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Wood Energy in Alaska–Case Study Evaluations of Selected Facilities

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Cover photos by David Nicholls.

Abstract

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Biomass resources in Alaska are extensive and diverse, comprising millions of acres of standing small-diameter trees, diseased or dead trees, and trees having low-grade timber. Limited amounts of logging and mill residues, urban wood residues, and waste products are also available. Recent wildfires in interior Alaska have left substantial volumes of burned timber, potentially usable for biomass energy. Motivated, in part, by rising fuel prices, organizations across the state—including businesses, schools, and government agencies—have all expressed an interest in wood energy applications. Numerous sites have pursued feasibility studies or engineering design analysis, and others have moved forward with project construction. Recent advances in biomass utilization in Alaska have been enabled by numerous factors, and involve various fuel sources, scales of operation, and end products. Already, thermal wood energy systems are using sawmill residues to heat lumber dry kilns, and a public school heating system is in operation. Management policies on national forests and state forests in Alaska could determine the type and amounts of available biomass from managed forests, from wildland-urban interface regions, and from salvage timber operations. Biomass products in Alaska having potential for development are as diverse as wood pellets, cordwood (firewood), compost, wood-plastic composite products, and liquid fuels. In addition, new technologies are allowing for more efficient use of biomass resources for heating and electrical generation at scales appropriate for community power. This case study review considers successes and lessons learned from current wood energy systems in Alaska, and also considers opportunities for future bioenergy development.

Keywords: Alaska, biomass, bioenergy, wood energy, renewable, cordwood, sawmill residues.

Introduction

Biomass resources in Alaska are extensive and diverse, comprising millions of acres of standing small-diameter trees as well as limited amounts of forest harvesting residues and wood products manufacturing residues. Low-quality logs and small-diameter trees within commercial stands also represent an important potential source of biomass in Alaska (Alaska Department of Natural Resources 2008). Recent wildfires in interior Alaska, including the summer of 2004, in which more than 6.7 million acres burned (Ipsen 2004), have also created large amounts of standing dead timber, a potentially large biomass source. Over the past two decades, beetle infestations have affected millions of board feet of timber in south-central Alaska, and bioenergy and other biobased products may be one remaining use for this material.

Recent developments in bioenergy and biomass utilization in Alaska have been modest, yet interest in new installations is high. Motivated, in part, by rising fuel prices, organizations across the state—including businesses, schools, and government agencies—have expressed interest in wood energy. Applications as diverse as space heating for buildings, lumber drying, and power generation are being considered. Numerous promising projects have reached the feasibility, design, or construction stages. This new-found interest builds on several existing wood energy systems currently in operation in Alaska that have the potential to serve as examples for future successes. Many agencies, natural resource professionals, business owners, and tribal leaders across Alaska are now working toward the goal of increased use of biomass as well as energy independence at the community level. This case study summarizes several of the most noteworthy wood energy developments in Alaska, documenting several operating systems. It reviews some of the technical aspects, resource requirements, and community support needed for successful systems.

Alaska Bioenergy Case Studies

In recent years, several wood energy facilities in Alaska have started operation, others are currently under construction, and numerous feasibility studies have been recently completed. Some of the first facilities were associated with wood-products manufacturing facilities. They burn sawmill wastes for energy to heat lumber dry kilns or other buildings. More recently, wood energy systems have been installed to heat schools and other community buildings. Most systems are hot-water (or thermal) systems in which heated water is delivered via pipes to then heat a building, dry kiln, or other end use. Some facilities are fueled with cordwood (Nicholls and Miles 2008), although at least one chip-fired facility with automated fuel-handling systems has recently become established. There are few, if any, steam-generating

A total of nine facilities in three Alaska regions are reviewed.

systems, and there are no known electrical systems in Alaska using wood energy. Thus, an important element of the systems now found in Alaska is their simplicity and small size. This case study considers facilities that are currently in operation or that were substantially completed as of August 2008; however, planned facilities (i.e., preconstruction) are not considered. A total of nine facilities in three Alaska regions (southeast, south-central, and interior) are reviewed (fig. 1). The following case-study summaries provide an overview of recent wood energy developments in Alaska but are not intended to be a complete review of all wood energy facilities in the state.

