Biomass Energy
Native Village of Ruby

Preliminary Feasibility Assessment

This preliminary feasibility assessment considers the potential for heating community buildings in Ruby with woody biomass from regional forests and river logs.

Dalson Energy Inc.

308 G St. Ste 303
Anchorage, Alaska 99501

907-277-7900

8/25/2012

Dalson Energy

Table of Contents

Project Summary 3
Summary of Findings 4
Wood fuel supply in Ruby 5
Biomass Energy Operations and Maintenance 6
Biomass Harvest Plan 6
Operations Plan 7
Community Facilities Information 8
Ruby School 8
Recommended technology and fuel requirements 9
Initial investment 10
Financial Analysis 12
Conclusion 17
Supplement: Community Wood Heating Basics 19
Wood fuel as a heating option 19
The nature of wood fuels 19
The basics of wood-fueled heating 20
Available wood heating technology 24
Cordwood Boilers 24
Bulk Fuel Boilers 24
District heat loops 25

Figure 1: Land Ownership Surrounding Ruby, AK. 5
Figure 2: TCC Timber Inventory, 1990. 6
Figure 3: Illustration of Unmanaged Wood Harvesting Efforts 6
Figure 4: Illustration of Planned Wood Harvest by Harvest Area and Time Period. 7
Figure 5: Ruby School Boilers 7
Figure 6: Cordwood 19
Figure 7: Wood briquettes, as a substitute for cordwood. Cross sections of these briquettes make "wafers" which can be automatically handled in biomass boiler systems. 19
Figure 8: Ground wood chips used for mulch. 19
Figure 9: Wood pellets 19

Project Summary

Interior Regional Housing Authority (IRHA) and Tanana Chiefs Conference (TCC) contracted Dalson Energy to do a Pre-Feasibility Study (Pre-FS) for biomass heating of community buildings in the Native Village of Ruby.

Dalson Energy biomass specialists Thomas Deerfield and Wynne Auld visited the community on June 16, 2012 for the initial assessment. Deerfield and Auld made their assessment based on available data, interviews with local stakeholders and authorities, observations, and research and review of previous studies done in Ruby.

It was noted that there are several other studies and reports that address various aspects of biomass energy in Ruby, including Forestry Resource assessments done by TCC Forester Will Putman and DNR Division of Forestry. Clare Doig of Forest and Land Management Inc. is also completing a forest management plan for the regional corporation, Gana'a'Yoo. These previous studies are the foundation for further evaluation of institutional heating with woody biomass in Ruby, as exercised in this prefeasibility assessment.

This report was prepared by Thomas Deerfield, Wynne Auld, Louise Deerfield, and Clare Doig.

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

City - City of Ruby
P.O. Box 90
Ruby, AK 99768
Phone 907-468-4401
Fax 907-468-4443

Tribe-- Ruby Village, federally-recognized
P.O. Box 68210
Ruby, AK 99768
Phone 907-468-4479
Fax 907-468-4474
E-mail rubynativecouncil@hotmail.com

Ed Sartan, project contact

School—Ruby School
Don Honea Jr, Maintenance Manager

Summary of Findings

Currently, the opportunities for wood heating with commercial-scale biomass heating systems in the Community of Ruby appear to be financially challenged by low heat loads and relatively long payback terms. Small residential-scale heating systems (woodstoves, etc) are always a viable option, but are not in the scope of this study.

The two identified projects are (1) the School and (2) the Washateria. The Washateria is completely heated by waste heat, so it was not evaluated for wood heat. The School has a relatively low consumption of fuel oil, so under the current assumptions the capital cost of investment cannot be recouped. The School was evaluated for a HELE (high efficiency, low emission) cordwood boiler system.

	Boiler Size (BTU/hr)	Capital Cost	Annual Operations Cost, Yr. 1	Annual Cash Savings, Yr. 1	Simple Payback, Yrs.	NPV Net Benefit	B/C
School	350,000	$279,900	$30,765	$4,593	60.9	($151,805)	0.44

The next step is full report findings presentation to IRHA and TCC. As service providers to the Village of Ruby, they will determine the next steps forward.

