Consultant strongly recommends developing these Plans prior to project development.

	Boiler Size (btu/hr)	**Capital Cost**	**Annual Operations Cost, Yr. 1**	**Annual Cash Savings, Yr. 1**	**Simple Payback, Yrs.**	**NPV**	**IRR**
Blackwell School	350,000	$298,000	$41,300	$29,600	10.0	$479,000	9%
District	350,000	$385,500	$44,500	$25,800	14.9	$417,000	4%

The next step is to present the findings of this pre-feasibility study to IRHA and TCC. As service providers to the Village of Anvik, they will help determine the next steps forward.

Wood fuel supply in Anvik

Anvik , with a population of 79 (2011 Labor Department Estimate) is located on the Anvik River, west of the Yukon River approximately 34 miles north of Holy Cross. The local Native village corporation Deloy Ges, Inc. owns 92,160 acres surrounding the community. Doyon, Limited, the regional corporation owns lands adjacent to Deloy Ges, Inc. lands. No forest inventory information is available for this area, however from satellite imagery, it is evident that surrounding areas support both spruce and hardwood species of trees that is suitable for firewood or fuel for a biomass heating system.

Figure 1: Satillite View of Anvik, AK.

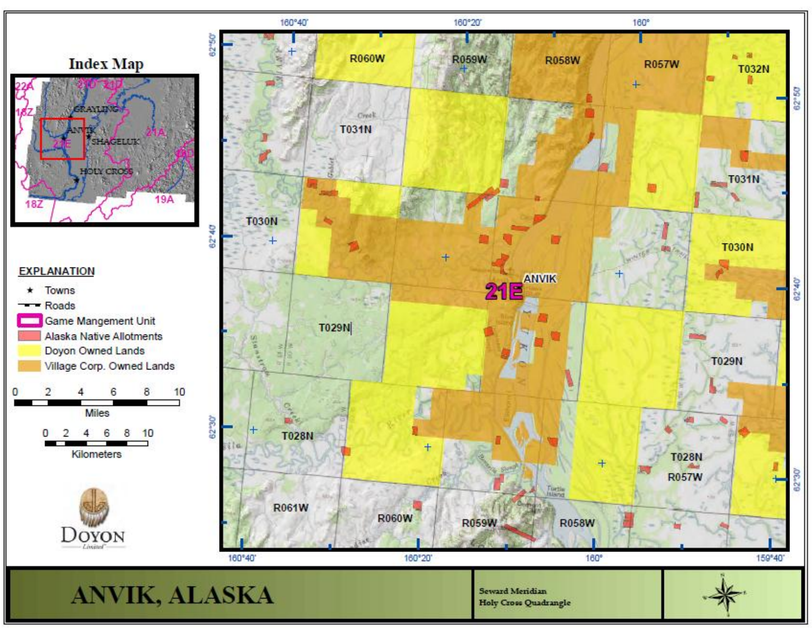

Figure 2: Map of Corporate Land Ownership Surrounding Anvik, AK.

Biomass Energy Operations and Maintenance

Biomass Harvest Plan

Wood cutting is a subsistence activity in almost all interior villages adjacent to forest land. This subsistence resource must be carefully managed or biomass energy projects may be detrimental to the Community.

If biomass harvests are unmanaged, the natural tendency is to harvest the most accessible wood supply first, as illustrated below. The effect is increased scarcity and rising harvest cost, and, consequently, biomass fuel costs, for both the project and household woodcutters. This puts community members' energy security and the project's success at risk.

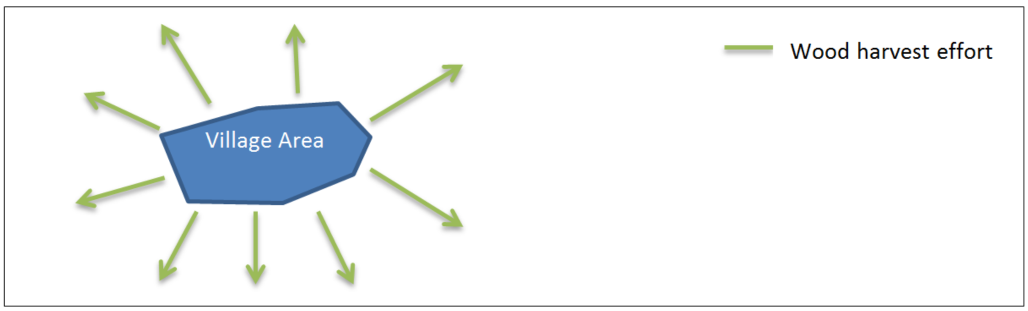

Figure 3: Illustration of Unmanaged Wood Harvesting Efforts

The project's success depends on a well-developed and executed Harvest Plan. The Harvest Plan accounts for the biomass harvests over the project lifetime, at least 20 years. It may also designate areas for Personal Use (household wood cutting). The Harvest Plan also describes how who is responsible for executing the Harvest Plan, and how access will be managed. See figure 4 below.