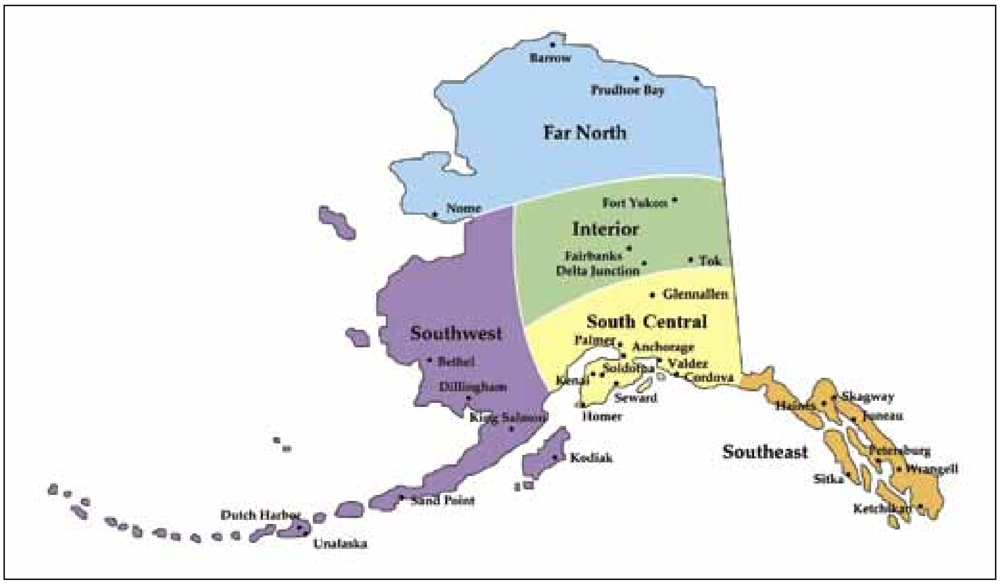

Figure 1—Alaska, by geographic region (State of Alaska 2008).

Wood Energy Site: Logging and Milling Associates, Delta Junction, Alaska

Overview

This wood energy facility is located at a forest products manufacturing site near Delta Junction, Alaska (see fig. 1). Logging and Milling Associates produces primarily tongue-and-groove lumber for decking and roofing, house logs, and molded wood products from white spruce (*Picea glauca* (Moench) Voss) harvested within the Tanana River drainage. They harvest largely from timber sales on Alaska state forest lands. The company specializes in custom, complete tongue-and-groove log home kits, and they market their products throughout interior and south-central Alaska (Nicholls 2005). However, about 90 percent of their business is conducted with consumers in the Fairbanks area.

Logging and Milling Associates is an integrated company that handles the harvesting, milling, drying, planing, and surfacing of wood products followed by construction into log homes. Their wood processing equipment includes a circular saw headrig, a secondary saw, and a production molder. Recent capital projects have included construction of a lumber dry kiln, a lumber storage area, and a processing and warehouse area. Wood energy is used to dry lumber in kilns and to heat a building that houses lumber storage and a shop area (fig. 2). The system capacity is about 40 to 42 horsepower, and has eliminated the need to buy fossil fuels that would have been used for heating buildings.

Daniel Parrent

Figure 2—Wood energy facility (Logging and Milling Associates Delta Junction, Alaska).

Logging and Milling Associates currently has 14 employees and produces about 10 log homes per year. Innovation in developing and marketing new products has been cited as a key to success for Logging and Milling Associates (Nicholls 2005). They have remained competitive by differentiating their product line (in particular, tongue-and-groove products) from other area sawmills that are also involved in house-log production.

