Shageluk Native Village
Biomass Heat Pre-Feasibility Study

Prepared for Interior Regional Housing Authority

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Prepared by:

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With Support from:

The Alaska Energy Authority

ENERGY ACTION

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Acknowledgements

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Summary of Findings

The School Board of the Iditarod Area School District (IASD) has expressed interest in assessments to determine good candidates for biomass heat systems in IASD buildings.

This pre-feasibility assessment considers biomass heat at the main School building of the Innoko River School, located in Shageluk Native Village. The proposed biomass project would be located inside the existing Shop building and would heat the Shop and School via a district heat loop. The project would use an estimated 31 cords per year to displace 3,040 gallons of fuel oil (40% of the buildings' fuel oil consumption). The project is considered financially unfeasible at this time, largely because the local price of cordwood does not represent sufficient savings over the purchase price of fuel oil.

Sensitivity analysis has been performed so that the IASD School Board can review price points of fuel oil and cordwood at which the proposed project is considered financially pre-feasible.

The project also faces technical challenges, since cordwood systems are not very effective when serving building heat loads that operate in a narrow temperature range, such as 180 /160°F. School maintenance personnel may wish to experiment with broader temperature set points to see if desired heat output can be maintained with the existing heat system.

It is recommended that IASD consider other ways of reducing energy costs, which may include energy management, retro-commissioning, energy efficiency upgrades, and other types of renewable energy.

Statement of Purpose

Since 2008, the Alaska State Legislature has supported renewable electric and thermal energy projects through the Renewable Energy Grant Recommendation Program, administered by the Alaska Energy Authority. In Round 6 of the Program, Interior Regional Housing Authority, which seeks opportunities to promote community self-sufficiency through community energy projects, received money to complete pre-feasibility studies of biomass heat in community buildings in seven villages. The following pre-feasibility study has been funded through that grant.

Community & Facility Information

Shageluk Native Village (population 76) is an Alaska Native village located on the east bank of the Innoko River, approximately 20 miles east of Anvik and 34 miles northeast of Holy Cross. The Innoko River is a tributary of the Yukon River.

Shageluk transportation facilities include cargo barge access, a seaplane base, and gravel airstrip. Shageluk has a 3,400' x 75' gravel runway. Air freight goods are transported by truck, ATV, or snow machine about four miles from the airstrip to Shageluk Native Village.

The Iditarod Area School District (IASD) owns and operates the project buildings, which comprise the Innoko River School. Additional buildings that were considered but not evaluated for biomass are described below.

The Innoko River School was selected for pre-feasibility assessment because it is the largest heat load in the community and the School Board has expressed interest in assessments to determine good candidates for biomass heat systems. The School District is governed by a School Board and managed by a Superintendent. The maintenance department of led by the Head of Maintenance, Steve Graham, who attended the site visit.

Fuel is purchased by IASD in Shageluk for $3.95 per gallon (see Appendix B). Delivery is by barge.

The current going rate for drycordwood is $345 per cord, per the posting at the Shageluk Native Village office which advertised the purchase of cordwood for elders (May 15, 2014).

Electricity is 66.10 cents per kWh, delivered from the AVEC power plant in Shageuk (see Appendix B).

Shageluk Native Village moved it its present location in 1967. Most of the new community is 20' or more above the Innoko River. There is no known flooding at the present townsite.

The Innoko River School is comprised of the main school building ("School"), teacher housing duplex, Generator Building, Shop, and vocational education building. At about 13,600 ft^2, the School is the main heat load. Both the Generator Building and Shop are heated by a Toyostove.

Based on available records and discussions with maintenance personnel, the School uses an estimated 7,000 gallons of fuel oil #1 per year. The Generator Building and Shop each use an estimated 600 gallons per year, and the teacher housing duplex uses an estimated 1,000 gallons per year. The vocational education building uses an estimated 400 gallons per year (see Appendix B).

The School heat system includes two (2) Burnham fuel oil boilers, each with 266,000 Btu net output. Although the boilers were installed in 2009, the model number was unreadable. The hi /lo setting is 180 /160°F, except during the coldest time of the year when the hi setting is bumped up to 200°F.

Two zones deliver heat to end uses. Zone 1 provides heat to the Kitchen, Gym, Weight Room, and High School Wing. Zone 2 provides heat to the Boiler Room, Elementary Wing, Bathroom, Attic, Commons, Office, Library, Pre-K, and Student Store.

Heat emitters include baseboard with thermostatic radiator valves, fan convector heaters, and an air handling system (for the gymnasium). The air handling system is not operational.

One 80-gallon Amtrol BoilerMate produces domestic hot water from the boilers.

Biomass Resource Availability

This pre-feasibility study was completed simultaneous to a reconnaissance-level biomass resource assessment by Tanana Chiefs Conference, which will be complete in fall 2014. The draft biomass resource assessment takes account of biomass stocking by ownership, resource distance from Shageluk Native Village, estimated delivered cost, and other factors. In summary, within a 5-mile radius of Shageluk Native Village, there are approximately 195,000 cords of biomass, with about 91% of this material located on Zho-Tse, Incorporated lands. The average cost within a 5-mile radius of Shageluk Native Village is $84.59 per cord. This figure includes harvest, stumpage, administration, and transport costs, but does not include the cost of processing logs into cordwood or profit.

Site Control

The project site is vested in "SOA Department of Education," recorded by U.S. Survey 4493. Please see Appendix C.

Permitting

Applicable project permitting is considered below:

- The Alaska Department of Public Safety, Division of Fire and Life Safety must approve the project plans before construction is started. Mechanical and electrical review is limited to that which is necessary to confirm compliance with fire and life safety requirements.
- Commercial harvests associated with the project may or may not be required to comply with the Alaska Forest Practices and Resources Act. While most commercial operations are required to comply, commercial operations of minor or small scale are sometimes exempted. The Act addresses forest management along water bodies, erosion mitigation, and reforestation.
- The 40CFR63 NESHAP Rule does not apply to the project. The Rule does not apply to a hot water heater, which is defined in Subpart 6J as a boiler with a heat input capacity is less than 1.6 million Btu/hr and that does not generate steam.
- If State or Federal money is used to construct the project, the Alaska Department of Natural Resources Office of History and Archaeology, State Historic Preservation Office should review project plans to determine whether historic, prehistoric, or archaeological resources are likely to be affected. The Office also offers suggestions to mitigate potential effects on resources.

Proposed Biomass System

The proposed project configuration is a 325,000 Btu cordwood boiler with hydronic heat storage located in the existing Shop building. The project would heat the School and Shop via a district heat loop.

The proposed site is controlled by IASD, has sufficient space for the proposed projects, and reduces the project cost by using existing building space.

Cordwood systems are not very effective when serving building heat systems that operate in a narrow temperature range, such at 180 /160°F. The project building currently operates in this range, and the biomass boiler operating and maintenance requirements have been modeled to maintain the existing temperature set points.

