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Cordwood Energy Systems for Community Heating in Alaska–An Overview

David Nicholls and Tom Miles

Authors

David Nicholls is a forest products technologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Alaska Wood Utilization Research and Development Center, 204 Siginaka Way, Sitka, AK 99835; and **Tom Miles** is a consultant, T.R. Miles, Technical Consultants, Inc., 1470 SW Woodward Way, Portland, OR 97225.

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Abstract

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Wood has become an important energy alternative in Alaska, particularly in rural areas where liquid fuel costs can be substantial. In some cases, wood fuel is readily available to communities, increasing the attractiveness of wood energy. Wood energy systems in rural Alaska can also lead to employment gains as well as benefits to local cash economies. Many Alaska villages are now considering wood as a fuel source for community heating, several have completed feasibility studies, and others are moving forward with design and construction activities.

Cordwood is readily available in many regions of Alaska, although not always in commercial quantities. However, for many small-scale applications, efficient cordwood systems could be a viable energy option. In this paper, we provide a qualitative review of factors such as wood fuel availability, cordwood system size, wood fuel cost, wood quality, labor, fuel drying, and underground piping. Other general observations are noted, based on case studies of operating cordwood systems in Alaska.

Keywords: Wood energy, cordwood, rural Alaska, community development, economic development.

Introduction

Woody biomass has become an increasingly important energy alternative as fossil fuel prices have risen in recent years. This is particularly apparent in rural Alaska, where many communities depend on fuel oil for their primary energy needs. In some cases, fuel must be flown in to remote communities at considerable expense, resulting in delivered heating oil costs greater than $6.00 per gallon based on September 2006 prices (table 1). When relatively inexpensive wood energy systems can be used to burn wood in place of high-priced heating oil, the result can often be major cost savings. Low-cost cordwood, generated from forest residues, hazard fuel removals, or sawmill residues, can further increase the attractiveness of wood energy systems. An added benefit of rural wood energy systems may be increased local employment needed for fuelwood harvesting, transportation, and system operation. In some areas of Alaska, regional production and delivery of cordwood serving numerous communities might be possible (while also resulting in economies of scale needed for business startups).

A recent review of potential wood energy sites in Alaska has revealed generally strong potential for thermal systems providing heat for schools and other community buildings.

A recent review of potential wood energy sites in Alaska has revealed generally strong potential for thermal systems providing heat for schools and other community buildings (Miles 2006). This report also determined that for many applications over a given range of system sizes, high-efficiency cordwood systems could be economically attractive. More expensive chip-fired systems, having automated fuel loading and other automated features, would be cost effective only for larger systems (i.e., those displacing more than about 100,000 gal of heating oil per year). Many of the community heating applications in Alaska villages would be best suited for cordwood systems, but would not be large enough to justify the expense of automated chip-fired systems.

This paper considers the feasibility of efficient cordwood energy systems for community heating in rural Alaska. These systems are characterized by efficient wood combustion and energy transfer to water, typically held in a jacket surrounding the combustion chamber. Efficient systems often have firebrick or other refractory material lining the combustion chamber, resulting in higher burning temperatures and more complete combustion. Efficient, controlled combustion conditions lead to low particulate emissions and generally good air quality.

We provide a qualitative review of factors such as wood fuel availability, cordwood system size, wood fuel cost, wood quality, labor, fuel drying, and air quality. Other general observations are noted, based on case studies of cordwood systems in Alaska. It is not within the scope of this paper to provide a detailed economic analysis nor an evaluation of engineering or design parameters. However, these items would become important for wood energy sites having strong potential