Facts and Figures

Location:

- Near Delta Junction, Alaska (interior Alaska), about 150 mi southeast of Fairbanks

Type of system:

- Hot water boiler system using sawmill residues

Wood energy startup date:

- November 2004

Host facility:

- Logging and Milling Associates, Delta Junction, Alaska
- http://www.loggingandmilling.com

System capacity:

- 1.2 million British thermal units (Btu) per hour maximum
- 400,000 Btu per hour to heat two dry kilns
- 800,000 Btu per hour for dry lumber storage facility and molding shop
- One building (60 by 120 ft)

Energy use:

- Wood energy system runs at about 33 percent of capacity (year-round average)
- January (mid-winter)—about 50 percent capacity
- July (mid-summer)—about 25 percent capacity
- System is generally in use continuously except during summer months

Labor required:

- Owing to automated fuel handling and feeding, no additional labor is required
- Very little maintenance needed (ash removal, minor repairs)

Wood fuel parameters:

- Approximately 99.5 percent of fuel is sawdust generated onsite at the sawmill
- Approximately 0.5 percent of fuel is planer shavings or sawdust from a lumber resaw. This material is mixed in when fewer logs are being sawn at headrig (i.e., less green sawdust is being generated).
- 20 to 30 percent (green basis) moisture content

Wood fuel consumption:

- Approximately 1 ton per day of green sawdust (peak use conditions)

Fuel storage:

- Covered storage from sawmill directly into covered silo

Fuel handling:

- A completely automated process transports sawdust from the saw to the burner.
  - Step 1—A chain and paddle sweep recovers sawdust from sawing area.
  - Step 2—A blower transports sawdust to a cyclone.
  - Step 3—Wood fuel is transported from a cyclone to a screw auger.
  - Step 4—An auger transports fuel to the top of the storage silo.
  - Step 5—An auger transports fuel from the base of storage silo to a surge bin.
  - Step 6—An auger transports fuel from a surge bin into a burner.

Combustion equipment:

- Step grate burner
  - Step 1—Sawdust is delivered to the top of grate.
  - Step 2—Air is introduced from below via holes in grate.
  - Step 3—Preheated air is blown in from above.
  - Step 4—As the fire burns, smaller particles tend to fall down steps.
  - Step 5—At the exiting end of grate, only ash remains.

Ash removal:

- Under normal operating conditions, a 55-gal drum of ash is generated about once every 2 weeks.

Wood Energy Feature: Fuel Storage in Cold Climates

White spruce in interior Alaska typically contains 30 percent (all moisture contents based on green basis) or more water, and has the potential to freeze quickly when reduced to sawdust. In arctic climates, fuel handling and storage can be very important for successful wood energy operations. Past observation at Logging and Milling Associates has indicated that when outside sawdust piles are formed in winter, the interior zone is very wet, the exterior zone is frozen, and a relatively small intermediate zone is a “shell” of good-quality fuel (Squires 2008). Other research on outdoor wood fuel storage in northern climates has confirmed this same layering effect (Nicholls and Feng 1992).

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Logging and Milling Associates has considered storing fuel in an unheated building (on a concrete slab); however, freezing could still occur. They have also considered storing fuel in heated buildings; however, this option could be expensive, result in ventilation problems, require additional materials handling, and reduce the space available for other uses (such as storing lumber). Very little fuel freezing has been observed in their storage silo (however, there is a limited storage capacity here). Ideally, they would like to find a way to store larger amounts of wood fuel onsite without moisture problems or freezing.

Wood Energy Feature: Efficient Fuel Handling

Logging and Milling Associates has a highly automated system, which feeds small waste particles from the sawmill (primarily sawdust and hog fuel) into a boiler, providing heat for shop buildings and a lumber dry kiln. Because this system operates automatically, fuel feeding occurs without interruption throughout this process (see "Facts and Figures" above). This results in considerably lower labor requirements when compared to solid wood (i.e., cordwood) burners, which are usually loaded manually.

An advantage of the automated fuel-handling system is that wood fuel stays very clean throughout the process (from sawmill to burner). Because there is no need for handling by front end loaders or other equipment, there is no contact with the ground or dirt, and therefore very little fuel contamination. The sawmill owner estimates that fresh sawdust is often deposited into the storage silo within as little as 2 minutes after being sawn from lumber (Squires 2008).