The following assumptions were made for the purpose of completing the pre-feasibility assessment, and are not a substitute for heat load calculations and boiler sizing to be completed by the project engineer during project development:

- Annual consumption of 7,600 gallons of fuel oil #1 per year, 95% of which serves space heat load, 5% of which serves domestic hot water
- One (1) 325,000 cordwood boiler with 1,830 gallons of water storage, delta T = 40°F
- Boilers are turned off May 20 – August 20
- Maximum 4 firings per day, with additional heat demand served by oil. Each firing requires 20 minutes labor
- Annual inflation
    - Biomass O&M and scheduled repairs – 1.5%
    - Cordwood – 3.0%
    - Oil O&M and scheduled repairs – 1.5%
    - Oil – 4.8%
- Input prices, year 1
    - Cordwood -- $345/cord
    - Oil -- $3.95/gal
    - Loaded labor rate -- $20.17/ hr

Alternatives Considered

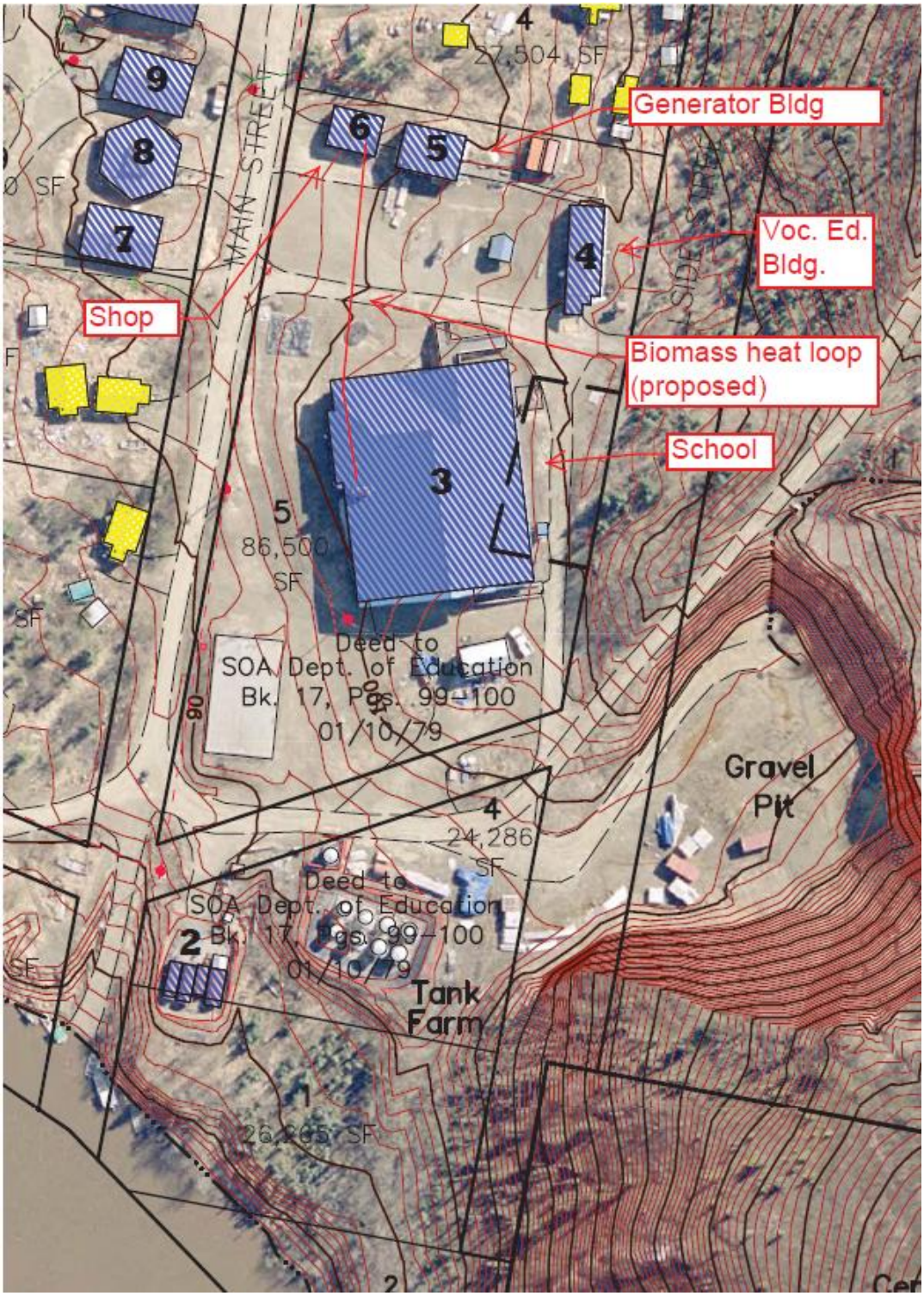
A stand-alone boiler building at IASD was not considered because of the additional capital cost.

Additional biomass boiler capacity, to offset 85% or more of the heat load at the School, was not considered because the additional capital cost of a new building was not anticipated to be financially feasible. The proposed biomass boiler can fit inside the existing Shop.

Heating the Shop and Generator building with a small biomass boiler was briefly considered. These buildings can be efficiently and cost-effectively heated with large cordwood stoves. Weatherization is recommended first.

With regard to community buildings outside of the Innoko River School, neither the Washateria nor the new multi-use facility was evaluated for biomass. These buildings may be good candidates for future assessment, but at the time of the site visit, City Mayor and Tribal Administrator Rebecca Wulf declined to participate in the assessment. The City owns and operates the Washateria, and Shageluk Native Village operates the multi-use facility.

Figure 1: Biomass Project Site Map



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Heat Load & Biomass Operating Requirements

Figure 2: Fuel Energy Values

	Gross Btu/unit	System efficiency	Delivered Btu/unit	Gross $/unit	Delivered $/MMBtu
Oil (gal)	134,500	80%	107,600	$ 3.95	$ 36.71
Biomass, 20% MC* (cord)	16,400,000	65%	10,660,000	$ 345	$ 32.36

*MC is Moisture Content. Moisture in biomass fuel evaporates and absorbs energy in combustion, thereby decreasing the net energy value of the fuel.

Figure 3: Current Annual Fuel Use & Cost

Facility	Fuel Oil (gal)	$ / gal	Annual Fuel Cost
School + Shop	7,600	$ 3.95	$ 30,020
		Total	**$ 30,020**

Figure 4: Projected Annual Fuel Use & Cost, Biomass

60%	Oil
40%	Biomass
3040	gallons displaced

Facility	Fuel Type	Units	$ / unit	Annual Fuel Cost
School + Shop	Biomass, 20% MC* (cord)	30.7	$ 345	$ 10,586
School + Shop	Oil (gal)	4560	$ 3.95	$ 18,012
			Total	**$ 28,598**

Figure 5: Biomass Stoking Requirements & Cost

Facility	Total Stokings per Yr	Stoking Hrs Per Yr	$ / hr	Annual Stoking Cost
School + Shop	654	218	$ 20.17	**$ 4,394**

Figure 6: Biomass O&M Costs (non-stoking)

Boiler size (Btu)	325,000
Boiler fuel	Biomass, 20% MC* (cord)
Cost of Labor	$ 20.17
Cost of Electricity	$ 0.66
Number of Stokings	654

MATERIALS			Yrs to replacement		Cost per Lifetime
Lower Gasket	$	23	5	$	92
Motor mount	$	27	10	$	54
Rear cleanout gasket kit	$	46	10	$	92
Manway cover gasket	$	19	10	$	38
5" cleaning brush	$	24	5	$	96
Motor assembly	$	518	12	$	863
3/4 HP motor	$	353	12	$	588
Motor mount kit	$	87	12	$	145
Motor mount ring & screws	$	17	12	$	28
Misc.	$	250	5	$	1,000
Anode Rod	$	98	5	$	392
Chemicals	$	250	1	$	5,000
			Total Cost per Lifetime	$	8,389
			Straight-Line Average Cost per Yr.	**$**	**419**