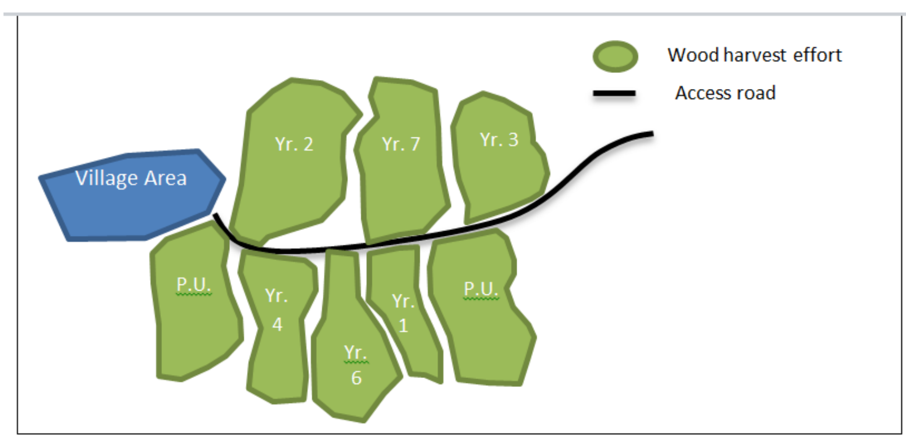

Figure 4: Illustration of Planned Wood Harvest by Harvest Area and Time Period.

Because the project's success is *critically dependent* on a Biomass Harvest Plan, the Consultant strongly recommends developing this Plan prior to project development.

Operations Plan

In many Villages biomass boiler projects will depend on collaboration among a variety of entities, including contract wood cutters, the boiler technician, building owners and operators, forest landowners, and various governmental entities.

A strategy for collecting biomass, paying wood suppliers, allocating costs among heat users, and operating and maintaining the boiler and heat distribution system is crucial to the project's success. Persons responsible for each task must be identified.

Because the project's success is critically dependent on an Operations Plan, the Consultant strongly recommends developing this Plan prior to project development.

Community Facilities Information

The institutional heating opportunities considered for this report were the Blackwell School, City building, Washateria, Clinic, and Tribal Building.

The City building, Washateria, and Clinic are clustered in an area approximately 200 ft. x 60 ft. The Tribal Hall is across the road from the cluster, approximately 180 ft. away. The Blackwell School is southeast of this area. Please see Figure 6.

City Building, Washateria, Clinic, and Tribal Hall Cluster

The City Hall building is approximately 1800 sq. ft. and uses approximately 900 gallons of fuel oil #1 per year. Currently, the City Hall uses heat from the Washateria boiler. The City Hall also has it's own designated heat system, a Wiel McClain P-66HE Series 3 boiler. At the moment, that boiler is mostly dormant because the City Hall draws most of its heat from the Washateria. The City Hall is occupied during the work week, and the thermostat is turned down to about 60 degrees Farenheit on the weekends. However, at the time of inspection, a control valve was not functioning properly and the heat system needed to be turned on/off

Figure 5: Aerial view of Anvik, Alaska, at the Yukon River.

manually.

The Washateria and water treatment plant is an estimated 960 sq. ft. building outfitted with two (2) 268,000 btu/hr Peerless (JO-5PFI-WUP) boilers. The system produces hot water that is distributed via radiant floor and baseboard heaters. Additionally, a 700-gallon Hurst Ace Buehuler boiler (VG30045190) heats domestic hot water. The Washateria uses approximately 7,000 gallons of fuel oil #1 per year. This figure includes oil used to heat the City Hall. The Washateria operates 7 days per week, 10 hours per day.

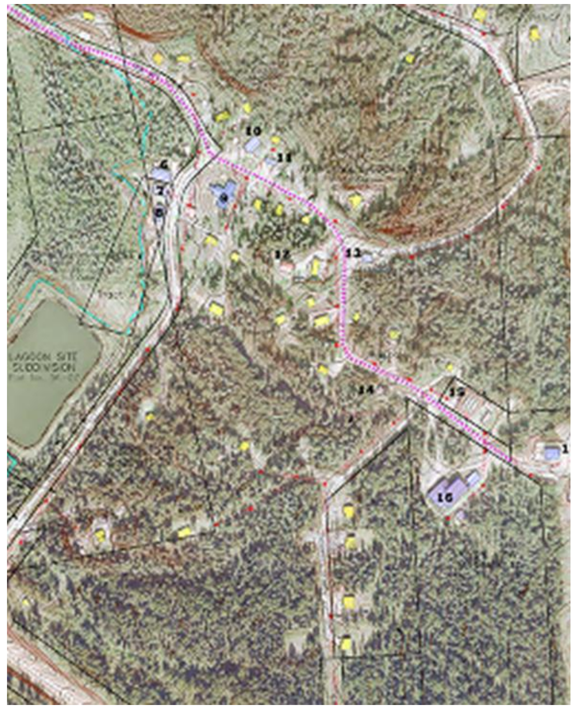

Figure 6: Map of Anvik. Buildings considered for biomass heating. City Building (6), Washateria (7), Clinic (8), Tribal Hall (9) and Blackwell School (16).

Photo Credit: Alaska Division of Community and Regional Affairs

Built in 1997, the Clinic is a relatively new 1200 sq. ft. facility served by a small Burnham boiler and Togo heater. The Clinic also distributes hydronic heat via baseboards, using approximately 900 gallons of fuel oil #1 per year. The Clinic operates 5 days per week.

The Tribal Hall is an approximately 3,800 sq. ft. building outfitted with one (1) Buderus G115/5WS Fuel Oil boiler rated at 136,000 btu/hr. Additionally, the Tribal Hall uses a Blaze King woodstove and two (2) Toyo Laser 73 heaters, each rated for a maximum for 40,000 btu/hr. The log building, which was completed in 2010, has partial in-floor radiant heating and some baseboard heaters. However, additional zones are needed in the entry way and main room to meet full heat demand from the central boiler. The Tribal Hall operates 5 days per week and uses approximately 1,100 gallons of fuel oil #1 per year.