Wood fuel supply in Ruby

In 1987 Tanana Chiefs Conference completed a timber inventory of the ANCSA Native Village lands around Ruby. Much of this material could be considered woody biomass suitable for wood fueled heating systems. Doyon, Limited, the regional corporation, is the other major landowner in the region, as indicated by Figure 1: Land Ownership Surrounding Ruby, AK.

While these inventory figures indicate a substantial timber resource, sites supporting tree growth are widely distributed and may be difficult to access because of the area characteristics and the lack of existing roads. The Village is located along a major river system with expansive low elevation wetlands, resulting in widely distributed higher elevation sites that support tree growth. These factors impact the economics of fuel availability, which in turn impacts the size and fuel demand for a wood fueled heating system in the community. Additional considerations include 1) the landowner's contractual agreement for harvest and compensation for the resource, 2) public acceptance of larger scale timber harvest than has been experienced in recent history, and 3) total project (from timber harvest to operation of the heating system) economic feasibility.

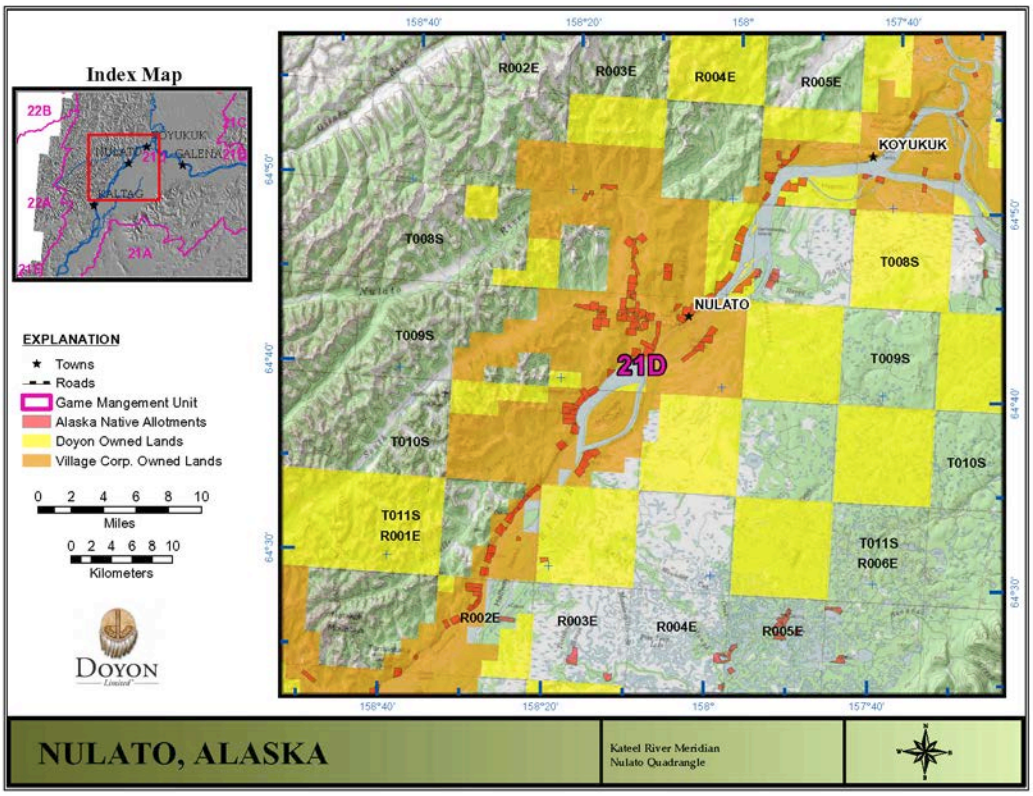

Figure 1: Land Ownership Surrounding Ruby, AK.