Table 1—Delivered heating oil costs[a] in Alaska communities

Alaska community	Region	Fuel oil No. 1 cost	Transport method for fuel delivery	Primary fuel use
		Dollars per gallon		
Alatna	Interior	4.50	Air	Home heating
Arctic Village	Interior	6.36	Air	Electrical generation and heating
Eagle	Interior	3.00	Truck	Home heating
Hughes	Interior	6.00	Air	Public facilities and heating
Tanana	Interior	4.69	Barge, air	Home heating
Regional average (interior)		4.91		
Kaktovik	North slope	1.75	Barge	Hunting
Nuiqsut	North slope	2.25	Truck	Electricity generation
Regional average (north slope)		2.00		
Chignik	South coastal	3.45	Barge	Home heating
King Cove	South coastal	3.08	Barge	Public
Larsen Bay	South coastal	3.22	Barge	All
New Stuyahok	South coastal	4.87	Barge	Public
Saint George	South coastal	4.47	Barge	Public use vehicles
Togiak	South coastal	4.07	Barge	Home heating
Valdez	South coastal	2.97	Barge, truck	Home heating
Regional average (south coastal)		3.73		
Gustavus	Southeast	3.08	Barge	Electrical generation and heating
Kake	Southeast	3.70	Barge	Home heating
Point Baker	Southeast	4.10	Barge	Electric generation
Wrangell	Southeast	3.47	Barge	Home heating, electrical generation
Regional average (southeast)		3.59		
Atmautluak	Western	3.92	Barge	No response
Deering	Western	3.80	Barge	No response
Golovin	Western	4.42	Barge	Multipurpose
Kotlik	Western	4.41	Barge	Heating fuel, outboard motors
McGrath	Western	4.87	Barge	Sales to public
Grayling	Western	5.60	Barge	Transportation and facilities
Russian Mission	Western	5.32	Barge	Home heating
Shishmaref	Western	2.99	Barge	Home heating
Teller	Western	4.79	Barge	Home heating
Tuntutuliak	Western	4.27	Barge	Home heating
White Mountain	Western	3.69	Barge	Home heating, subsistence
Regional average (western)		4.37		

[a] Delivered cost of No. 1 fuel oil, current as of September 2006, as indicated by survey response.
Source: State of Alaska 2006.

for development, and would be conducted after preliminary feasibility studies. For the purposes of this paper, we use the term "cordwood" to refer to all forms of solid wood biomass that has not been reduced to chips or other small pieces. Therefore, "cordwood" will also encompass firewood, roundwood, stickwood, slabs, and edgings.

Small-Scale Wood Fuel Heating Systems

Cordwood Systems

Cordwood systems are generally appropriate for smaller applications where the maximum heating demand ranges from 100,000 to 900,000 British thermal units (BTUs) per hour (Miles 2006). Cordwood or sawmill residues are manually loaded into the boiler (i.e., they are "stoked"), often several times per day. An important consideration for cordwood systems is the ability to find dependable and cost-effective labor to stoke the system when needed, and to perform minor maintenance and repair.

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Cordwood systems can further be divided into high-efficiency systems (in which controlled combustion is used to minimize particulate emissions) and lower efficiency systems (in which burning conditions are less controlled and air quality is generally reduced). Cordwood systems generally represent a "low technology" wood energy option, and small systems often cost less than $100,000. Energy systems displacing between 2,500 and 30,000 gal per year would be suitable for cordwood (Parrent 2007).

Bulk Fuelwood Systems

Bulk fuelwood systems that burn chips, sawdust, bark, hog fuel, and shavings among other fuel types are generally found where the maximum heating demand exceeds 1 million BTUs per hour. Owing to the need for automated systems to store and convey wood, the cost of bulk fuel systems is often multiples of that of cordwood systems. It is not uncommon for complete systems to cost in excess of $1 million. A key advantage of these systems is that little or no labor is needed for fuel handling, a significant cost savings over the life of a wood energy system.

For Alaska communities considering bulk fuelwood systems, important factors to consider are the system size (i.e., the displaced volume of fuel oil) and the ability to secure a dependable and economical source of bulk fuel. Often, this bulk fuel could be hog fuel or other sawmill residues, or chipped residues from salvage operations (e.g., beetle-killed or fire-killed trees). An important consideration for bulk fuel systems is that wood chips are often generated as part of larger production facilities (e.g., medium and large sawmills, biomass export facilities, etc.) and therefore would not be well suited to the scale needed for many of the bioenergy applications in rural Alaska. Regardless of which wood energy design is used, an existing oil-fired system could be retained for backup use during wood energy system downtime.

High-Efficiency Cordwood Energy Systems

High-efficiency cordwood energy systems are designed to burn cordwood fuel cleanly with a minimum of particulate emissions. A significant difference between high- and low-efficiency cordwood systems is that high-efficiency systems make better use of fans to control combustion conditions, and typically have larger water storage units resulting in more efficient heat transfer to the end destination. High-efficiency systems also typically have refractory firebrick lining the firebox, helping to maintain high temperatures in the combustion chamber.