Wood Energy Site: Thorne Bay Wood Products, Thorne Bay, Alaska

Overview

Thorne Bay Wood Products is located on Prince of Wales Island, in southeast Alaska, about 40 miles west of Ketchikan (see fig. 1). They manufacture dimension lumber, shop lumber, and surfaced and molded products (Parrent 2004), serving primarily local markets. They also produce log siding and house logs. Recent capital improvement projects at Thorne Bay Wood Products include adding a new lumber storage building, dry kiln, and a molder. Solid wood residues, including slabs, edgings, and small roundwood sections are burned in an outdoor heating system adjacent to the lumber storage building, supplying hot water to the 15 thousand-board-foot-(mbf)-capacity dry kiln and storage building (Cabe 2008). Estimated mill output in calendar year 2005 and 2006 was 680 mbf and 600 mbf, respectively (Scribner C log scale) (Brackley and Crone 2009).

The outdoor wood boiler can easily handle large firewood and small cross sections without the need to reduce wood into chips or hog fuel. A disadvantage of outdoor wood boilers is that air quality can sometimes be a concern when burning larger chunks of high-moisture wood in systems having relatively low combustion efficiency. Also, these units tend to cycle on and off frequently, which can result in more smoke. Another potential disadvantage is that all fuel handling is done manually. However, these disadvantages must be weighed against the benefits of a low-cost system that does not require hogs or chippers to generate small particles, nor augers or conveyors for material handling.

Facts and Figures

Location:

- Thorne Bay, Alaska (southeast Alaska, Prince of Wales Island), about 40 mi west of Ketchikan

Type of system:

- Firewood hot water boiler system

Wood energy startup date:

- 2005

Host facility:

- Thorne Bay Wood Products, Thorne Bay, Alaska

System capacity:

- 1 million Btu per hour maximum

Energy use:

- Two lumber dry kilns (each one 10-mbf capacity)
- One lumber storage building (130 by 60 ft)
- One shop building (24 by 36 ft, two stories)

Labor required:

- No additional employees needed beyond normal staffing of sawmill

Wood fuel parameters:

- Mostly green wood (bucked log ends from Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.))

Wood fuel consumption:

- 0.25 cords per day (at peak use)

Combustion equipment:

- Outdoor wood boiler

The cluster effect has the potential to create energy projects that benefit a group of firms.

Wood Energy Feature: Wood Products Clusters

Thorne Bay Wood Products is situated in the Thorne Bay Industrial Park and is part of a cluster of firms, allowing several advantages for efficient use of wood fuel. A "cluster" can be defined as a "group of firms whose linkages mutually reinforce and enhance their competitive advantage" (Rojas 2007: 3). In this context, cluster members could be competitors, customers, partners, suppliers, or research and development contacts. Business clusters can also be considered as "groups of companies that interact based on systemic relationships among firms and organizations in a region" (State of Oregon 2008). In Thorne Bay, Alaska, firms located at the industrial park include several shingle manufacturers, sawmills, a dry kiln, and a planing/molding facility. As of 2008, at least 10 wood products companies were identified in the Thorne Bay area. The cluster effect has the potential to create energy projects that benefit a group of firms.

Wood Energy Site: St. Nick Forest Products, Craig, Alaska (formerly W.R. Jones and Son Lumber)

Overview

Saint Nick Forest Products is a producer of kiln-dried specialty lumber products located in Craig, Alaska, on Prince of Wales Island in southeast Alaska, west of Ketchikan (see fig. 1). They sell lumber to local markets, as well as supplying secondary wood products manufacturers. Much of their marketing is through word-of-mouth referrals. The mill produces both green and dried flooring, paneling, trim, and molding, which are sold to several lumberyards and suppliers in the continental United States and also markets in Hawaii (Nicholls 2005). Estimated mill output in calendar year 2005 and 2006 was 690 and 600 mbf, respectively (Scribner C log scale) (Brackley and Crone 2009).