Ruby (1987)	Acres	Cubic Feet	Board Feet (thousands)
Saw Timber Types: (10.5"+ d.b.h.)			
White Spruce	2,157	5,755,000	15,804
Black Spruce	319	286,000	385
Hardwood	14,541	33,637,000	63,671
Mixed White Spruce/Hardwood	7,875	19,483,000	48,685
Mixed White Spruce/Cottonwood	333	584,000	1,675
Subtotal	25,225	59,745,000	130,220

Figure 2: TCC Timber Inventory, 1987.

The community of Ruby also practices river logging and reportedly uses the river extensively for transporting wood via rafts from areas up and down river. Dependability and volume of river-caught logs have not been documented.

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.

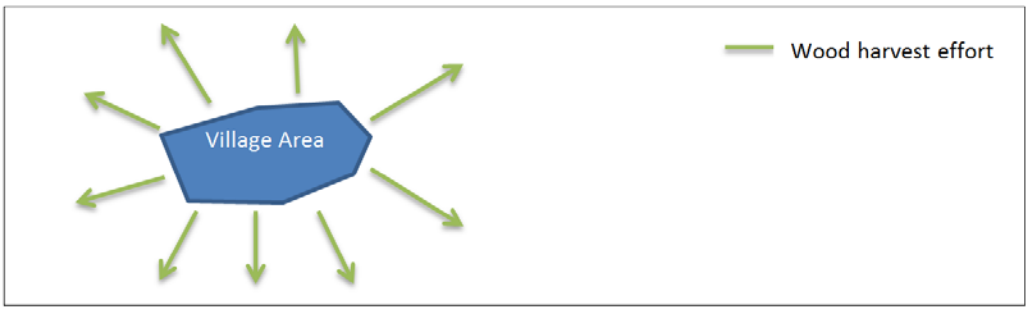

Figure 3: Illustration of Unmanaged Wood Harvesting Efforts

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. Please see figure below.

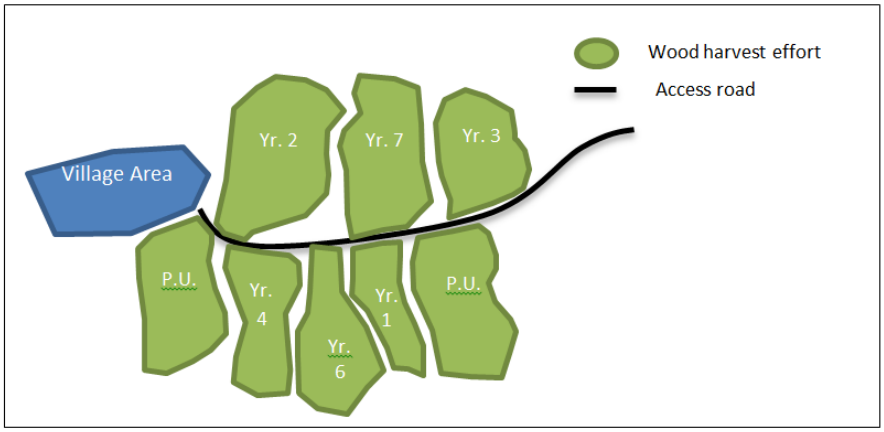

Figure 4: Illustration of Planned Wood Harvest by Harvest Area and Time Period.

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, forest landowners, the boiler technician, building owners and operators, and various governmental entities.

Figure 5: Ruby School Boilers

A plan 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

Only one community buildings in Ruby was evaluated for biomass heating -- the Ruby School. Other buildings considered include the City and Tribal Offices, and the Washateria. The City and Tribal Offices are located in a flood zone and have very low fuel oil consumption, and the Washateria gets all of its heat from a waste heat system. Therefore, these buildings were not evaluated further.

Ruby School

The Ruby School uses one (1) 404 MBH fuel oil boiler, and retains a second boiler for back up. The School also produces hot water for teacher housing, but the houses have their own Toyostove for space heating. All appliances in the school are hydronic. The system uses 6,000 – 7,000 gallons per year of oil.