LABOR	Hours labor	Yrs to labor	Cost per Lifetime
Water test and replace	0.50	1	$ 202
Cleanout covers and heat xger	2	1	$ 807
Clean blower motor	0.75	0.5	$ 605
Clean Ash & Combustion Air Intake	0.08	0.05	$ 614
Check & replace gaskets	3	5	$ 242
		Total Cost per Lifetime	$ 2,469
		Straight-Line Average Cost per Yr.	**$ 123**

ELECTRICITY			Yrs. To Cost		Cost per Lifetime
Electricity 3/4 HP fan	$	40	1	$	805
			Ave. Cost per Yr.	$	40
			Straight-Line Average Cost per Yr.	**$**	**583**
Electricity -- pump				$	420
			Total Annual Biomass O&M (non-stoking)	**$**	**1,003**

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Opinion of Probable Cost

Figure 7: Force Account Summary

Site & Foundation Work	$0
Fire Protection	$260
Biomass heat system	$55,870
End-user building integration	$29,155
Miscellaneous	$8,700
Overhead	$16,100
Freight	$13,013
CONSTRUCTION SUB-TOTAL	**$123,097**
Design & Construction Admin	$11,034
Construction Management	$4,414
PROJECT SUB-TOTAL	**$138,546**
Contingency @ 20%	$27,709
Admin @ 4%	$5,542
TOTAL PROJECT COST	**$171,796**

Figure 8: Force Account Detail

ITEM	QUAN	UNIT	UNIT COST	MATL COST	UNIT HRS	LAB HRS	LAB RATE	LABOR COST	CONTR COST	FREIGHT COST	TOTAL COST	UNIT WT	TOTAL WT(#)
SITE & FOUNDATION WORK													
FIRE PROTECTION	1	lump	$250	$250	0.10	0.10	$95	$10			$260	5	5
BIOMASS HEAT SYSTEM													
Boiler -- GARN 2000 or equivalent	1	ea.	$16,000	$16,000	16	16	$95	$1,520			$17,520	3600	3600
Pipe/Valves/Ftgs/Gauges	1	lump	$5,000	$5,000	54	54	$100	$5,400			$10,400	800	800
Circ pump	1	ea.	$500	$500	4	4	$100	$400			$900	60	60
Circ pump	1	ea.	$1,000	$1,000	4	4	$100	$400			$1,400	120	120
Plate HXR, (300 MBh @ 20F)	1	ea.	$2,500	$2,500	2	2	$100	$200			$2,700	250	250
Misc Strut & Pipe Hangers	1	lump	$1,000	$1,000	20	20	$95	$1,900			$2,900	500	500
Tank Insulation	1	lump	$1,200	$1,200	3	3	$95	$285			$1,485	50	50
Stack -- 6" dia double wall UL listed + supporting infrastructure	1	lump	$1,700	$1,700	4	4	$95	$380			$2,080	3.8	4
Ventilation & Combustion Air Intake	1	lump	$1,200	$1,200	3	3	$95	$285			$1,485	50	50
BTU meter	0	ea.	$2,500	$0	18	0	$95	$0			$0	0	0
Electrical	1	lump	$5,000	$5,000	100	100	$100	$10,000			$15,000	750	750
INTEGRATION													
Arctic Pipe -- 2" PEX	408	lf	$25	$10,200	0.27	110	$95	$10,465			$20,665	1	408
PEX accessories --	408	1/ft	$5	$2,040	0	0	$95	$0			$2,040	*1*	408
Pipe penetration exclosure	2	lump	$750	$1,500	5	10	$95	$950			$2,450	*200*	400
Temp controls	1	lump	$750	$750	8	8	$100	$800			$1,550	*200*	200
Electrical work	1	lump	$1,250	$1,250	12	12	$100	$1,200			$2,450	*200*	200
MISCELLANEOUS													
Misc Hardware	1	lump	$2,500	$2,500	0	0	$95	$0			$2,500	500	500
Misc Tools & Safety Gear	1	lump	$1,500	$1,500	0	0	$95	$0			$1,500	1446	1446
Consumables, Gases, Etc.	1	lump	$2,000	$2,000	0	0	$95	$0			$2,000	1500	1500
Wood splitter	1	ea	$2,700	$2,700	0	0	$95	$0			$2,700	657	657
OVERHEAD													
ROW Legal Work	0	lump							$0		$0		0
Rent Heavy Equip	1	lump							$1,500		$1,500		0
Misc Tool Rent	1	lump							$1,250		$1,250		0
Commission System & Training	20	hr			1	20	$90	$1,800			$1,800		0
Superintendent Overhd Off-Site	20	hr			1	20	$90	$1,800			$1,800		0
Superintendent Overhd On-Site	40	hr			1	40	$90	$3,600			$3,600		0
Crew Travel Time	10	hr			1	10	$90	$900			$900		0
Crew Airfares	2	trips	$1,050						$2,100		$2,100		0
Crew Per Diem	28	mn.dy.	$60						$1,650		$1,650		0
Housing Rent	1	mo.	$1,500						$1,500		$1,500		0
FREIGHT													**11,908**
Ground Freight	3600	lb.	$1.24							$4,464			
Barge	11908	lb.	$0.34							$4,049			
Barge Freight Tool Mob & Demob	1	lump	$1,500							$1,500			
Misc Small Freight & Gold Streaks	1	lump	$3,000							$3,000			
CONSTRUCTION SUB-TOTAL				$59,790		440		$42,295	$8,000	$13,013	$123,097		
Engineering (Design & CCA)	10	%							$11,034				
Construction Management	4	%							$4,414				
PROJECT SUB-TOTAL				$59,790				$42,295	$ 23,448	$13,013	$138,546		
Contingency	20	%									$27,709		
Admin Fee	4	%									$5,542		
CONSTRUCTION TOTAL											**$171,796**		

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Financial Analysis

Financial Summary

The project is considered financially unfeasible at this time.

Benefit/ Cost	n/a
Simple Payback Period	n/a
Net present value	($182,133)

Benefit/ Cost Model

The following model was designed by University of Alaska Anchorage Institute of Social and Economic Research, for use by the Alaska Energy Authority. The model has been adapted to the project and completed according to the aforementioned assumptions.