Together, the four buildings comprising this building cluster use approximately 10,000 gallons of fuel oil#1 per year. They are all partially or fully heated by hydronic heating systems. Therefore, a small, biomass-powered district heating system could provide heat to the central heating systems at all four buildings.

Blackwell School

The Blackwell School, part of the Iditarod Area School District, serves approximately 19 K-12 students. The School is heated by two (2) Weil McLain boilers (PS 851-M120) rated at 400,000 btu each. The boilers are redundant, with only one operating at any given time. In 1998 the School was outfitted with a domestic hot water heat (DHW) exchanger to DHW with the central boilers. All space heating and DHW is accomplished with 9,000 – 10,000 gallons per year.

During the Consultant's site visit, there were issues with the building temperature controls. Some spaces, particularly the gym, were unnecessarily warm.

Figure 7: Anvik City Office and Washateria

Figure 9: Tribal Hall

Building Name	City Building	Washateria	Clinic	Tribal Hall	Blackwell School
Annual Gallons (Fuel Oil #1)	7,000		900	1,100	9,500
Building Usage	Year-round	Year-round	Year-round	Year-round	Year-round
Heat Transfer Mechanism	Hydronic	Hydronic	Hydronic	Hydronic	Hydronic
Heating infrastructure need replacement?	No	No	No	No	No

Each of these buildings may have separate domestic hot water heaters from the space heating system. The School uses a heat exchanger from the space-heating boiler to heat domestic hot water. The analysis that follows assumes that project development will design the project so that the domestic hot water systems draw heat from the biomass systems. However, further analysis should be undertaken to determine if this is actually the best option. The volume and frequency of domestic hot water use, as well as existing domestic hot water heating infrastructure, are the most important components of that future analysis.

Recommended technology and fuel requirements

The recommended system design is a pre-fabricated, modular, containerized wood biomass-fueled boiler unit. At a scale of the Blackwell School and District, the preferred system is a cordwood boiler. However, if both the Blackwell School and District were to install biomass heating systems, the preferred scale may well be one or two woodchip-fired boilers with shared chip harvesting, processing, and handling infrastructure. The Village already has a 966 loader, D-8 dozer, and dump trucks.

Containerized cordwood boiler systems are sold by GARN, TARM USA and others. The GarnPac has about 350,000 BTU output and is currently being developed in Thorne Bay. This type of system design is recommended because it has demonstrated reliability, uses an accessible fuel, and it is a modular unit and therefore has lower installation cost, as well as advantages to a granting or lending agency. The consultants recommend adding providers of these units, Garn/Dectra, TARM, Greenwood, and similar system manufacturers, to the list of potential vendors of equipment.

Containerized wood chip systems are sold by TARM USA, KOB, and others. TARM has two boilers that are particularly applicable to interior heating projects: the Froling TX-150 is a small-scale woodchip or pellet system that pre-dries chips prior to combustion. The Froling Turbomatic is small-scale chip boiler that can burn cordwood in cases of emergency. The Turbomatic is not currently distributed in the USA, but may be soon. These units are also available as modularized containerized systems.

To complete this prefeasibility analysis, the consultants have chosen a representational boiler, the GarnPac containerized unit. One (1) GarnPac boiler (or equivalent systems) could service the Blackwell School. One (1) GarnPac boiler (or equivalent systems) could service the City Hall, Washateria, Clinic, and Tribal Hall. The existing Fuel Oil systems would be retained to meet peak demand and as back-up in every project building.

Other communities operating HELE cordwood boilers of a similar size, such as Dot Lake and Ionia, report 2 cordwood stokings per day and 0.125 – 0.5 FTE[1] (Full-time equivalent employee) per boiler.

Fuel Consumption

Assumptions:	
16.2	MMBTU/ Cord White Spruce
0.1250	MMBTU per gallon Oil #1

	Annual Gallons	Annual MMBTU	Annual Cords* for Biomass/ Oil system	Annual Fuel Oil gallons for Biomass/ Oil system
Blackwell School	10,000	1,250	67	1,244
District	9,000	1,125	66	1,212
City Hall				
Washateria	*7,000*	*875*		
Clinic	*900*	*113*		
Tribal Office	*1,100*	*138*		

* Based on Dalson Energy Heating Degree Day data model

Initial project development costs for a wood heating system costs *may* include:

- **Capital costs:** boiler, hydronic pipe and other hardware, wood storage shelter, fuel-handling equipment, shipping costs.
- **Engineering:** storage design, plumbing integration, fuel-handling infrastructure.[2]
- **Permitting:** no permits required. In lieu of permits, all regulations must be met.
- **Installation:** Site work, installation, and integration into existing system.
- **Fuel storage:** storage building, firewood chutes, or preparation of existing storage room.
- **System building:** (if required).

Ongoing operational costs *may* include:

- **Financing:** Principal and interest payments from project debt, or profits from project equity investment. In Village projects, financing costs likely do not apply.
- **Wood fuel purchases.**

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[1] Nicholls, David. 2009. Wood energy in Alaska–case study evaluations of selected facilities. Gen. Tech. Rep. PNW-GTR-793. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 33 p.

2 Not all projects require engineering design.

- **Amortization costs:** capital equipment and other infrastructure.[3] When projects are grant financed, amortization does not apply.
- **Operations and Maintenance (O&M) labor.**
- **Fossil fuel purchases and labor.**[4]

Economic feasibility

Initial investment

School

The Blackwell School has an estimated Capitalization Cost of $298,000.

The District, including City Hall, Washateria, Clinic, and Tribal Office has an estimated Capitalization Cost of $385,000.