The School maintenance technician is Don Honea Jr, who has maintained the School since 1986. He works part-time. Don stated he is "all for" a wood energy system. Don has maintained the School since 1986. Ed Sartan and the Principal, Ann Titho, would also champion the project.

It is also worth noting that a community member, Gary Brown, has undertaken biomass boiler training with Rex Goulsby of Lars Construction and also suggested he would champion a project.

Building Name	**School**
Annual Gallons (Fuel Oil #1)	6,000 – 7,000 gal/ yr
Building Usage	During the School year
Heat Transfer Mechanism	Hydronic
Maximum cords to heat the building	49

Recommended technology and fuel requirements

For the School, a pre-fabricated, modular, containerized HELE (high efficiency, low emissions) cordwood boiler is recommended. These types of systems are produced by GARN, TARM USA and others. The GarnPac has about 350,000 BTU output and is currently being employed in Thorne Bay. This type of system design is recommended because it has demonstrated reliability, uses an accessible fuel, cordwood, and it is a modular unit and therefore has lower installation cost and financing advantages. The Consultant recommends adding providers of these units, Garn/Dectra, TARM, Greenwood, and similar system manufacturers, to the list of potential equipment providers.

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.

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.**
- **Amortization costs:** capital equipment and other infrastructure.[3] When projects are grant financed, amortization does not apply.

---

[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.

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.

4 Fossil fuel purchases and labor.

- **Operations and Maintenance (O&M) labor.**

Initial investment

The School has an estimated Capitalization Cost of $279,700.

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

Initial investment: School

Biomass System	
Rating -- Btu/hr	350,000
Btu stored	415,000

	footnote			*notes*
Building and Equipment Costs (B&E) $				
Fuel Storage Building (fabricated building, gravel pad, $27/sf)		$	26,460	(49 cds @ 20 sq. ft. / cd.)
Pre-Fabricated Boiler System				
Base price	A	$	100,000	
Shipping to Hub	B	$	20,000	
Bush Delivery	B	$	20,000	
Plumbing and electrical	B	$	2,500	
Site Prep	B	$	4,500	
Integration (Wash + Waterplant)	B	$	15,000	
Subtotal-B&E Costs		***$***	***188,460***	
Contingency -- 20%		***$***	***37,692***	
Grand Total		**$**	**226,152**	
Soft Costs $				
Project Management	B	$	18,092	8% of B&E
A/E Design Services	B	$	13,569	6% of B&E
Fire Marshall Plan Review	B			pre-approved
Equipment Commissioning and Training	B	$	4,000	
Construction Management	B	$	18,092	8% B&E
Subtotal -- Soft Costs		**$**	**53,753**	
Recommended Project Budget -- Design and Construction Cost		**$**	**279,905**	

footnote	
A	Based on quotes from viable suppliers
B	Estimate

Financial Analysis

Project Description	
Community	Ruby
Nearest Fuel Community	
Region	Rural
RE Technology	Woody biomass heat
Project ID	
Applicant Name	Village of Ruby
Project Title	School
Category	

Results	
NPV Benefits	$119,948
NPV Capital Costs	$271,753
B/C Ratio	0.44
NPV Net Benefit	($151,805)

Performance	Unit	Value
Displaced Electricity	kWh per year	-
Displaced Electricity	total lifetime kWh	-
Displaced Petroleum Fuel	gallons per year	6,003
Displaced Petroleum Fuel	total lifetime gallons	162,500
Displaced Natural Gas	mmBtu per year	-
Displaced Natural Gas	total lifetime mmBtu	-
Avoided CO2	tonnes per year	61
Avoided CO2	total lifetime tonnes	1,649

Proposed System	Unit	Value
Capital Costs	$	$ 279,905
Project Start	year	2013
Project Life	years	25
Displaced Electric	kWh per year	-
Displaced Heat	gallons displaced per year	5,850
Displaced Transportation	gallons displaced per year	0.00
Renewable Generation O&	$ per BTU	
Electric Capacity	kW	0
Electric Capacity Factor	%	0
Heating Capacity	Btu/hr.	350,000
Heating Capacity Factor	%	86