AEA B/C Model (adapted)

Project Description		
Community	Shageluk	
Nearest Fuel Community	Shageluk	
Region	Rural	
RE Technology	Biomass	
Project ID		
Applicant Name	Iditarod Area School District	
Project Title	Shageluk School and Shop_Biomass	
Category		

Results		
NPV Benefits	($20,198)	
NPV Capital Costs	$161,935	
B/C Ratio	(0.12)	
NPV Net Benefit	($182,133)	

Performance	**Unit**	**Value**
Displaced Petroleum Fuel	gallons per year	3,040
Displaced Petroleum Fuel	total lifetime gallons	60,800
Avoided CO2	tonnes per year	31
Avoided CO2	total lifetime tonnes	617

Proposed System	**Unit**	**Value**
Capital Costs	$	$171,796
Project Start	year	2015
Project Life	years	20
Displaced Heat	gallons displaced per year	3,040
Heating Capacity	Btu/hr	325,000
Heating Capacity Factor	%	40%

Parameters	**Unit**	**Value**
Heating Fuel Premium	$ per gallon	
Discount Rate	% per year	3%
Crude Oil	$ per barrel	

Annual Savings (Costs)	Units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Project Capital Cost	$ per year	$ 171,796	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Electric Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Heating Saving (Costs)	$ per year	($3,976)	($3,798)	($3,603)	($3,391)	($3,159)	($2,907)	($2,634)	($2,338)	($2,018)	($1,673)	($1,301)	($900)	($470)	($8)	$488	$1,019	$1,587	$2,195	$2,845	$3,539
Transportation Savings (Costs)	$ per year	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Savings (Costs)	**$ per year**	($3,976)	($3,798)	($3,603)	($3,391)	($3,159)	($2,907)	($2,634)	($2,338)	($2,018)	($1,673)	($1,301)	($900)	($470)	($8)	$488	$1,019	$1,587	$2,195	$2,845	$3,539
Net Benefit	**$ per year**	**($175,772)**	**($3,798)**	**($3,603)**	**($3,391)**	**($3,159)**	**($2,907)**	**($2,634)**	**($2,338)**	**($2,018)**	**($1,673)**	**($1,301)**	**($900)**	**($470)**	**($8)**	**$488**	**$1,019**	**$1,587**	**$2,195**	**$2,845**	**$3,539**

Heating	Units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Proposed																					
Renewable Heat	gal. disp./ yr.	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040	3,040
Renewable Heat O&M (non-stoking)	$ per yr.	$ 1,003	$ 1,018	$ 1,033	$ 1,049	$ 1,065	$ 1,081	$ 1,097	$ 1,113	$ 1,130	$ 1,147	$ 1,164	$ 1,182	$ 1,199	$ 1,217	$ 1,236	$ 1,254	$ 1,273	$ 1,292	$ 1,311	$ 1,331
Renewable Heat -- Stoking	$ per yr.	$ 4,394	$ 4,460	$ 4,527	$ 4,595	$ 4,664	$ 4,734	$ 4,805	$ 4,877	$ 4,950	$ 5,024	$ 5,100	$ 5,176	$ 5,254	$ 5,333	$ 5,413	$ 5,494	$ 5,576	$ 5,660	$ 5,745	$ 5,831
Renewable Fuel Use Qty (biomass)	cords	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7
Renewable Fuel Cost	$ per unit	$ 345	$ 355	$ 366	$ 377	$ 388	$ 400	$ 412	$ 424	$ 437	$ 450	$ 464	$ 478	$ 492	$ 507	$ 522	$ 537	$ 554	$ 570	$ 587	$ 605
Total Renewable Fuel Cost	$ per yr.	$ 10,586	$10,904	$11,231	$11,568	$11,915	$12,273	$12,641	$13,020	$13,411	$13,813	$14,227	$14,654	$15,094	$15,546	$16,013	$16,493	$16,988	$17,498	$18,023	$18,563
Supplemental Fuel Qty (Oil)	gal.	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560	4560
Fuel Cost	$ per gal.	$ 3.95	$ 4.14	$ 4.34	$ 4.55	$ 4.76	$ 4.99	$ 5.23	$ 5.48	$ 5.75	$ 6.02	$ 6.31	$ 6.62	$ 6.93	$ 7.27	$ 7.61	$ 7.98	$ 8.36	$ 8.76	$ 9.19	$ 9.63
Supplemental Fuel Cost	$ per yr.	$ 18,012	$18,877	$19,783	$20,732	$21,727	$22,770	$23,863	$25,009	$26,209	$27,467	$28,786	$30,167	$31,615	$33,133	$34,723	$36,390	$38,137	$39,967	$41,886	$43,896
Proposed Heat Cost	**$ per yr.**	**$ 33,996**	**$ 35,259**	**$ 36,574**	**$ 37,944**	**$ 39,371**	**$ 40,857**	**$ 42,406**	**$ 44,019**	**$ 45,700**	**$ 47,451**	**$ 49,277**	**$ 51,179**	**$ 53,162**	**$ 55,229**	**$ 57,384**	**$ 59,631**	**$ 61,974**	**$ 64,417**	**$ 66,964**	**$ 69,622**
Base																					
Fuel Use	gal. per yr.	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600
Fuel Cost	$ per gal.	$ 3.95	$ 4.14	$ 4.34	$ 4.55	$ 4.76	$ 4.99	$ 5.23	$ 5.48	$ 5.75	$ 6.02	$ 6.31	$ 6.62	$ 6.93	$ 7.27	$ 7.61	$ 7.98	$ 8.36	$ 8.76	$ 9.19	$ 9.63
Fuel Cost	$ per yr.	$ 30,020	$31,461	$32,971	$34,554	$36,212	$37,950	$39,772	$41,681	$43,682	$45,779	$47,976	$50,279	$52,692	$55,221	$57,872	$60,650	$63,561	$66,612	$69,809	$73,160
Base Heating Cost	**$ per yr.**	**$ 30,020**	**$ 31,461**	**$ 32,971**	**$ 34,554**	**$ 36,212**	**$ 37,950**	**$ 39,772**	**$ 41,681**	**$ 43,682**	**$ 45,779**	**$ 47,976**	**$ 50,279**	**$ 52,692**	**$ 55,221**	**$ 57,872**	**$ 60,650**	**$ 63,561**	**$ 66,612**	**$ 69,809**	**$ 73,160**

ENERGY ACTION

Sensitivity Analysis

Sensitivity analysis was also performed. All other variables remaining equal, the following variable results in an economically feasible project.

Variable	*Fuel Oil Price per Gal, Yr. 1*	$	7.22
Results	Benefit / Cost		1.25
	NPV Net Benefit		$39,901

Sensitivity analysis was also performed for the price of cordwood. If the project owner can source fuel at $125 per cord, as the Tanana Chiefs Conference reconnaissance-level biomass resource assessment suggests, the following variable fuel oil price results in an economically feasible project.

Variable	*Cordwood, $ / cord, Yr. 1*	$	125
	Fuel Oil Price per Gal, Yr. 1	$	5.35
Results	Benefit / Cost		1.25
	NPV Net Benefit		$40,192

Recommendations

Biomass heat at the Innoko River School "School" and Shop building is considered financially unfeasible at this time, largely because the local price of cordwood does not represent sufficient savings over the purchase price of fuel oil.

If the price of fuel oil reaches $7.22 per gallon, the project may be considered financially pre-feasible, all other variables remaining equal.

If the project owner can source cordwood at $125 per cord per year or less, as the Tanana Chiefs Conference reconnaissance-level biomass resource assessment suggests, the project may be considered financially pre-feasible if the price of fuel oil reaches $5.35 per gallon or more.

The project also has challenges with technical feasibility, because the existing heat system operates in a narrow temperature range, 180 /160°F. Cordwood systems are not very effective when serving building heat systems that operate in a narrow temperature range. The School maintenance personnel may wish to experiment with broader temperature set points to see if desired heat output can be maintained with the existing heat system. The operations and economics of the project will improve if the system can operate in a broader temperature range.

It is recommended that the IASD consider other ways of reducing energy costs, which may include energy management, retro-commissioning, energy efficiency upgrades, and other types of renewable energy.