Their primary saw is a mobile dimension unit, which includes a movable circular saw and edgers that work together to process stationary logs, and total lumber production is about 150 mbf per year. In an energy-conserving effort, they recently converted the sawmill from gas power to electric. Their secondary processing equipment includes a molder, which can produce profiled products such as tongue-and-groove siding (Sharp 2008).

Their wood energy system was among the first in Alaska to provide heat for commercial lumber drying (fig. 3). They burn primarily slabs and edgings from their sawmill operation, including species such as Sitka spruce, western hemlock, western redcedar (*Thuja plicata* Donn. ex D. Don), and Alaska yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach), with Alaska yellow-cedar being

Figure 3—Original wood energy combustion system, in operation from 2001 to 2006, at St. Nick Forest Products (formerly W.R. Jones and Son Lumber Co.).

burned the most. An outdoor wood boiler system, acquired within the past year, provides hot water heating for an 18-mbf-capacity dry kiln as well as a lumber storing warehouse.

Facts and Figures

Location:

- Craig, Alaska (southeast Alaska, Prince of Wales Island), about 60 mi west of Ketchikan

Type of system:

- Outdoor firewood hot water boiler system

Wood energy system startup date:

- Original—2001
- Current—2008 (upgrade to new wood-fired boiler)

Host facility:

- St. Nick Forest Products, Craig, Alaska (formerly W.R. Jones and Son Lumber Co.)

Primary wood products:
- Specialty products
- Dimension lumber
- Kiln-dried lumber
- Siding
- Molded products

Energy use:
- Currently heats an 18-mbf-capacity lumber dry kiln
- Plan to heat a lumber storage building and a greenhouse

Labor required:
- Approximately 2 hours per day (0.25 full-time employees)

Wood fuel parameters:
- Residue type: green slabs and edgings all species (no sawdust)
- Moisture content: estimate 35 percent (green basis); some air drying occurs while wood is stored on pallets prior to burning

Wood fuel consumption:
- Approximately 800 lb per day at peak use
- The wood energy system is manually loaded (i.e., stoked) an average of two times per day

Combustion equipment:
- Outdoor wood boiler (hot water system)

Wood Energy Feature: Wood Energy for Drying Lumber

Saint Nick Forest Products operates an 18-mbf-capacity dry kiln. In their system, wood energy is used to heat water to supply heat to the dry kiln. Hot water kilns operate at temperatures less than the boiling point of water (typically in the range of 140 to 180 °F). Heat is dissipated into the drying chamber via fin tubes made of copper, aluminum, or other material. An advantage of hot water systems is that they operate in nonpressurized lines, requiring less monitoring and maintenance compared to low-pressure steam systems. Lumber drying times can often range from several days to several weeks depending on important variables such as species, size of lumber, wood specific gravity, initial moisture content, final moisture content, and airflow.

An important consideration is consistent and uniform heat delivery during the drying period to all parts of the kiln. Lumber drying can be energy intensive, representing up to 80 percent of the total energy requirements for some sawmills (Reeb 1997). In many wood products manufacturing facilities, lumber drying may consume a portion of the generated wood wastes, but not all of the wastes (fig. 4). Therefore, other outlets for wood waste (e.g., animal bedding) may be needed, potentially providing additional revenues. By using wood instead of fuel oil for dry kilns, St. Nick Forest Products has realized considerable cost savings. Additional energy savings have been realized by the use of electricity instead of liquid fuels for the primary sawmill.