Base System	Unit	Value
Diesel Generator O&M	$ per kWh	$ 0.033
Diesel Generation Efficien	kWh per gallon	

Annual Savings	(Costs)	Units	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Entered Value	Project Capital Cost	$ per year	$ 279,905	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Electric Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Heating Saving (Costs)	$ per year	$4,222	$4,593	$4,845	$5,196	$5,671	$6,113	$6,527	$6,899	$7,232	$7,473	$7,714
	Transportation Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Total Savings (Costs)	**$ per year**	$4,222	$4,593	$4,845	$5,196	$5,671	$6,113	$6,527	$6,899	$7,232	$7,473	$7,714
	Net Benefit	**$ per year**	**($275,684)**	**$4,593**	**$4,845**	**$5,196**	**$5,671**	**$6,113**	**$6,527**	**$6,899**	**$7,232**	**$7,473**	**$7,714**

Annual Savings	(Costs)	Units	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Entered Value	Project Capital Cost	$ per year	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Electric Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Heating Saving (Costs)	$ per year	$7,920	$8,094	$8,235	$8,316	$8,333	$8,312	$8,244	$8,115	$7,932	$7,753	$7,554
	Transportation Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Total Savings (Costs)	**$ per year**	$7,920	$8,094	$8,235	$8,316	$8,333	$8,312	$8,244	$8,115	$7,932	$7,753	$7,554
	Net Benefit	**$ per year**	**$7,920**	**$8,094**	**$8,235**	**$8,316**	**$8,333**	**$8,312**	**$8,244**	**$8,115**	**$7,932**	**$7,753**	**$7,554**

Annual Savings	(Costs)	Units	2035	2036	2037	PV
Entered Value	Project Capital Cost	$ per year	$ -	$ -	$ -	**$271,753**
	Electric Savings (Costs)	$ per year	$0	$0	$0	**$0**
	Heating Saving (Costs)	$ per year	$7,381	$7,441	$7,504	**$119,948**
	Transportation Savings (Costs)	$ per year	$0	$0	$0	**$0**
	Total Savings (Costs)	**$ per year**	$7,381	$7,441	$7,504	**$119,948**
	Net Benefit	**$ per year**	**$7,381**	**$7,441**	**$7,504**	**($151,805)**

Heating		Units	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Proposed													
	Renewable Heat	gallons displ	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850
Entered Value	Renewable Heat Scheduled Re	$ per year	$ 300	$ 303	$ 306	$ 309	$ 312	$ 315	$ 318	$ 322	$ 325	$ 328	$ 331
Entered Value	Renewable Heat O&M	$ per year	$ 12,361	$ 12,485	$ 12,610	$ 12,736	$ 12,863	$ 12,992	$ 13,122	$ 13,253	$ 13,385	$ 13,519	$ 13,654
Entered Value	Renewable Fuel Use Quantity (	cords	49	49	49	49	49	49	49	49	49	49	49
Entered Value	Renewable Fuel Cost	$ per unit	$300.00	$303	$306	$309	$312	$315	$318	$322	$325	$328	$331
	Total Renewable Fuel Cost	$ per year	$ 14,700	$ 14,847	$ 14,995	$ 15,145	$ 15,297	$ 15,450	$ 15,604	$ 15,760	$ 15,918	$ 16,077	$ 16,238
	Remaining Fuel Oil (supplemen	gallons rema	650	650	650	650	650	650	650	650	650	650	650
	Total Fuel Cost (supplement)	$ per year	$ 3,404	$ 3,474	$ 3,532	$ 3,601	$ 3,684	$ 3,764	$ 3,840	$ 3,913	$ 3,981	$ 4,040	$ 4,099
	Proposed Heat Cost	**$ per year**	**$ 30,765**	**$ 31,109**	**$ 31,443**	**$ 31,791**	**$ 32,156**	**$ 32,520**	**$ 32,885**	**$ 33,248**	**$ 33,609**	**$ 33,964**	**$ 34,322**
Base													
	Fuel Use	gallons per y	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
	Fuel Cost	$ per gallon	$5.24	$5.35	$5.43	$5.54	$5.67	$5.79	$5.91	$6.02	$6.13	$6.22	$6.31
Entered Value	Fuel Scheduled Repairs	$ per year	$ 200	$ 202	$ 204	$ 206	$ 208	$ 210	$ 212	$ 214	$ 217	$ 219	$ 221
Entered Value	Fuel O&M	$ per year	$ 750	$ 758	$ 765	$ 773	$ 780	$ 788	$ 796	$ 804	$ 812	$ 820	$ 828
	Fuel Cost	$ per year	$ 34,036	$ 34,743	$ 35,319	$ 36,008	$ 36,839	$ 37,635	$ 38,403	$ 39,128	$ 39,813	$ 40,398	$ 40,987
	Base Heating Cost	**$ per year**	**$ 34,986**	**$ 35,702**	**$ 36,288**	**$ 36,987**	**$ 37,827**	**$ 38,634**	**$ 39,412**	**$ 40,147**	**$ 40,842**	**$ 41,437**	**$ 42,037**