Appendix

A—Biomass Technology
B – Utility Receipts
C – Site Control
D – Site Photos

Appendix A – Biomass Technology

Although humans have used wood for heat for millennia, modern high-efficiency biomass boilers have only been in use for a few decades. Biomass boilers may use wood fuels such as cordwood, wood chips, or wood pellets, to heat commercial buildings. Biomass boiler projects depend on sustainable forest management, quality biomass fuel sourcing, processing, and storage, and reliable fuel handling. Biomass boilers frequently integrate with conventional hydronic heat systems, which use water to move heat from where it is produced to where it is needed. Small-scale biomass systems often incorporate a hot water storage tank, which promotes efficient combustion and improves the availability of biomass heat. To provide reliable heat, the biomass boiler, building heat distribution system, controls, and heat emitters must be properly matched.

Sustainable Forest Management | Wood fuel Processing & Storage | Handling | Combustion | Thermal Storage | Heat Distribution

The Nature of Wood Fuels

Composition

All wood is made primarily of cellulose, hemi-cellulose, and lignin. It is about 50% Carbon, 44% Oxygen, and 6% Hydrogen. Theoretically, complete combustion (100% efficient) would result in only two products: carbon dioxide and water. In practice, biomass boilers range from about 77 -- 83% efficient. Wood that is not completely burned become carbon monoxide and hydrocarbons, often in the form of smoke and ash.[1]

Combustion

Biomass fuel undergoes fascinating changes as it burns. Pyrolysis occurs at 500 – 600°F, in which organic gasses leave behind charcoal solids. Primary combustion is burning of charcoal solids.[2] Secondary combustion is burning of organic gasses. Because about 60% of the heating value is contained in gasses, secondary combustion is essential to high efficiency wood burning.

[1] Rick Curkeet, PE, *Wood Combustion Basics,* EPA Burnwise Workshop 2011, http://www.epa.gov/burnwise/workshop2011/WoodCombustion-Curkeet.pdf (June 19, 2014).
[2] Curkeet, Rick.

Emissions

In wood burning, the primary emissions concern is particulate matter 2.5 microns or less in size ("PM 2.5"), which is hazardous to human health. Additionally, unburned wood signifies lost heat and potential creosote formation. Creosote formation results in higher fuel costs, shortens the life of the boiler, and increases other maintenance costs. Boiler manufacturers have certified emissions tests conducted according to the ASTM E2618-13 standard that document boiler efficiency. High efficiency wood boilers emit about 0.07 – 0.3 lbs of PM 10 per million BTU in test conditions.

Boiler manufacturers specify operating conditions for the field. One important condition is wood fuel specifications, which include moisture content and fuel dimensions. Other important conditions for efficient operation include proper fuel storage, routine operations and maintenance, and system design (such as proper boiler sizing and incorporating a hot water storage tank).

One valuable source of information for seasoning cordwood in Interior Alaska is available at the Cold Climate Housing Research Center's (CCHRC) website.[3] "Properly prepared and stored" cordwood can be dry enough to burn safely within six weeks during the summer. In regions other than the Interior, similar storage principles would apply, but recommended storage durations may be different. Below is a summary of how to properly prepare and store cordwood:

- Cut to stove length (two feet or shorter)
- Split the wood at least once
- Stack in a pile with air space between the pieces
- Store wood in a shed or cover only the top of the pile with a large piece of plywood or some waterproof tarp
- Allow sun and air to reach the sides of the wood pile to help dry the wood
- Season at least six weeks during the summer months
- If beginning after August 1st, wait to burn until the next summer
- When properly stored, more time is always better

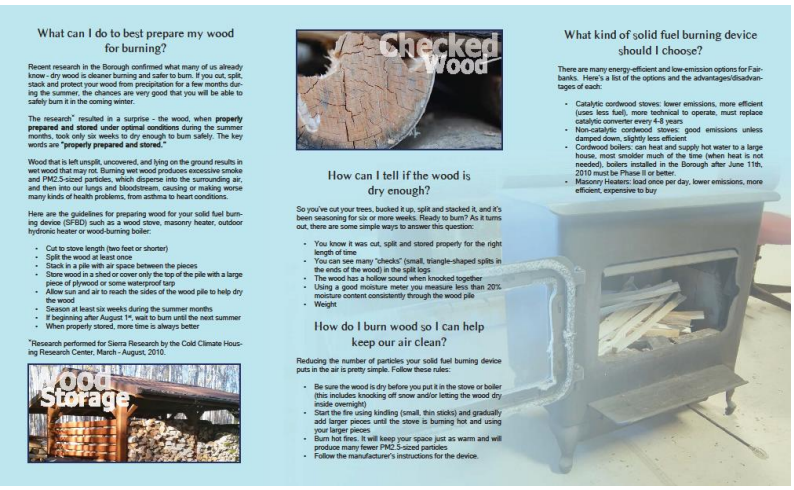
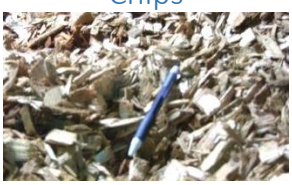


Figure 1: Excerpt from CCHRC's Cordwood Handling Brochure

[3] http://www.cchrc.org/docs/best_practices/Cordwood_Handling_Brochure.pdf

Wood Fueled Heating Systems

Below are the characteristics of cordwood, wood chip, and wood pellet boiler systems.

	Advantages	Disadvantages
Cordwood 	• Local wood resource • Small size (less than 1 MMBTU) • Simple to operate	• Higher labor costs, including hand-feeding the boiler, manual ash removal, and manual grate cleaning • Labor is needed intermittently, so someone must be available "on site" • Typically non-pressurized, which may require more frequent boiler chemical additions
Pellets 	• Can operate unattended, and automatically match heat load • Scalable from small to large sizes (generally 100,000 btu – 1 MMBTU) • Relatively small footprint • Typically the most efficient biomass combustion	• Pellet fuel is typically not locally produced, and therefore depends on "imports" • Shipping pellets is very costly; even a freight rate of $0.05 per lb. results in an additional cost of $100 per ton. • Relatively expensive wood fuel • Ash removal and grate cleaning may be automated or manual
Chips 	• Can operate unattended, and automatically match heat load • Wood chips may be the lowest cost fuel • Local wood resource may be available or produced • Large projects achieve economies of scale • Creates jobs in the woods and at the boiler plant	• Large systems are expensive • Typically large sizes > 1,000,000 MMBTU • Wood chip fuel can be diverse, which can make it difficult to meet fuel specifications. Screens and other devices can improve fuel quality.

B – Utility Receipts

AVEC
ALASKA VILLAGE ELECTRIC COOPERATIVE

Account Number	Village Number	Due Date	Total Amount Due	Amount of Payment Enclosed
	45	05/01/14	3723.63	$.

4831 Eagle Street
ANCHORAGE, AK 99503-7431
1-800-478-1818 or 1-907-561-1818

IDITAROD AREA SCHOOL DISTRICT
PO BOX 90
MCGRATH AK 99627-0090

MEMBER PHONE #
907-524-3599

Please write your Account # on your check or money order and make payable to AVEC. Please detach and Return this stub with payment.