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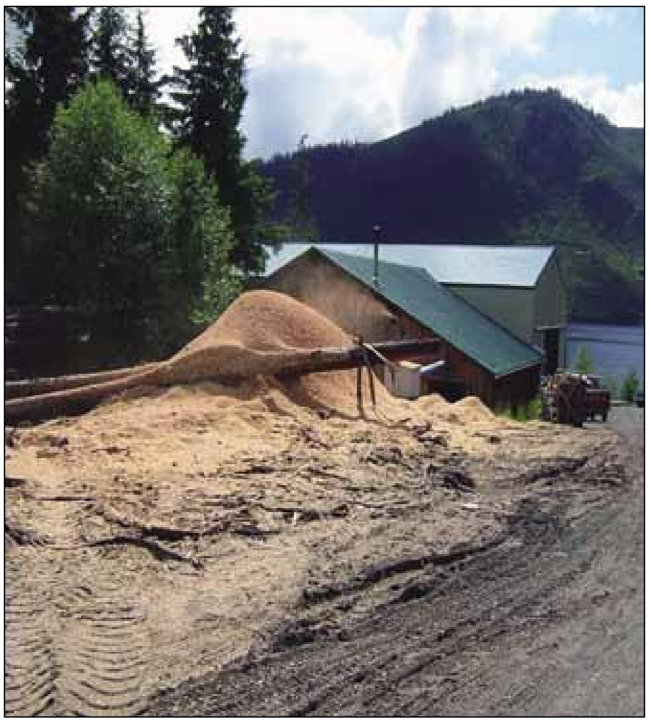

Jon Bolling

Figure 4—A potential fuel source for the Craig, Alaska, wood energy system is sawdust from a local sawmill.

Wood Energy Site: Community of Dot Lake, Alaska

Overview

Dot Lake, Alaska, is a small community in interior Alaska, located between Tok and Delta Junction (see fig. 1). Winter conditions can be severe, with temperatures often below 0 °F. Their thermal heating system, used to heat seven homes and a laundromat using cordwood, was installed for approximately $66,000 and is rated at about 900,000 Btu per hour (Miles 2006).

A 4,400-gal water storage tank, capable of storing 2 million Btu of heat, transfers wood combustion heat to nearby buildings. An advantage of high-efficiency systems such as these is their ability to store heat for later use, reducing the need for frequent fuel loading (fig. 5). Under full-use conditions, the Dot Lake system can replace about 7,000 gal per year of heating oil for a fuel savings of more than $21,000 (based on heating oil at $3.20 per gal) (Frederick 2008). Price increases in heating oil above this level would result in even greater cost savings when heating with wood. Dot Lake salvages primarily fire-killed timber from nearby burned areas for use in their wood energy system; however, slabs and edgings from sawmill operations are also used.

Daniel Parrent

Figure 5—High-efficiency cordwood burner in Dot Lake, Alaska. The combustion chamber is surrounded by a water reservoir, which stores heat generated from the burning cordwood.

Facts and Figures

Location:

- Dot Lake, Alaska (interior Alaska), located between Tok and Delta Junction

Type of system:

- GARN[1] wood-fired hydronic heaters

Wood energy startup date:

- 1998

[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.

Capital cost:

- Approximately $66,000

Host facility:

- Community of Dot Lake, Alaska

Capacity:

- 950,000 Btu per hour (maximum capacity)

Energy use:

- Heats seven homes and a laundromat

Labor required:

- About 20 hours per week (0.5 full-time employees); tasks include cutting slabs to length, storing wood, loading wood, removing ash, operating and maintaining the wood energy system

Wood fuel parameters:

- Source material is slabs from lumber from fire-killed timber (fig. 6)
- Fuel moisture content: approximately 18 percent (green basis)
- Fuel storage conditions: full length storage (outside), then cut to length (and stored inside)
- Fuel-handling methods: all manual (after initial delivery)

David Frederick

Figure 6—Slabs and edgings from sawmill operations, such as this stack at Dot Lake, Alaska, provide an excellent fuel source for cordwood energy systems.

Wood fuel consumption:

- Maximum use: 600 to 700 lb per day
- Average use: 300 to 400 lb per day

Combustion equipment:

- GARN (high-efficiency wood burner)

Wood Energy Feature: High-Efficiency Cordwood Energy Systems

High-efficiency cordwood energy systems are designed to burn cordwood fuel cleanly, with minimal particulates. They often include fans to maintain high-temperature combustion conditions, have refractory materials in the firebox, and have large water storage units, resulting in efficient heat transfer to the end destination (Nicholls and Miles 2008). Cordwood boilers are generally best suited for thermal loads from 100,000 to 900,000 Btu per hour (Miles 2006).