Several high-efficiency systems are in use in Alaska. A Tarm[1] gasification boiler is being used to heat a house in Palmer, Alaska. Tarm USA supplies boilers from 100,000 to 198,000 BTUs per hour maximum heat output and claims heating efficiencies of 80 percent (Tarm USA Inc. 2003).

A GARN burner by Dectra Corporation is used in Dot Lake, Alaska, to heat several homes and a laundromat, replacing 7,000 gal per year of No. 2 fuel oil (Dectra Corporation 2008). This system has a heat output of 900,000 BTUs per hour, and uses 4,400 gal of water to heat seven homes and the laundry facility (Frederick 2007). High-efficiency cordwood burners are ideal for applications from 100,000 to 1 million BTUs per hour, although both larger and smaller applications are possible (Parrent 2008).

Table 2 shows the results for a GARN cordwood energy system tested between 157,000 and 173,000 BTUs per hour by the state of Michigan, and using the new American Society for Testing and Materials testing procedures (with comparison to U.S. Environmental Protection Agency standards for wood stoves and boilers). At 0.00631 oz per million BTUs, the GARN system had the lowest particulate emissions of any of the systems tested. It is important to remember that wood-fired systems are not entirely smokeless, and even very efficient systems can burn less cleanly for several minutes during startup (Intertek 2006, Miles 2006).

Table 2—Particulate emissions from wood heating systems

Systems	Particulate emissions
	Ounces per million BTUs
EPA certified noncatalytic stove	0.0176
EPA certified catalytic stove	.0088
EPA industrial boiler	.0079
GARN WHS 1350 boiler	.0063

EPA = U.S. Department of the Interior, Environmental Protection Agency.
Source: Intertek Testing Services 2006.

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Some general features of high-efficiency cordwood burners include the following:

- Manually fed
- Relatively high boiler efficiencies (70 percent or higher)
- Typical heat output into storage of 350,000 to 950,000 BTUs per hour
- Controlled combustion conditions—generally good air quality with low levels of particulate emissions
- Many have water storage capacities ranging from about 1,500 to 4,400 gal

Practical Considerations for High-Efficiency Cordwood Energy Systems

System Cost

High-efficiency cordwood systems are a relatively inexpensive wood energy option owing, in part, to their simple design, higher labor requirements, and lack of automation (vs. more expensive chip-fired systems). Small cordwood systems are often available for less than $100,000, even in Alaska where construction, transportation, and labor are all likely to be more expensive than locations in the continental United States.

For example, the estimated costs of equipment for two separate cordwood systems are $37,000 (Craig, Alaska) and $31,900 (Thorne Bay, Alaska) (Miles 2006). Each of these systems is rated at 350,000 BTUs per hour. A somewhat larger system (rated at 450,000 BTUs per hour), requiring a larger boiler and more piping, had an estimated cost of $104,300. An important variable influencing project cost is the potential need to construct new buildings (or renovate existing buildings) to house the wood energy system and fuel storage. Low-cost construction (e.g., pole barns) can be used in some cases. In other cases, cordwood energy systems could be installed in existing buildings.

Given the potential for significant cost advantages in favor of high-efficiency cordwood systems, they should not be overlooked as a viable option for wood heating in rural Alaska where either roundwood or sawmill residues are available, and where system requirements of less than about 1 million BTUs per hour are expected.

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Wood Fuel Source

Many Alaska communities are close to forested areas that in some cases (notably in interior Alaska) are not capable of producing commercial sawtimber, but could produce abundant small-diameter cordwood. Community heating needs can often be met sustainably by harvesting cordwood that is close to communities, in relatively small amounts on a sustainable basis. For example, a proposed wood energy system in McGrath, Alaska, would require harvesting only 20 to 30 ac (250 cords) annually (McGrath Light and Power 1999). In some cases, fuel sources are close enough to a community to be considered a hazard, with increased urgency of removal (these areas are commonly called wildland-urban interface zones).