ALASKA VILLAGE ELECTRIC COOPERATIVE 4831 Eagle Street Anchorage, Alaska 99503-7431 1-800-478-1818 1-907-561-1818

Account Number	Bill Date	Payments Received Through	Due Date	Service Dates	Days in Cycle
	03/31/14	03/31/14	05/01/14	From 02/28/14 To 04/02/14	33

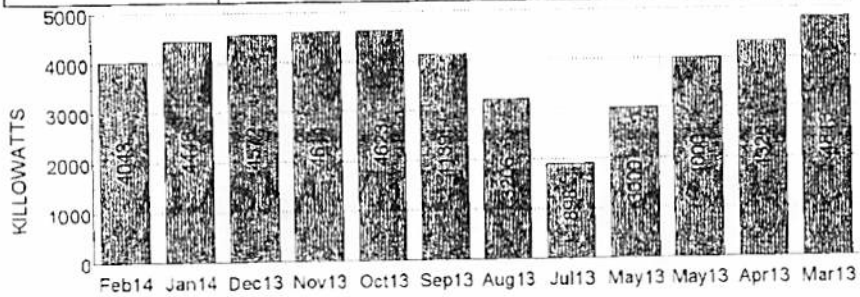
Customer Name & Village	Service Address
IDITAROD AREA SCHOOL DISTRICT SHAGELUK AVEC	SHAGELUK HIGH SCHOOL

Meter Serial #	Previous Reading	Current Reading	Rate Code	kWh Used
11028428	185944	190526	845	4582

Billing Description

PRIOR BALANCE DUE	3507.49
PAYMENT 04/03/14	3507.49
ADJUSTMENTS	0.00
CUSTOMER CHARGE	45.00
ENERGY	180.00
ENERGY	123.28
DEMAND	1721.25
FUEL COST	1654.10

Charge Type	kWh Used X Rate	Charge Amount
CUSTOMER CHARGE		45.00
ENERGY	1500 KWH X 00.1200	180.00
ENERGY	3082 KWH X 00.0400	123.28
DEMAND	38.25 KW X 45.0000	1721.25
FUEL COST	4582 KWH X 00.3610	1654.10



NOTICE - THE UTILITY WILL BE PAID UNDER THE STATE OF ALASKA PCE PROGRAM (AS 44.83.162) TO ASSIST THE UTILITY AND ITS CUSTOMERS IN REDUCING THE HIGH COST OF GENERATION OF ELECTRIC ENERGY. FOR THE MOST RECENT MONTHLY REPORTING PERIOD, THE FUEL EFFICIENCY FOR EACH AVEC LOCATION PER KILOWATT HOURS PER GALLON AND THE FUEL EFFICIENCY STANDARD SET OUT IN THE REGULATIONS FOR THE PCE PROGRAM FOR EACH LOCATION IS PUBLISHED AND SENT TO EVERY MEMBER. THIS INFORMATION IS ALSO POSTED ON OUR WEB SITE WWW.AVEC.ORG

ENDING BALANCE	3723.63

** ACCOUNT STATUS **

Current 1-30	Days	3723.63
30-60	Days	0.00
60-90	Days	0.00
90-120	Days	0.00
Over 120	Days	0.00

The first round of disconnects will begin April 21st - be sure to bring your account up to date o contact Member Services if you have any questions.

Ruby Marine Inc.
PO Box 269
Nenana, AK 99760
907-832-1062
907-832-1063 fax

RUBY MARINE

Invoice

Date	Invoice No.
07/30/13	13-274

Bill To

Iditarod Area School District
PO Box 90
McGrath, AK 99627

P.O. Number	Terms
	on delivery

Description	Quantity	Rate	Amount
Diesel #1 delivered to Shageluk	14,000	3.959 0.00	55,426.00 0.00

Thank you for your business!

Total	$55,426.00
Balance Due	$55,426.00

BegBal 13,346
+ 5000
18,346
- 9251
9095 used

Shageluk Fuel Inventory Work Sheet

BARGE DELIVERY 5,000
Reading date: *8/9/11*
NAME:

Month:	**Tank #1**	**Tank #2**	**Tank #3**	**Tank #5**	**Tank #6**	**Tank #7**	**School Tank**	**Voc Ed Tank**	**Garage Tank**	**Generator Tank**	**Shageluk Teacher 1**	**Shageluk Teacher 2**	**Total:**	**Fuel Used**
MAY	1405	188	1840	3250	1410	4245		2	31	464	292	219	13346	
JUNE														
JULY														
AUGUST	2800	5000	400											
AUGUST														
SEPTEMBER														
OCTOBER														
NOVEMBER														
DECEMBER	1184	4356	2123	826	848	3962	475	15	0	0	22	277	14088	
JANUARY														
FEBRUARY									0	0	84	61	145	
MARCH									0	453	72	40		
APRIL									0	453	72	40	9251	
MAY	1184	1441	2264	771	1723	1097	84	122						

Upper Elem -

74 237 = 311
x 3.04
945.44

used 9095 -
3346 @ 2.83 = 9469.18
5749 @ 3.04 = 17,477
26,946.18

Avail 4251 x 3.04 = 12,923.04
19,950

C – Site Control

ENERGY ACTION

2004-000045-0
Recording Dist: 411 - Mt. McKinley
3/15/2004 2:54 PM Pages: 1 of 3
ALASKA

SHAGELUK SCHOOL SITE DEED

After Recording Return to:
Alaska Department of Education & Early Development
ESS/Facilities
801 West 10th Street, Suite 200
Juneau, AK 99801

"State Business-No Charge"

OK 17 PAGE 996
Kuskokwim Recording District

DEED

SHAGELUK SCHOOL SITE

WHEREAS, the Act of August 23, 1950 (64 Stat. 470), directs the Secretary of the Interior to convey certain school land and the improvements thereon in Alaska to school authorities of Alaska whenever he determines said property to be no longer required by the United States for Native school purposes, subject to the terms, conditions, limitations, and reservations contained in said Act; and

WHEREAS, the Secretary of the Interior, by and through his authorized representative, has determined that the lands described hereinbelow comprising the smallest practicable tract necessary for the administration of such school facility together with the improvements, buildings, structures, facilities, fixtures, equipment, expendable supplies and materials, and related personal property located thereon and therein, described in the Property Inventory, Assignment of Interest, Agreement and Receipt attached hereto and by reference incorporated herein are no longer required by the United States for Native school purposes; and

WHEREAS, the hereinbelow named school authorities of Alaska have requested a conveyance of the school facility described hereinbelow from the United States for public school purposes; and

NOW, THEREFORE, the Secretary of the Interior, by and through his authorized representative and pursuant to the Act of August 23, 1950 (64 Stat. 470), for and in consideration of the premises and as provided by statute, does hereby quitclaim and convey unto the State of Alaska, Department of Education, Pouch F, Juneau, Alaska 99811, hereinafter referred to as Grantee, all of the right, title, and interest of the Bureau of Indian Affairs, Department of the Interior, in and to that certain parcel or tract of land previously known as the Shageluk Native school and more particularly described as: Lot Four (4), Block Nine (9), as shown on the official plat of U.S. Survey 4493, Shageluk Addition Townsite as accepted by the Chief, Division of Cadastral Survey for the Director, on August 6, 1975.