See charts below for cost estimates and sources. Full feasibility analysis and/or bids would provide more detailed numbers.

3 Cash and accrual basis are two different accounting methods for project investment. Accrual accounting amortizes project investment over the project lifetime ("lifecycle costs"). This method results in monies to reinvest in new equipment at the end of its lifetime. Cash basis is simply on the dollars spent to operate, maintain, and finance the project.

8 The existing oil heat infrastructure will be retained for supplement heat and back-up. Therefore, the fossil fuel system has ongoing O&M costs, albeit lower than if used as the primary heat source.

Blackwell School

Blackwell School		
System Size (estimated net BTU/ hr)		**350,000**

Capitalization costs		Footnote
Capital equipment		
GarnPac FOB Minnesota, qty. (1)	$ 100,000	A
Freight	$ 15,000	B
Boiler Integration	$ 50,000	C
subtotal	*$ 165,000*	
Commissioning and training	$ 4,000	D
Project Management and Design		
Engineering/ design	$ 50,000	E
Permitting	$ 2,000	F
Project Management	$ 50,000	G
sub-total	**$ 271,000**	
Contingency (10%)	$ 27,100	
Total	**$ 298,100**	

Footnotes	
A	Dectra Corp estimate
B	Crowley & Lynden Transport estimates, 4/17/12
C	Dalson Energy estimate
D	Alaskan Heat Technologies estimate
E	Dalson Energy estimate
F	Dalson Energy estimate
G	Dalson Energy estimate

District

District	
System Size (estimated net BTU/ hr)	**350,000**

Capitalization costs		Footnote
Capital equipment		
GarnPac FOB Minnesota	$ 100,000	A
Freight	$ 15,000	B
Boiler Integration	$ 50,000	C
District heat loop	$ 54,500	D
subtotal	*$ 219,500*	
Commissioning and training	$ 4,000	E
Project Management and Design		
Engineering/ design	$ 75,000	F
Permitting	$ 2,000	G
Project Management	$ 50,000	H
sub-total	**$ 350,500**	
Contingency (10%)	$ 35,050	
Total	**$ 385,550**	

	Footnotes
A	Dectra Corp estimate
B	Crowley & Lynden Transport estimates 4/17/12
C	Dalson Energy estimate
D	RET Screen analysis.
E	Alaskan Heat Technologies estimate
F	Dalson Energy estimate
G	Dalson Energy estimate
H	Dalson Energy estimate

Operating Assumptions

The following assumptions are embedded in all financial analyses in this assessment. They include crucial project variables, such as the price of fuel oil, wood fuel, and labor operating costs. See chart below.

Assumptions for project buildings	School	District	Footnotes
Total MMBTU per year	1,250	1,125	A
% load served by wood fuel	87%	87%	B
% load served by fuel oil	13%	13%	C
Total Cordwood per year (cords)	67	66	D
Total Fuel Oil #1 per year (gal)	1,244	1,212	E
Price per cord	$ 300	$ 300	F
Price per gallon	$ 7	$ 7	G
Biomass labor hours per year	600	780	H
Oil labor hours per year	45	45	I
Price per hour of labor	18	18	J
Biomass preventative maintenance supplies cost	$ 66	$ 66	K
Oil nozzles and filters	$ 250	$ 250	L
Biomass boilers (lifetime operating hours)	60,000	60,000	M
Biomass boilers (operating hours per year)	3,000	3,000	
Biomass refractories (lifetime operating hours)	45,000	45,000	N
Oil boiler (lifetime operationg hours)	60,000	60,000	O
Electricity ($/kWh)	$ 0.58	$ 0.58	P
Electricity Consumption (biomass system)	1,800	1,800	Q
Amount financed Term Rate	Subject to full feasibility study		

Footnotes	
A	Estimates of annual fuel gallon useage, from year 2011
B	Dalson Energy HDD analysis
C	Dalson Energy HDD analysis
D	Dalson Energy HDD analysis
E	Dalson Energy HDD analysis
F	Survey
G	Survey
H	Estimated 3 hours per day, 300 days per year per boiler. Consistent with Dot Lake and Ionia Ecovillage cordwood boiler labor requirements.
I	Dalson Energy estimate
J	Survey
K	Information from Alaskan Heat Technologies. Chemicals max at $250/ yr. Gasket kit at $75. Refractory replaced every 15 years at $500 -- $1,000.
L	Dalson Energy estimate
M	Dalson Energy estimate
N	Based on Information from Alaskan Heat Technologies. Entire refractory replacement after 15 years of operation
O	Dalson Energy estimate
P	Estimated $0.63/kWh
Q	Estimated 1 kWe consumption per hour for boiler fan when operating. Estimated 1800 hours uptime for School and District.

Operating Costs & Annual Savings

The following analyses estimate the operating costs and annual savings. These financial summaries do not include any financing costs but they do include amortization of project equipment, known as lifecycle costs. Lifecycle costs are accrued over the project lifetime and, when the equipment has fulfilled its useful life, monies has been accounted for to purchase the next system. Accrual-based accounting is standard practice.

Special attention should be given to designing an investment and operating structure that suits the system owners and operators. Third party financing, ownership, and O&M (Operations and Maintenance) services may be available. The selected technology provider should provide the training services to equip any daily operator with the knowledge and skills to safely and reliably operate the biomass system.

Savings are calculated on both a cash and accrual basis.