In other cases, communities plan to sustainably harvest biomass as part of long-term forest management plans. In the Fort Yukon area of interior Alaska (fig. 1), it is estimated that 15,000 tons of biomass per year could be harvested on 833 ac/yr to meet regional village heating and electrical needs (Olsen 2007). This evaluation assumed a biomass yield of 18 tons/ac and a rotation age of 60 years, with approximately 50,000 ac of forest land being managed. In many interior Alaska communities, there are no sawmills or existing forest products infrastructure that produce wood residues. Therefore, sustainable harvests for wood energy could represent a high-value use of forest resources.

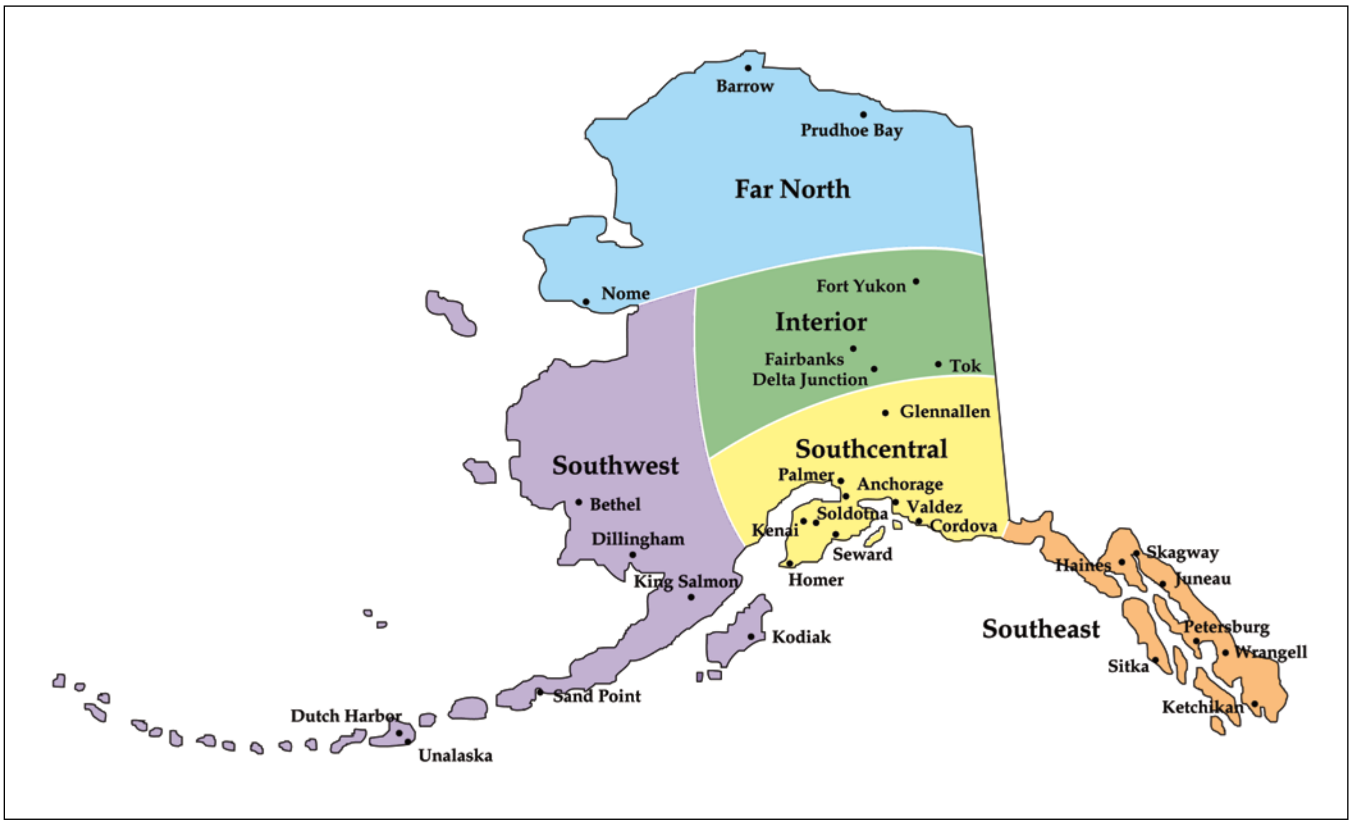

Figure 1—Alaska, by geographic region (source: State of Alaska 2008).