At Dot Lake, the relatively small capital investment of about $66,000 is considerably less than systems that require wood chips and have automated fuel-handling features. However, an important consideration for successful operation of cordwood systems is having a dedicated labor source available to "break away" from other responsibilities to give part-time attention to the wood energy system. In addition to fuel loading, other duties could include routine maintenance tasks such as removing ash, inspecting fans, and coordinating fuel arrivals. In cases where dedicated labor cannot be ensured, a backup system (automatically switching to fuel oil as needed) could provide heat as needed.

The Dot Lake system provides heat to several buildings, connected with underground piping to transfer hot water between buildings. For the Dot Lake system, typically some oil heat is required during days, with all wood heat at night (and the fire is actively stoked by the operator overnight). High-efficiency cordwood energy systems in use in Alaska usually operate at about 70 to 80 percent (as claimed by manufacturers) (Miles 2006).

Wood Energy Site: Campbell Creek Science Center, Anchorage, Alaska

Overview

Wood fuel requirements are estimated to be 10 to 15 cords of wood per year, primarily beetle-killed spruce.

The Campbell Creek Science Center (CCSC), as part of the U.S. Department of the Interior Bureau of Land Management, has purchased and installed an outdoor wood furnace (fig. 7) to provide heat for several of their buildings. Heat transfer from the furnace to the buildings will be through pipes buried to a depth of about 3 ft. Propylene glycol is pumped through two nonpressurized heating loops to heat the main building and also the storage sheds. Wood fuel requirements are estimated to be 10 to 15 cords of wood per year, primarily beetle-killed spruce. Recently, the Bureau of Land Management has been removing beetle-killed spruce trees within the Campbell Tract (i.e., the location of the biomass demonstration project) and also creating fire breaks to reduce wildfire hazard. An important feature of this facility, as a demonstration project, is its proximity to Alaska's largest metropolitan area, Anchorage.

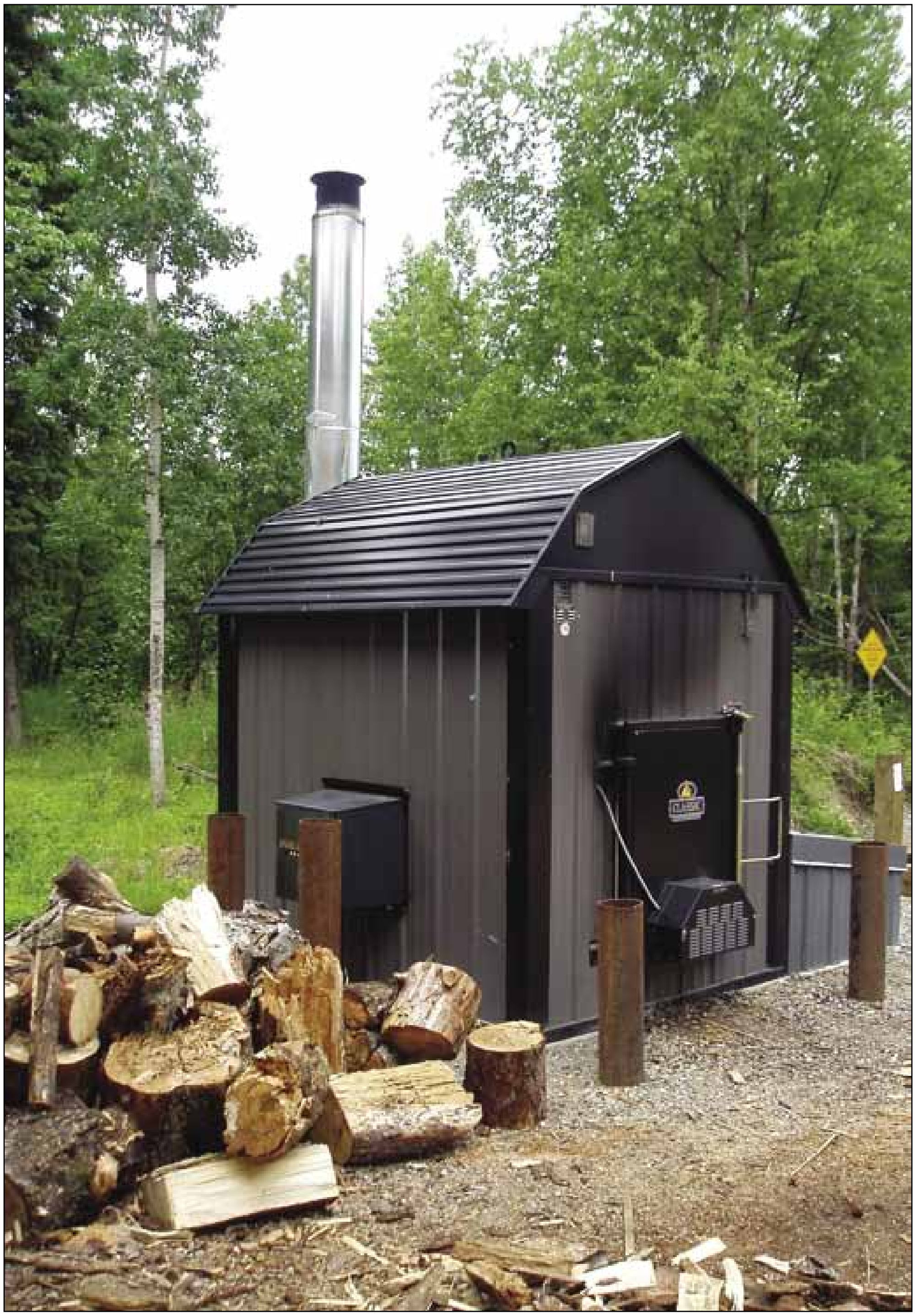
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Figure 7—Wood fuel and combustion chamber at the Campbell Creek Science Center near Anchorage, Alaska.