AND

That portion of Lot Five (5), Block Four (4), described as follows: BEGINNING at the Northwest corner of Lot Five (5), Block Four (4), Thence S. 29° 48' E., 251.61 feet; Thence N. 89° 13' E., 85.00 feet; Thence N. 00° 47' W., 58.00 feet; Thence S. 87° 30' 46" E., 105.17 feet; Thence S. 00° 47' E., 52.00 feet; Thence N. 89° 13' E., 142.11 feet; Thence N. 00° 47' W., 220.03 feet; Thence S. 89° 13' W., 454.15 feet; to the point of beginning, containing 80,725 square feet, as shown on the official plat of U.S. Survey 4493, Shageluk Addition Townsite, as accepted by the Chief, Division of Cadastral Survey, for the Director, on August 6, 1975, together with all buildings, structures, facilities, improvements, fixtures, equipment, expendable supplies and materials, and related personal property, on and used in connection with said land; including but not limited to those items set forth in the Property Inventory, Assignment of Interest, Agreement and Receipt annexed hereto and by reference incorporated herein;

TO HAVE AND TO HOLD the said land, buildings, structures, facilities, improvements, fixtures, equipment, expendable supplies and materials, and related personal property, with all the rights, privileges, immunities, and appurtenances, of whatsoever nature, thereunto belonging, unto the said Grantee, its successors, and assigns, forever, PROVIDED, that this conveyance is subject to the terms, conditions, limitations, and reservations of the Act of August 23, 1950 (64 Stat. 470), incorporated herein by reference including but not limited to the following: subject to all valid existing rights and claims; use for school or other public purposes only; that any school facilities maintained thereon or therein shall be available to all the Native children of such town, city, or district; that there are reserved to the United States, all mineral deposits in the lands and the right to prospect for and remove the deposits under such rules and regulations as the Secretary of the Interior may prescribe; and that the Secretary of the Interior, if at any time he determines that the Grantee has violated or failed to observe the conditions or provisions of the Act and that such violation or failure has continued for a period of at least one year may declare a forfeiture of the grant of this conveyance. Such determination by the Secretary shall be FINAL, and thereupon the lands and improvements covered thereby shall revert to the United States and become part of the public domain subject to administration and disposal under the public land laws.

IN WITNESS WHEREOF the Area Director, Department of the Interior, Bureau of Indian Affairs, Juneau Area, Juneau, Alaska, pursuant to the authority delegated in 209 DM 8 and 10 BIAM 3.1, dated November 17, 1981, has hereunto set his hand and seal this 31st day of July, 1984.

NOTARY PUBLIC STATE OF ALASKA

Acting Area Director, Juneau Area
Bureau of Indian Affairs

ACKNOWLEDGEMENT

State of Alaska, 1st Judicial District

The foregoing instrument was acknowledged before me this 31st day of July 1984 by Joseph P. Donahue.

84-271

RECORDED - FILED NC
KUSKOKWIM REC. DIST.
DATE 10-1 1984
TIME 3:15 PM
Requested by AK STATE OF
Address DEPT of EDUCATION
Pouch F, Juneau, Ak 99811

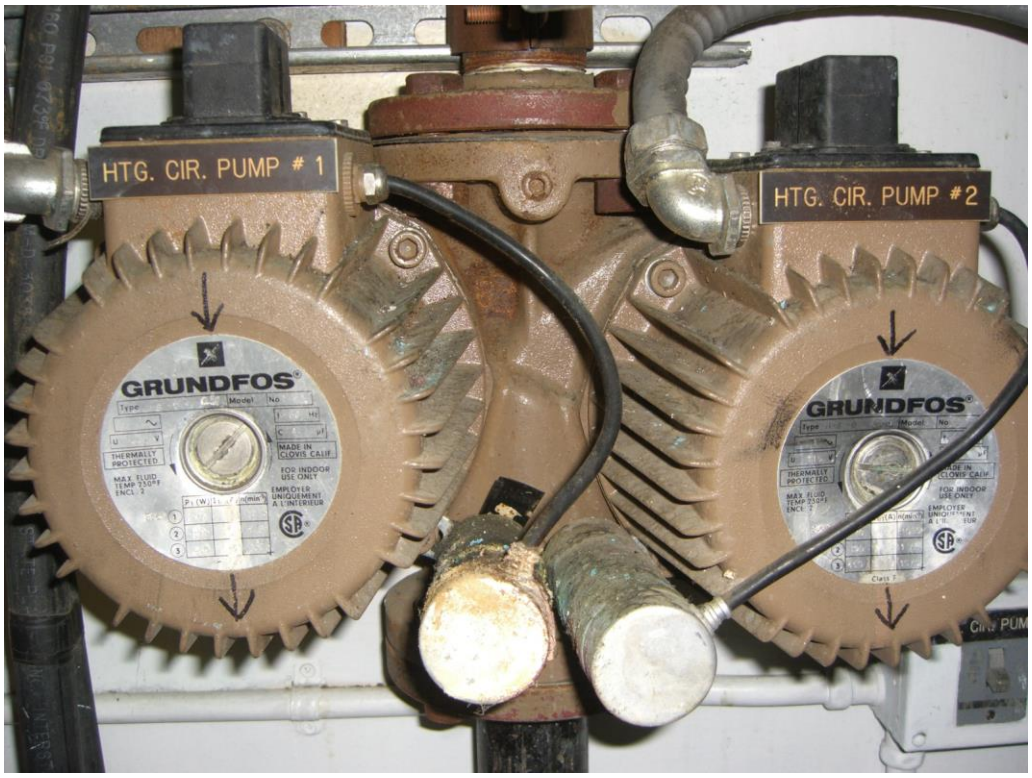
Notary Public
My Commission Expires: August 26, 1985.

2004-000046-0
3 of 3

Appendix D

ENERGY ACTION

ENERGY ACTION



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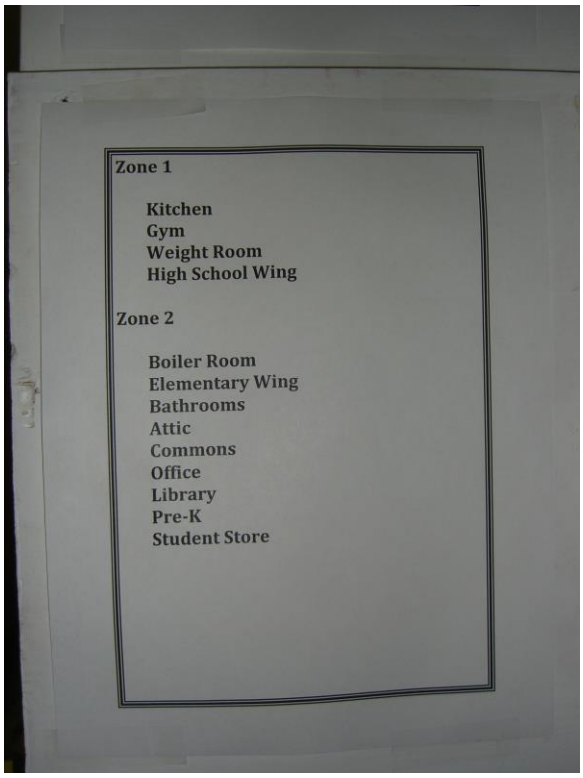