For communities close to sawmills, lumber slabs and edgings (fig. 2) could potentially be combined with cordwood and burned in efficient cordwood systems. When sawmill residues are available inexpensively, significant economic benefits can result vs. the use of harvesting residues or other more expensive biomass. Some Alaska sawmills are known to have excess sawmill residues that would likely be available at little or no cost for wood energy systems; however, some transportation costs would usually be required.


Dave Frederick

Figure 2—Slab wood fuel for high-efficiency burner at Dot Lake, Alaska.

Air-Drying of Fuelwood

The recoverable energy from cordwood is increased by drying before burning, in order to realize greater heating values. A rule of thumb is to dry wood to about 20 percent moisture content (green basis) before burning. In some cases, little or no air drying would be needed; for example, when using fire-killed spruce (*Picea* spp.) trees (Frederick 2008). Initial moisture content, air-drying temperature and humidity, wood density, diameter, and the presence of bark are all variables that can influence air-drying times.

In certain regions of Alaska (notably interior Alaska), air drying could occur relatively quickly during summer periods of low humidity and higher temperatures. In other regions of Alaska having high rainfall (including southeast Alaska), covered drying could be beneficial, combined with longer drying times. Splitting firewood into sections can greatly accelerate air-drying rates.

Wood Measurements

A standard cord encloses a volume 4 ft by 4 ft by 8 ft (128 ft^3) and is a common method for selling wood by volume. Depending on the location, cordwood may be sold based on weight, loose volume, or stacked volume. In many North American jurisdictions, standards for sale and methods of measurements are defined by the Sealers of Weights and Measures. In Alaska, however, there are no formal standards in place. Selling cordwood based on green weight or dry weight is perhaps the most accurate method; however, many Alaska locations would be unlikely to have truck scales or necessary weighing equipment. Thus, accurate indirect methods would need to be developed for measuring wood volume, and then converting to weight by using reliable conversion factors for a given species.

The actual volume of fuel in a cord of wood may differ from about 60 to 110 ft^3 depending on the wood diameter, the form (split vs. unsplit), and the method of piling (e.g., air space between wood) (Bond 2008, Briggs 1994). In Alaska, 80 ft^3

per cord has been used when estimating wood fuel properties of four commercial species (table 3). For a given volume of stacked cordwood, the weight could differ depending on species, wood moisture content, bark content, and average diameter among other factors. Thus, consistent procedures are needed for volume-to-weight conversions for Alaska species to ensure fair buyer-to-seller arrangements. Additional resources could include assistance from registered scalers who are trained to measure cordwood and involvement by the Bureau of Weights and Standards to develop measurement codes and standards.

Table 3—Wood fuel heating values for Alaska species

Species	Higher heating value at 0-percent moisture content	Gross heating value at 20-percent moisture content	Heat value per cord 80-ft^3 basis
	BTUs per pound		*Million BTUs*
Western redcedar (*Thuja plicata* Donn)	8,620	6,896	12.8
Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.)	8,338	6,670	13.9
Sitka spruce (*Picea sitchensis* (Bong.) Carr.)	8,200	6,650	13.4
White (Englemann) spruce (*Picea engelmannii* Parry ex Engelm.)	8,401	6,721	13.7

BTU = British thermal unit.
Source: Miles 2006.

Wood Fuel Cost

Wood fuel cost can differ depending on Alaska region, and whether cordwood or sawmill slabs and edgings are used. Other variables affecting cordwood prices include species (hardwood vs. softwood), moisture content (seasoned vs. unseasoned), point of purchase (delivered vs. undelivered), wood size (split vs. unsplit), and wood length (e.g., 8 ft lengths vs. shorter).

On Prince of Wales Island in southeast Alaska (west of Ketchikan; see fig. 1), cordwood prices were found to range from $75 to $160 per cord, with typical market prices of $100 to $125 (Miles 2006). More recent estimates indicate market prices of about $150 per cord (Peterson 2008).

Farther north in Dot Lake, Alaska (near the town of Tok; see fig. 1), a market price of $125 per cord is common. Here, wood is delivered in 8 ft lengths and includes standing dead spruce (Frederick 2008). This wood is then cut to 32 to 38 inches in length for use in cordwood burners. In the Glenallen, Alaska, area (see fig. 1), market prices as of May 2008 were close to $160 per cord for undelivered firewood (i.e., consumer picks up wood at a distribution point) (Veach 2008). In many cases, cordwood was small enough in diameter to burn as is (without the need for splitting).