Blackwell School

O&M Costs Fuel Oil		O&M Costs: Biomass + Fuel Oil (supplement)		Annual Savings	
		Biomass			
Oil	70,000	Wood fuel	$ 20,100		
Labor	$ 810	Labor	$ 10,800		
Supplies	$ 250	Preventative maintenance supplies	$ 66		
Lifecycle	$ 1,500	Electricity	$ 1,044		
		Lifecycle	$ 14,905		
		Financing	subject to feasibility		
		Fuel Oil (supplement)			
		Oil	$ 8,708		
		Labor	$ 405		
		Supplies	$ 250		
		Lifecycle	$ 195		
Total Annual O&M Costs (accural basis)	**$ 72,560**	**Total Annual O&M Costs (accural basis)**	**$ 56,473**	**$ 16,087**	**Accrual**
Total Annual O&M Costs (cash basis)	**$ 71,060**	**Total Annual O&M Costs (cash basis)**	**$ 41,373**	**$ 29,687**	**Cash**

District

O&M Costs Fuel Oil		O&M Costs: Biomass + Fuel Oil (supplement)		Annual Savings	
		Biomass			
Oil	69,300	Wood fuel	$ 19,800		
Labor	$ 810	Labor	$ 14,040		
Supplies	$ 250	Supplies	$ 66		
Lifecycle	$ 2,750	Electricity	$ 1,044		
		Lifecycle	$ 19,278		
		Financing	subject to feasibility		
		Fuel Oil (supplement)			
		Oil	$ 8,484		
		Labor	$ 810		
		Supplies	$ 250		
		Lifecycle	$ 358		
Total Annual O&M Costs (accural basis)	**$ 73,110**	**Total Annual O&M Costs (accural basis)**	**$ 64,129**	**$ 8,981**	**Accrual**
Total Annual O&M Costs (cash basis)	**$ 70,360**	**Total Annual O&M Costs (cash basis)**	**$ 44,494**	**$ 25,866**	**Cash**

Financial metrics

The following financial analyses are entirely reliant on the preceding assumptions and O&M models. These same models can be refined to reflect more sophisticated financial profiles if additional study is warranted.

Simple payback period

SIMPLE PAYBACK	School	District
Initial Investment	$ 298,100	$ 385,550
Cash savings, Year 1	$ 29,687	$ 25,866
Simple Payback (Years)	**10.0**	**14.9**

Present Value

The prefeasibility Scope of Work does not allow building a full economic model with escalation rates of fuel, labor, and supplies cost. Present value analysis is completed on the basis of the savings demonstrated in this section.

Present Value

Assumptions	
Interest Rate	5.50%
Term (years)	10

School		District	
Initial investment	$ 298,100	Initial investment	$ 385,550
Future value (cash value of new project)	$ 29,687	Future value (cash value of new project)	$ 25,866

Equation Values	School	District
Interest Rate per Month	0.46%	0.46%
Number of Payments in project lifetime	120	120
Payment per month	$ (2,484)	$ (3,213)
Future Value (cash value of new project)	$ 29,687	$ 25,866
Payments at end of period = 0	0	0
Present Value	**$211,751**	**$281,108**

Net Present Value

The prefeasibility Scope of Work does not allow building a full economic model with escalation rates of fuel, labor, and supplies cost. Net present value analysis is completed on the basis of the savings demonstrated in Year 1, generally inflating at 1.5% per year.

Net Present Value	Discount Rate	3.50%
	General Inflation Rate	1.50%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	NPV
School	$ 29,687	$ 30,132	$30,584	$31,043	$31,508	$31,981	$32,461	$32,948	$33,442	$33,944	$34,453	$34,969	$35,494	$36,026	$36,567	$37,115	$37,672	$38,237	$38,811	$39,393	**$479,614**
District	$ 25,866	$ 26,254	$26,648	$27,047	$27,453	$27,865	$28,283	$28,707	$29,138	$29,575	$30,018	$30,469	$30,926	$31,389	$31,860	$32,338	$32,823	$33,316	$33,815	$34,323	**$417,883**

Internal Rate of Return

The prefeasibility Scope of Work does not allow building a full economic model with escalation rates of fuel, labor, and supplies cost. IRR analysis is completed on the basis of the savings demonstrated in this section.

Internal Rate of Return	General Inflation Rate	1.50%

Year	0	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	IRR
School	$ (298,100)	$ 29,687	$ 30,132	$ 31,043	$ 31,508	$31,981	$32,461	$32,948	$33,442	$33,944	$34,453	$34,969	$35,494	$36,026	$36,567	$37,115	$37,672	$38,237	$38,811	$39,393	**9%**
District	$ (385,550)	$ 25,866	$ 26,254	$ 27,047	$ 27,453	$27,865	$28,283	$28,707	$29,138	$29,575	$30,018	$30,469	$30,926	$31,389	$31,860	$32,338	$32,823	$33,316	$33,815	$34,323	**4%**

Life cycle cost analysis (LCCA) for School

Life Cycle Costs of Project Alternatives Blackwell School	
District:	Iditarod
School:	Kuskokwim School
Project:	Biomass Boiler
Project No.	NA
Study Period:	20
Discount Rate:	3.50%

	Alternative #1 (low)	Alternative #2 (high)
Initial Investment Cost	$ 271,000	$ 298,100
O&M and Repair Cost	$ 718,842	$ 708,854
Replacement Cost	$ 50,257	$ 75,385
Residual Value	$ 25,128	$ 15,077
Total Life Cycle Cost	$ 1,065,226	$ 1,097,415
GSF of Project	29,916	29,916
Initial Cost/ GSF	$ 9.06	$ 9.96
LCC/ GSF	$ 35.61	$ 36.68