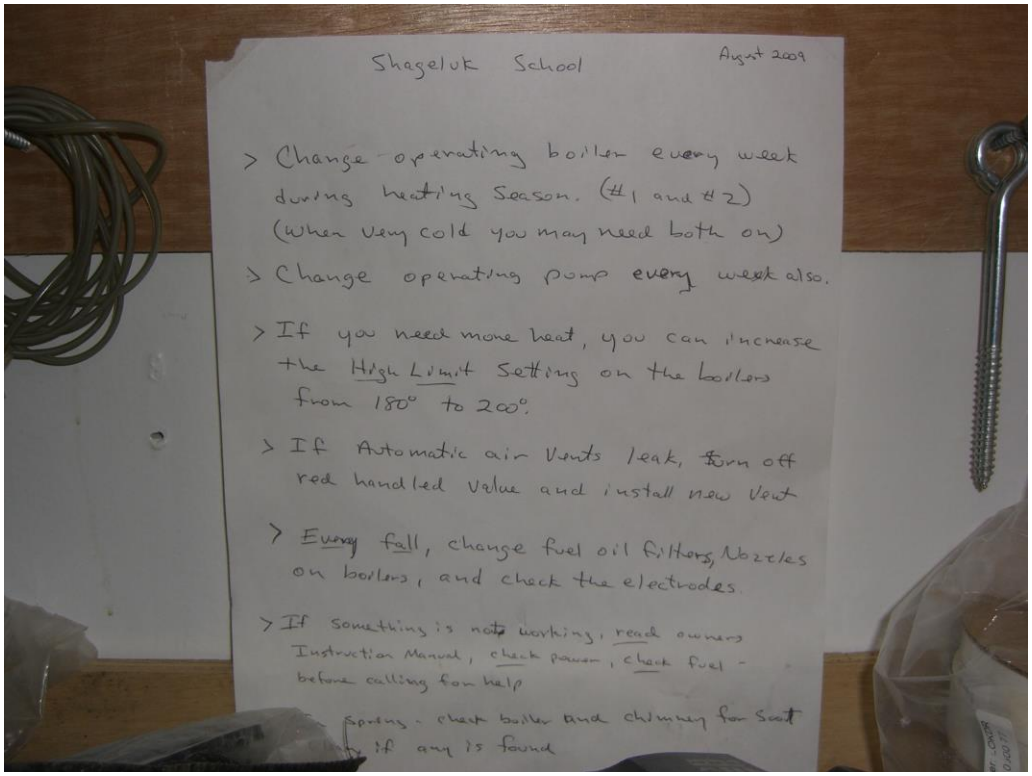

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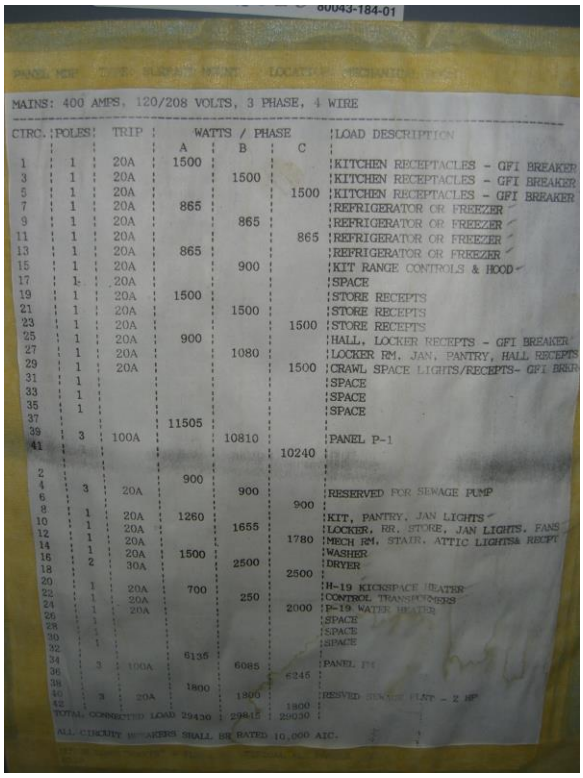
ENERGY ACTION

ENERGY ACTION

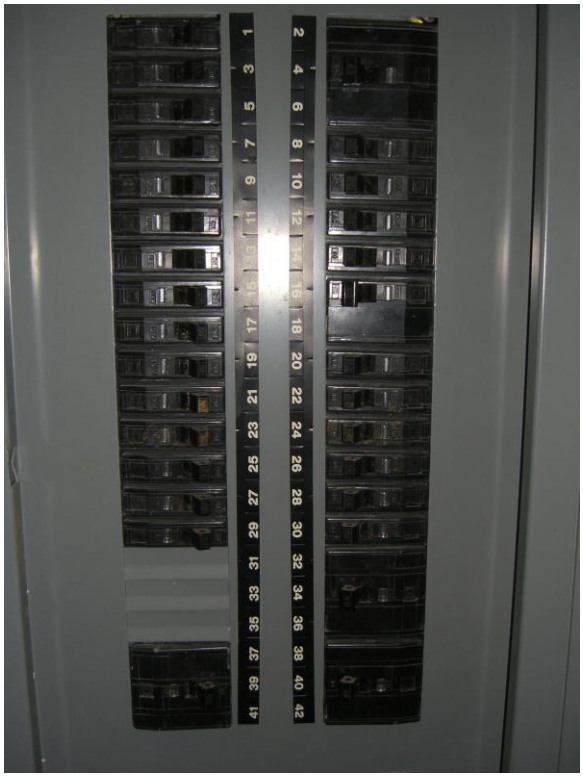


80043-184-01

MAINS: 400 AMPS, 120/208 VOLTS, 3 PHASE, 4 WIRE

CIRC.	POLES	TRIP	WATTS / PHASE A	B	C	LOAD DESCRIPTION
1	1	20A	1500			KITCHEN RECEPTACLES - GFI BREAKER
3	1	20A		1500		KITCHEN RECEPTACLES - GFI BREAKER
5	1	20A			1500	KITCHEN RECEPTACLES - GFI BREAKER
7	1	20A	865			REFRIGERATOR OR FREEZER
9	1	20A		865		REFRIGERATOR OR FREEZER
11	1	20A			865	REFRIGERATOR OR FREEZER
13	1	20A	865			REFRIGERATOR OR FREEZER
15	1	20A		900		KIT RANGE CONTROLS & HOOD
17	1	20A				SPACE
19	1	20A	1500			STORE RECEPTS
21	1	20A		1500		STORE RECEPTS
23	1	20A			1500	STORE RECEPTS
25	1	20A	900			HALL, LOCKER RECEPTS - GFI BREAKER
27	1	20A		1080		LOCKER RM, JAN, PANTRY, HALL RECEPTS
29	1	20A			1500	CRAWL SPACE LIGHTS/RECEPTS- GFI BREA
31	1					SPACE
33	1					SPACE
35	1					SPACE
37			11505			
39	3	100A		10810		PANEL P-1
41					10240	
2			900			
4	3	20A		900		RESERVED FOR SEWAGE PUMP
6					900	
8	1	20A	1260			KIT, PANTRY, JAN LIGHTS
10	1	20A		1655		LOCKER, RR, STORE, JAN LIGHTS, FANS
12	1	20A			1780	MECH RM, STAIR, ATTIC LIGHTS& RECPT
14	1	20A	1500			WASHER
16	2	30A		2500		DRYER
18					2500	
20	1	20A	700			H-19 KICKSPACE HEATER
22	1	20A		250		CONTROL TRANSFORMER
24	1	20A			2000	P-19 WATER HEATER
26						SPACE
28						SPACE
30						SPACE
32			6135			
34	3	100A		6085		PANEL P1
36					6345	
38			1800			
40	3	20A		1800		RESVED SPACE FLAT - 2 HP
42					1800	
TOTAL CONNECTED LOAD			29430	29815	29030	

ALL CIRCUIT BREAKERS SHALL BE RATED 10,000 AIC.



ENERGY ACTION

ENERGY ACTION

ENERGY ACTION