In the Fairbanks, Alaska, area (see fig. 1), a local area supplier for solid fuels indicated current cordwood prices of about $200 per cord undelivered (or $225 per cord delivered) in May 2008. Discounted prices of about $160 per cord are possible for purchases of 10 cords at a time (about one truckload). In parts of interior Alaska, prices as high as $300 per cord are not uncommon (Elder 2007, Gorman 2008). These communities are not part of the road system and therefore must rely on local harvesting (or in some cases river transportation). An important consideration for users of high-efficiency systems would be whether established cordwood markets exist locally (vs. requiring a startup business to harvest, process, and transport cordwood).

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Wood Fuel Sizing

Wood sizing is an important consideration for high-efficiency cordwood systems, in order for pieces to easily fit within fireboxes. One commercial vendor (GARN) indicates firebox lengths ranging from 42 to 52 in on some of its models, and therefore cordwood length should be somewhat less than this (Frederick 2008). In some cordwood systems (fig. 3), 24-in-long sections are optimal; however, 32-in sections are possible while still maintaining good system operation (Frederick 2008). Larger units having a similar design could accommodate pieces 32 to 48 in long.

Daniel Parrent

Figure 3—High-efficiency cordwood energy system showing open firebox and burning embers (note that water storage reservoir surrounds firebox).

Another wood energy system vendor has three different cordwood boilers ranging from about 100,000 to 200,000 BTUs per hour (Tarm USA, Inc. 2003). Recommended cordwood length ranges from 18 to 21 in (i.e., maximum of 0.5 m) (Nichols 2008).

Pieces greater than 6 to 8 inches in diameter should be sectioned into smaller pieces, and pieces of various diameters should be included within a given charge to enhance efficiency (rather than burning cordwood of all one diameter) (fig. 4). For manually fed systems, the average length and diameter of individual pieces could also influence fuel loading and burning times, as can airflow into the combustion chamber.

David Nicholls

Figure 4—Cordwood of various diameters are sectioned into smaller pieces in a covered storage area for a wood energy system in south-central Alaska.

Wood Species and Heating Values

Although the BTU energy per pound of dry wood is relatively constant, in practice, Alaska species differ considerably in their heating values (for both gross heating and recoverable heating). Recoverable heat is directly related to wood specific gravity. In Alaska, cottonwood (*Populus* spp.) is recognized as a lower density wood and Alaska yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) as a higher density wood. Alaska species are estimated to generate between 12.8 and 13.9 million BTUs per cord, with hemlock (*Tsuga* spp.) providing the greatest amount of heat per cord. Gross heating values (at 20-percent moisture content) for selected Alaska species average between about 6,600 and 6,900 BTUs per pound (see table 3).

When evaluating manufacturers' standards for cordwood systems, it is important to consider that tests are often done on eastern hardwoods having higher densities than most Alaska species. Therefore, greater volumes of Alaska woods may be needed to achieve equivalent results. However, softwoods are considered to have greater heating values per unit mass than hardwoods because softwoods normally have higher percentages of lignin. In some cases, essentially no performance issues have been noted in burning softwoods vs. hardwoods in cordwood systems (Frederick 2008), other than larger volumes of softwoods being needed.

Black spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.) should not be considered a suitable species for cordwood energy systems, although it is found in abundance near many rural communities; many ecological factors related to climate change could affect regeneration rates of black spruce in interior Alaska, and therefore it is not known whether this species could be harvested sustainably (Barber 2008). An exception would be the use of black spruce salvaged from recently burned areas (i.e., this fuel source would be suitable for cordwood energy systems).

Wood Energy System Sizing

High-efficiency cordwood systems are not feasible for very small applications (displacing less than 500 gal per year of heating oil). These may be satisfied with domestic wood appliances, such as wood stoves or pellet stoves or furnaces (Parrent 2008).

For larger systems, displacing between 500 and 2,000 gal per year, little or no savings would be expected with high-efficiency cordwood systems unless the following economic conditions are met (Miles 2006):

- They can be enclosed in an existing structure.
- Low-cost cordwood is available.
- Labor is free.
- Cost for a hot-water piping system between buildings is minimal.