YEAR		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Alt. 1	Discount Rate			3.50%																	
	Gen'l Inflation for O&M			1.50%																	
	NPV																				
O&M	$718,842	$ 44,494	$ 45,162	$ 45,839	$ 46,527	$ 47,225	$ 47,933	$ 48,652	$ 49,382	$ 50,122	$ 50,874	$ 51,637	$ 52,412	$ 53,198	$ 53,996	$ 54,806	$ 55,628	$ 56,463	$ 57,309	$ 58,169	$ 59,042
Replacement	$50,257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100,000
Residual	$25,128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50,000
Alt 2	Discount Rate			3.50%																	
	Gen'l Inflation for O&M			1.50%																	
	NPV																				
O&M	$708,854	$ 44,494	$ 44,494	$ 45,162	$ 45,839	$ 46,527	$ 47,225	$ 47,933	$ 48,652	$ 49,382	$ 50,122	$ 50,874	$ 51,637	$ 52,412	$ 53,198	$ 53,996	$ 54,806	$ 55,628	$ 56,463	$ 57,309	$ 58,169
Replacement	$75,385	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150,000
Residual	$15,077	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30,000

Conclusion

The village of Anvik has significant opportunities for biomass heating, owing to the high cost of fuel oil, accessible cordwood supply, and existing institutional heat loads that could be adequately served by one or more biomass boilers.

Cordwood is an accessible and sustainable biomass supply in the Village so long as a Biomass Harvest Plan is appropriately developed and executed. Because the project's success is *critically dependent* on a Biomass Harvest Plan, the Consultant strongly recommends developing this Plan prior to project development. Additionally, because the project's success is *critically dependent* on an Operations Plan, the Consultant strongly recommends developing this Plan prior to project development.

The two projects examined in this pre-feasibility analysis, a small district heat loop and the School, both show positive NPV and cash savings, which suggests that development may be warranted. However, the School is most easily adaptable to the biomass system and serves as the single largest heat load, in addition to representing the most attractive financial profile.

If both the District and School project moved forward, it may well be worthwhile to consider a small chip boiler and shared woodchip manufacturing equipment. This would alleviate increased pressure on the cordwood supply. Technology that can burn multi-fuels, such as chips and cordwood, may be preferred. It must be noted that a woodchip system would require additional hardware—a chipper and woodchip drying and conveyance system.

Some work will have to be done to adapt the load centers with the hydronic heat loop, and these adaptations have not been fully assessed. Additionally, hot water boilers will need to be connected to the district heat loop.

Consultant/Authors of this report:

Dalson Energy is a Renewable Energy Consulting and Technology Research firm based in Anchorage. Dalson staff and partners have decades of experience in construction project management, project development consulting and renewable energy technology research. Dalson teams with licensed engineers, architects and designers in Alaska, Canada and Lower 48.

Dalson Energy has worked with Alaska Energy Authority, Alaska Center for Energy & Power, University of Alaska Fairbanks, Washington State CTED (Community Trade & Economic Development) and California Energy Commission on biomass energy technology research.

Dalson's President, Thomas Deerfield, has been involved in biomass energy RD&D since 2001, winning grants and managing projects with NREL (National Renewable Energy Labs), USFS (US Forest Service), and CEC (California Energy Commission).

Thomas managed the field-testing of biomass CHP systems, including the first grid-connected biomass gasification CHP system in the US. (2007). Thomas coordinated the design and creation of the first prototype Biomass "Boiler in a Box" in Alaska, in 2010. That Garn-based system is now deployed in Elim, in the Bering Sea region.

Thomas founded Shasta Energy Group (SEG), a 501c3 nonprofit, and managed wind energy research, biomass energy feasibility studies, energy efficiency for buildings, and hydronic heating system research design and development (RD&D). He also initiated a rural economic development think tank and has engaged his writing skills to assist many other renewable energy project initiatives.

Wynne Auld is a Biomass Energy Specialist with Dalson Energy. She focuses on assessing and developing woody biomass energy projects. Over the past few years, she has supported the business development of integrated biomass energy campuses in Oregon and Idaho, especially related to their energy initiatives. Her efforts have included marketing Campus biomass heating products to major wholesalers and retail buyers, and planning and developing Campus sort yards and small-scale CHP.

Wynne also specializes in assisting commercial and municipal building managers in assessing the feasibility of biomass heating, and implementing their projects. She works to ensure vibrant rural communities through sustainable natural resource utilization.

Wood fuel as a heating option

When processed, handled, and combusted appropriately, wood fuels are among the most cost-effective and reliable sources of heating fuel for communities adjacent to forestland.

Figure 10: Cordwood

Compared to other heating energy fuels, wood fuels are characterized by lower energy density and higher associated transportation and handling costs. This low bulk density results in a shorter viable haul distance for wood fuels compared to fossil fuels. However, this "limit" also creates an advantage for local communities to utilize locally-sourced wood fuels, while simultaneously retaining local energy dollars and excercising local resource management.

Figure 11: Ground wood chips used for mulch.

Most Interior villages are particularly vulnerable to high energy prices because the region has over 13,500 heating degree days[5] (HDD) per year – 160% of Anchorage's HDDs, or 380% of Seattle's HDDs. For many communities, wood-fueled heating lowers fuel costs. For example, cordwood sourced at $250 per cord is just 25% of the cost per MMBTU as fuel oil #1 sourced at $7 per gallon. Besides the financial savings, local communities benefit from the multiplier effect of circulating fuel money in the community longer, more stable energy prices, job creation, and more active forest management.

Figure 12: Wood briquettes, as a substitute for cordwood. Cross sections of these briquettes make "wafers" which can be automatically handled in biomass boiler systems.