Heating		Units	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Proposed													
	Renewable Heat	gallons displ	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850
Entered Value	Renewable Heat Scheduled Re	$ per year	$ 335	$ 338	$ 341	$ 345	$ 348	$ 352	$ 355	$ 359	$ 362	$ 366	$ 370
Entered Value	Renewable Heat O&M	$ per year	$ 13,791	$ 13,929	$ 14,068	$ 14,209	$ 14,351	$ 14,494	$ 14,639	$ 14,786	$ 14,933	$ 15,083	$ 15,234
Entered Value	Renewable Fuel Use Quantity (	cords	49	49	49	49	49	49	49	49	49	49	49
Entered Value	Renewable Fuel Cost	$ per unit	$335	$338	$341	$345	$348	$352	$355	$359	$362	$366	$370
	Total Renewable Fuel Cost	$ per year	$ 16,400	$ 16,564	$ 16,730	$ 16,897	$ 17,066	$ 17,237	$ 17,409	$ 17,583	$ 17,759	$ 17,937	$ 18,116
	Remaining Fuel Oil (supplemen	gallons rema	650	650	650	650	650	650	650	650	650	650	650
	Total Fuel Cost (supplement)	$ per year	$ 4,154	$ 4,206	$ 4,255	$ 4,297	$ 4,333	$ 4,365	$ 4,391	$ 4,412	$ 4,427	$ 4,442	$ 4,456
	Proposed Heat Cost	**$ per year**	**$ 34,680**	**$ 35,037**	**$ 35,394**	**$ 35,748**	**$ 36,098**	**$ 36,448**	**$ 36,795**	**$ 37,140**	**$ 37,482**	**$ 37,828**	**$ 38,175**
Base													
	Fuel Use	gallons per y	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
	Fuel Cost	$ per gallon	$6.39	$6.47	$6.55	$6.61	$6.67	$6.71	$6.76	$6.79	$6.81	$6.83	$6.86
Entered Value	Fuel Scheduled Repairs	$ per year	$ 223	$ 225	$ 228	$ 230	$ 232	$ 235	$ 237	$ 239	$ 242	$ 244	$ 246
Entered Value	Fuel O&M	$ per year	$ 837	$ 845	$ 854	$ 862	$ 871	$ 879	$ 888	$ 897	$ 906	$ 915	$ 924
	Fuel Cost	$ per year	$ 41,540	$ 42,061	$ 42,548	$ 42,972	$ 43,329	$ 43,646	$ 43,914	$ 44,119	$ 44,266	$ 44,422	$ 44,559
	Base Heating Cost	**$ per year**	**$ 42,599**	**$ 43,131**	**$ 43,629**	**$ 44,064**	**$ 44,432**	**$ 44,760**	**$ 45,039**	**$ 45,255**	**$ 45,414**	**$ 45,581**	**$ 45,729**