Recent feasibility work in Alaska estimates the annual heating oil displacement for a large school (Delta Greely School in Delta Junction) to be 102,000 gal/yr (Fermann and Crimp 2007), a size that would most likely favor chip-fired systems rather than cordwood systems. A smaller school system (Copper Center Schools), displacing only 6,000 gal/yr, should be well suited for high-efficiency cordwood energy systems. The average heating oil displacement for six Alaska schools for which wood energy feasibility studies are underway is estimated to be 44,834 gal/yr (Fermann and Crimp 2007). If wood energy systems were established at all six of these schools, a mix of chip-fired systems and high-efficiency cordwood systems would probably produce the best results.

An important consideration when sizing cordwood energy systems is whether wood will be the only fuel used (capable of meeting all heating needs, even on the coldest days), or whether a dual fuel system (e.g., heating oil and wood) will become part of the final project design. In this case, oil-fired boilers would be available for peak demand or as a backup system if the wood system were to fail. For most high-efficiency cordwood applications (such as Alaska schools), reliable backup systems will be necessary to provide heat if the wood energy system were to become inactive (e.g., owing to temporary shortages of cordwood or labor).

Thus, wood energy adopters should be very cautious about using wood as their only fuel source. By using a heat exchanger, cordwood systems can supplement existing oil systems that would handle the peak loads. One way to reduce oil use is to increase the number of firings per day of wood. For example, a cordwood system in Dot Lake, Alaska, typically has about eight firings of wood per day during maximum heating needs (i.e., in midwinter). However, a similar system with increased insulation and optimal sizing might require only about three firings of wood per day, therefore requiring little or no use of oil as a secondary fuel (Frederick 2008).

Operating and Maintenance Costs

The primary operating cost for high-efficiency cordwood systems is often wood fuel, often followed by labor costs. Labor is required to move cordwood from the storage area to the boiler building, to stoke (i.e., to load cordwood into) the boiler, to clean the boiler, and to dispose of ash. A reasonable assumption for most locations in Alaska is that the boiler will operate every day for 210 days (i.e., 30 weeks) per year between mid-September and mid-April (Parrent 2008). The actual daily labor requirements will depend on the number of stokings per day; however, a reasonable assumption is for each stoking to take 15 minutes or less.

In addition to fuel loading, other duties could include routine maintenance tasks such as removing ash, inspecting fans, and coordinating fuel arrivals. An important consideration is having a dedicated labor source available to “break away” from other responsibilities to give part-time attention to the wood energy system. Where dedicated labor cannot be ensured, a backup system (automatically switching to fuel oil as needed) could provide heat, as needed.

There is also an electrical cost component to the boiler operation. An electric fan creates an induced draft, enhancing combustion and contributing to higher boiler efficiencies. One estimate predicted fan electrical costs ranging from $100 to $200 per year, based on electrical costs of $0.30 per kilowatt hour (Parrent 2008).

However, in many communities in interior Alaska, electrical costs of up to $0.50 per kilowatt hour are not uncommon. The cost of operating circulation pumps would not be significantly different for wood energy vs. oil-fired systems.

Underground Piping

When heating multiple buildings, an important consideration is the cost of insulated underground piping needed to circulate hot water between buildings. Numerous other variables could be considered to optimize heat delivery, including:

- Number of buildings to heat and total area of buildings.
- Distance between buildings: a rule of thumb in interior Alaska is a maximum distance of 100 ft between the boiler and the most distant building. Shorter distances between buildings will allow use of smaller diameter (less expensive) pipes. A pipe diameter of 1.26 in is fairly common for smaller systems (Frederick 2008).
- Permafrost: in some regions of Alaska, 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 (Frederick 2008).
- Piping materials used: several types of tubing are available for supply and return water. In one configuration, tubing is surrounded by insulation that is in turn encased within a corrugated high-density polyethylene jacket. Water can be piped in one direction (i.e., one pipe enclosed) or two directions (two pipes enclosed) for a given piping system. There are also many possible configurations of piping material, including “Microflex” (a hard jacket containing closed-cell polyethylene insulation), and also surrounding oxygen-barrier polyethylene (PEX) pipe (Frederick 2008).
- Cost of piping materials: as a rule of thumb, each lineal foot of “hard piping” normally used in Alaska will cost about $70 to install, and crosslinked PEX piping will cost about $40 (Miles 2006). Current prices (i.e., 2008) are likely to be higher than this, given recent overall price increases. An important cost consideration is the diameter of the PEX piping, which typically ranges up to 2 in diameter.
- Other considerations: pump size, thermal load (BTUs per hour), water temperature, and electrical use are other variables to consider when designing piping systems.