In all the Interior villages studied, the community's wood supply and demand are isolated from outside markets. Instead, the firewood market is influenced by land ownership, existing forest management and ecological conditions, local demand and supply, and the State of Alaska Energy Assistance program.

Figure 13: wood pellets

The nature of wood fuels

Wood fuels are specified by moisture content, granulometry, energy density, ash content, dirt and rocks, and fines and coarse particles. Each of these characteristics affects the wood fuel's handling characteristics, storage requirements, and combustion process. Fuels are considered higher quality if they have lower moisture, ash, dirt, and rock contents; consistent granulometry; and higher energy density.

[5] Heating degree days are a metric designed to reflect the amount of energy needed to heat the interior of a building. It is derived from measurements of outside temperature.

Many types of fuel quality can be used in wood heating projects so long as the infrastructure specifications match the fuel content characteristics. Typically, lower quality fuel will be the lowest cost fuel, but it will require more expensive storage, handling, and combustion infrastructure, as well as additional maintenance.

Projects in interior Alaska must be designed around the availability of wood fuels. Some fuels can be manufactured on site, such as cordwood, woodchips, and briquettes. The economic feasibility of manufacturing on site can be determined by a financial assessment of the project; generally speaking, larger projects offer more flexibility in terms of owning and operating harvesting and manufacturing equipment, such as a wood chipper, than smaller projects.

It is unlikely that interior communities will be able to manufacture pellets, from both a financial, operational, and fuel sourcing perspective. However, some interior communities may be able to manufacture bricks or firelogs made from pressed wood material. These products can substitute for cordwood in woodstoves and boilers, while reducing supply pressure on larger diameter trees than are generally preferred for cordwood. At their simplest, brick presses are operated by hand, but require chipped, dry fuel.

The basics of wood-fueled heating

Biomass heating systems fit into two typical categories: first, stoves and fireplaces that heat space directly through convection and radiation by burning cordwood or pellets; second, hydronic systems where the boiler burns cordwood, woodchips or pellets to heat liquid that is distributed to radiant piping, radiators or heat exchangers. The heated liquid is distributed out to users, then returned to the heat source for re-heating.

Hydronic systems are appropriate for serving individual buildings, or multiple buildings with insulated piping called heat loops. Systems that serve multiple buildings are called district heating loops. District heating is common in Europe, where larger boilers sometimes serve entire villages.

Biomass boilers are dependent on the compatibility of the chosen fuel, handling system, and combustion system. General categories for typically available biomass fuel systems follow:

- Batch load solid chunk boiler
- Semi-automated or fully-automated chipped or ground biomass boilers
- Fully-automated densified-fuel boiler, using pellets, bricks, or pucks

The system application is typically determined by size of heat load, available wood fuels, and available maintenance personnel. General categories for heat load and wood fuel follow:

- Loads < 1 MMBTU often use cordwood or pellet boilers
- Loads > 1MMBTU often use pellet or woodchip boilers
- Loads > 10MMTU often use hog-fuel (mixed ground wood)

Each wood fuel type has different handling requirements and is associated with different emission profiles. For example, industrial systems greater than 10 MMBTU often require additional particulate and emission controls because of the combustion properties of hog-fuel.

One category of system that is particularly appropriate for remote rural communities is cordwood boilers. Cordwood boilers are batch-loaded with seasoned cordwood. A significant advantage to cordwood is that very little infrastructure is needed to manufacture or handle the heating fuel. At its most basic, cordwood can be "manufactured" with a chainsaw (or handsaw) and an ax, and residents of rural communities are often accustomed to harvesting wood to heat their homes and shops. Harvesting in most Interior villages is accomplished with ATV's, river skiffs, sleds and dog teams, and snow machines. Since cordwood systems are batch loaded by hand, they do not require expensive automated material handling systems. Covered storage is required; such storage may be as simple as an existing shed or a vented shipping container, rather than newly constructed storage structures.

Challenges to cordwood include higher labor costs associated with manual loading. Some LEHE (low efficiency, high emission) technologies such as Outdoor Wood Boilers (OWBs) have been criticized for their high emissions and excessive wood consumption.

Cordwood systems are typically less than 1 MMBTU. However, if needed, some types of cordwood boilers can be "cascaded," meaning multiple boilers can meet heat demand as a single unit. However, above a certain heat load, automated material handling and larger combustion systems become viable.

Woodchip systems can be automated and thereby less labor intensive. However, woodchip systems have significantly higher capital costs than both cordwood and pellet systems. Additionally, a reliable stream of woodchips typically depends on a regionally active forest products manufacturing base in the area, and active forest management. In most Interior communities, institutional heating with woody biomass does not justify the purchase of log trucks, harvesting, handling, and manufacturing equipment.

Pellet systems are the most automated systems, and have lower capital equipment costs than woodchip systems. Lower costs are due to the smaller size of required infrastructure and simplified handling and storage infrastructure. However, pellet fuel and other densified fuels tend to be more expensive than other wood fuels, and require reliable access to pellet fuels.

For any system, the mass of feedstock required annually is determined by three parameters:

1) Building heat load
2) Net BTU content of the fuel
3) Efficiency of the boiler system

Building heat loads are determined by square footage, orientation and usage, as well as energy efficiency factors such as insulation, moisture barriers and air leakage. Usage is particularly important because it influences peak demand. For example, a community center which is used only a few times per month for events, and otherwise kept at a storage temperature of 55 d. F, would have a much different usage profile than a City Office which is fully occupied during the work day and occasionally during evenings and weekends.