Heating		Units	2035	2036	2037	PV
Proposed						
	Renewable Heat	gallons displ	5,850	5,850	5,850	
Entered Value	Renewable Heat Scheduled Re	$ per year	$ 373	$ 377	$ 381	**$5,813**
Entered Value	Renewable Heat O&M	$ per year	$ 15,386	$ 15,540	$ 15,695	**$239,497**
Entered Value	Renewable Fuel Use Quantity (	cords	49	49	49	
Entered Value	Renewable Fuel Cost	$ per unit	$373	$377	$381	
	Total Renewable Fuel Cost	$ per year	$ 18,297	$ 18,480	$ 18,665	
	Remaining Fuel Oil (supplemen	gallons rema	650	650	650	
	Total Fuel Cost (supplement)	$ per year	$ 4,473	$ 4,516	$ 4,560	
	Proposed Heat Cost	**$ per year**	**$ 38,530**	**$ 38,913**	**$ 39,301**	**$600,310**
Base						
	Fuel Use	gallons per y	6,500	6,500	6,500	
	Fuel Cost	$ per gallon	$6.88	$6.95	$7.02	$7.08
Entered Value	Fuel Scheduled Repairs	$ per year	$ 249	$ 251	$ 254	**$3,875**
Entered Value	Fuel O&M	$ per year	$ 934	$ 943	$ 952	**$14,531**
	Fuel Cost	$ per year	$ 44,728	$ 45,160	$ 45,599	**$701,852**
	Base Heating Cost	**$ per year**	**$ 45,911**	**$ 46,355**	**$ 46,805**	**$720,258**

Life cycle cost analysis (LCCA) for School

Life Cycle Costs of Project Alternatives Ruby School	
Project:	Cluster #1
Project No.	NA
Study Period:	20
Discount Rate:	3.50%

	Alternative #1 (low)	Alternative #2 (high)
Initial Investment Cost	$ 242,213	$ 279,905
O&M and Repair Cost	$ 199,703	$ 196,928
Replacement Cost	$ 166,792	$ 166,792
Residual Value	$ 27,772	$ 55,261
Total Life Cycle Cost	$ 636,481	$ 698,887
GSF of Project	29,916	29,916
Initial Cost/ GSF	$ 8.10	$ 9.36
LCC/ GSF	$ 21.28	$ 23.36

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	$199,703	$ 12,361	$ 12,546	$ 12,735	$ 12,926	$ 13,120	$ 13,316	$ 13,516	$ 13,719	$ 13,925	$ 14,134	$ 14,346	$ 14,561	$ 14,779	$ 15,001	$ 15,226	$ 15,454	$ 15,686	$ 15,921	$ 16,160	$ 16,403
Replacement	$166,792	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$ 224,644
Residual	$27,772	$ -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$ 55,261
Alt 2		Discount Rate		3.50%																	
		Gen'l Inflation for O&M		1.50%																	
	NPV																				
O&M	$196,928	$ 12,361	$ 12,361	$ 12,546	$ 12,735	$ 12,926	$ 13,120	$ 13,316	$ 13,516	$ 13,719	$ 13,925	$ 14,134	$ 14,346	$ 14,561	$ 14,779	$ 15,001	$ 15,226	$ 15,454	$ 15,686	$ 15,921	$ 16,160
Replacement	$166,792	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$ 224,644
Residual	$55,261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$ 55,261

Conclusion

The Village of Ruby does not have significant opportunities for biomass heating at this time. For the purposes of this project, containerized cordwood boilers were scoped as the appropriate technology. At the present, the capital cost of this technology is too expensive to pay back under the project assumptions. The project considered shows a negative net present value.

The community of Ruby does appear to have a substantial biomass resource that could perhaps be use for other beneficial purposes besides community heat energy.

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.

Supplement: **Community Wood Heating Basics**

Figure 6: Cordwood

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.

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 exercising local resource management.

Figure 8: 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[4] (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 7: 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 9: 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.

[4] 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[5]:

- 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.

5 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.