In some regions of Alaska, frozen soil could affect construction costs and project feasibility.

Thermal Storage Capacity

In high-efficiency cordwood systems, the firebox can be stoked intermittently, and heat of combustion is transferred to water that is stored in a "jacket" surrounding the combustion chamber (see fig. 3). Thermal storage capacity of heated water is important because it influences the frequency of stoking and can be a factor in determining overall system efficiency. In general, larger fireboxes and/or water reservoirs will require less frequent stoking. An important advantage of high-efficiency cordwood systems is that the wood energy benefits can be realized long after the fire in the firebox has died down (while heat is still available in the heated water). One commercial vendor indicates thermal storage capacities ranging from 1,500 to 4,400 gal on some of its models (Dectra Corporation 2008). Other vendors will supply external tanks for water storage (Tarm USA, Inc. 2003). It should be noted that the use of thermal storage capacity within a water reservoir could be used with other fuel types (i.e., heating oil, diesel, propane, etc.) and would not be limited to wood fuel.

Building Construction

Locations already having existing buildings in place (as well as readily available space for air-drying of cordwood) can have significant economic advantages over sites requiring new building construction. For example, a primary reason that the cordwood system in Dot Lake, Alaska, cost only $66,000 (Miles 2006) was that no new building construction was needed. In other cases, wood energy systems and buildings can be "bundled into" new construction projects, such as new schools. In rural Alaska, a reasonable assumption is that a pole barn could be constructed for fuel storage in addition to an enclosed boiler building. In other cases, more substantial structures may be needed. For example, three proposed cordwood systems in southeast Alaska (capacity 350,000 to 425,000 BTUs per hour) had building costs ranging from $6,500 to $21,600 (Miles 2006). It is not uncommon for the total cost of a cordwood energy system to be two to three times the cost of just the boiler.

Conclusions

This report reviews the feasibility of high-efficiency cordwood heating systems for use in Alaska communities by identifying several factors pertinent to their use. These systems could be well suited to utilize several types of biomass including cordwood, wood briquettes, small-diameter stems from hazardous fuel removals, or slabs and edgings from sawmills (but not bulk fuel sources such as sawdust or chips).

A significant advantage of cordwood energy systems is their relatively low cost. Relatively low-cost options can be explored for heat distribution systems (by using underground pipes) and for buildings to house wood energy systems and provide covered storage for fuel. As fossil fuel prices increase, the economic incentives to consider low-cost wood energy solutions would become even greater.

The cordwood systems discussed in this report use relatively small volumes of wood (often a few hundred tons per year), and therefore present opportunities to sustainably harvest biomass from nearby areas. Numerous benefits could accrue from wood energy use in rural Alaska including increased cash economy, higher employment (for wood energy system operation and cordwood harvesting), and greater forest health in areas surrounding communities.

Glossary[2]

biomass—The total volume of organic matter in a given area.

biomass boiler—A boiler that burns bark, sawdust, wood scraps, and other waste material. Also called a hogged-fuel boiler.

biomass harvesting—The practice of harvesting and using the entire tree, including the top, limbs, and stump, with the noncommercial portions generally chipped for fuel.

cordwood—Small wood or branches cut for firewood or to make charcoal.

firewood—1. Wood to be used as fuel. 2. Slang for short pieces used for crating, etc.

fuelwood—Wood salvaged from mill waste, cull logs, branches, etc., and used to fuel fires in a boiler or furnace.

roundwood—Logs, bolts, and other round sections as they are cut from the tree.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters
Feet (ft)	.3048	Meters
Square feet (ft^2)	.0929	Square meters
Cubic feet (ft^3)	.0283	Cubic meters
Acres (ac)	.405	Hectares
Gallons (gal)	3.78	Liters
British thermal units (BTUs)	1,050	Joules
Tons (t)	907	Kilograms
Pounds (lbs)	454	Grams
Ounces (oz)	28.4	Grams

[2] Source: Random Lengths 2000.

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Web site	http://www.fs.fed.us/pnw/
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
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Pacific Northwest Research Station
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