Building heat load analysis, including the building usage profile, is a particularly important part of boiler right-sizing. A full feasibility analysis would conduct analyses that optimize the return on investment (ROI) of systems. Typically, optimizing a biomass project's ROI depends on a supplementary heating system, such as an oil fired system, to meet peak demand and prevent short-cycling of the biomass boiler. Full feasibility analyses may not be necessary for small projects, especially for those employing cordwood boilers.

Biomass boiler efficiencies vary from 60% to 80%, depending on the manufacturer and the field conditions of the equipment. The efficiency is strongly influenced by the BTU value and MC (moisture content) of the fuel. Wood fuels with greater than 50% MC generally result in lower efficiency systems, because some energy is used to drive off moisture from the fuel during the combustion process. The reduction in energy output is mathematically equal; 50% MC generally means 50% reduction in potential BTU value.

Like other combustion-based energy systems, woody biomass boilers produce emissions in the combustion process. Compared to fossil fuels (coal, natural gas, and fuel oil), wood fuel emissions are low in nitrogen oxides (NOx); carbon monoxide (CO, a product of incomplete combustion); sulfur dioxide (SO2); and mercury (Hg). Because these compounds are all products of the forest and CO would release naturally during the process of decay or wildfire, they generally do not concern regulatory agencies. For emission control agencies, the real interest is particulate matter (PM) emissions, which affect the air quality of human communities. Some wood systems are extremely sophisticated, producing less than 0.06 lb/ MMBTU of PM.

Effective methods of PM control have been developed to remove most of the particles from the exhaust air of wood combustion facilities. These include introduction of pre-heated secondary air, highly controlled combustion, and PM collection devices.

Biomass boiler systems typically integrate a hot water storage tank, or buffer tank. The storage tank prevents short cycling for automated boilers and improves efficiency and performance of batch-fired systems, by allowing project buildings to draw on the boiler's hot water long after the combustion process. The GarnPac boiler design incorporates hot water storage into the boiler jacket itself, storing approximately 2,200 gallons of hot water. Other boilers are typically installed with a separate hot water storage tank.

Available wood heating technology

This section will focus generally on manufacturers of the types of technology discussed previously.

Cordwood Boilers

High Efficiency Low Emission (HELE) cordwood boilers are designed to burn cordwood fuel cleanly and efficiently.

Cordwood used at the site will ideally be seasoned to 25% MC (moisture content) and meet the dimensions specified by the chosen boiler. The actual amount of cordwood used would depend on the buildings' heat load profile, and the utilization of a fuel oil system as back up.

The following table lists three HELE cordwood boiler suppliers, all of which have units operating in Alaska. Greenwood and TarmUSA, Inc. have a number of residential units operating in Alaska, and several GARN boilers, manufactured by Dectra Corporation, are used in Tanana, Kasilof, Dot Lake, Thorne Bay and other locations to heat homes, Washaterias, and Community Buildings.

HELE Cordwood Boiler Suppliers		
Vendor	**Btu/hr ratings**	**Supplier**
Tarm	100,000 to 198,000	Tarm USA www.tarmusa.com
Greenwood	100,000 to 300,000	Greenwood www.greenwoodusa.com
GARN	250,000 to 700,000	Dectra Corp. www.dectra.net/garn
Note: These lists are representational of available systems, and are not inclusive of all options.		

Bulk Fuel Boilers

The term "bulk fuel" refers to systems that utilize wood chips, pellets, pucks, or other loose manufactured fuel. Numerous suppliers of these boilers exist. Since this report focuses on village-scale heating, the following chart outlines manufacturers of chip and pellet fuel boilers < 1 MMBTU.

HELE Bulk Fuel Boiler Suppliers		
Vendor	**Btu/hr ratings**	**Supplier**
Froling	35,800 to 200,000; up to 4 can be cascaded as a single unit at 800,000 BTU	Tarm USA www.tarmusa.com
KOB	512,000 – 1,800,000 BTU (PYROT model)	Ventek Energy Systems Inc. peter@ventekenergy.com

Binder	34,000 BTU – 34 MMBTU	BINDER USA contact@binder-boiler.com
Note: These lists are representational of available systems, and are not inclusive		

The following is a review of Community Facilities being considered for biomass heating. The subsequent section will recommend a certain type of biomass heating technology, based on the Facility information below.

District heat loops

District heat loops refers to a system for heating multiple buildings from a central power plant. The heat is transported in a piping system to consumers in the form of hot water or steam.

These are the key factors that affect the cost of installing and operating a district heating system[6]:

- Heat load density.
- Distance between buildings. Shorter distances between buildings will allow use of smaller diameter (less expensive) pipes and lesser pumping costs.
- Permafrost. In the Interior, frozen soil could affect construction costs and project feasibility. Aboveground insulated piping may be preferred to underground piping, such as the cordwood system recently installed in Tanana, Alaska.
- Piping materials used. Several types of tubing are available for supply and return water. Pre-insulated PEX tubing may be the preferred piping material for its flexibility and oxygen barrier.
- District loop design. Water can be piped in one direction (i.e., one pipe enclosed) or two directions (two pipes enclosed) for a given piping system. Design affects capital costs and equality of heat distribution.
- Other considerations. Pump size, thermal load (BTUs per hour), water temperature, and electrical use are other variables.

For the purposes of this study, the consultants have chosen to estimate the costs of district heat loops using the RET Screen, a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs), including district heat loops from biomass.

6 Nicholls, David; Miles, Tom. 2009. Cordwood energy systems for community heating in Alaska−an overview. Gen. Tech. Rep. PNW-GTR-783. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research
Station. 17 p.