Facts and Figures

Location:

- Anchorage, Alaska (south-central Alaska)

Type of system:

- Outdoor wood-fired hotwater boiler system

Wood energy startup date:

- Fall 2006

Host facility:

- Campbell Creek Science Center (Bureau of Land Management), Anchorage, Alaska
- http://www.blm.gov/ak/st/en/prog/sciencecenter.html

Wood energy use:

- Space heating for three buildings:
  - Science center building
  - Maintenance shed
  - Recreation shed

Labor required:

- About one full-time job (divided up among several people)
- Primary tasks are wood procurement, bucking, stacking, storing, and maintenance
- System has to be stoked (i.e., loaded) two times per day at 8 a.m. and 4 p.m.

Wood fuel parameters:

- Residue type: spruce, paper birch (*Betula papyrifera* Marsh.), and aspen (*Populus tremuloides* Michx.)
- Past uses have been primarily from a fire-mitigation plan (beetle-killed wood removals)
- Plan to use more birch (as it is made available from nearby military base)
- Plan to use minor amounts of aspen (some from Campbell Creek area)
- Cut wood to 3-ft lengths (then split larger rounds as needed)

Wood fuel consumption:

- 10 to 15 cords per year (under normal use conditions)
- System is idle during summer months (from about June 1 to September 1)

Combustion equipment:

- Dual fuel outdoor wood boiler

Wood Energy Feature: Outdoor Wood Boilers

Outdoor wood boilers can be characterized by low-combustion efficiency and relatively high particulate emissions. System efficiencies can often range from 35 to 40 percent, and emissions are more than nine times the standard for industrial boilers. It is often debatable where outdoor wood boilers can be safely and effectively used. Their use in crowded residential areas has created problems, primarily with particulate emissions, leading to bans in some states (NESCAUM 2006). However, in the past few years, standards are under development so that outdoor wood boiler manufacturers can provide specific performance information. Recently, the U.S. Environmental Protection Agency initiated a voluntary agreement with select manufacturers to develop cleaner burning systems. Although new standards for outdoor wood boilers could improve air quality and boiler efficiency, an important consideration will be the effect on system cost.

Although applications in more rural areas could potentially pose fewer human health risks, outdoor wood boilers located significant distances from the dwellings they heat would require greater construction costs for hot water piping and suffer greater heat loss over longer runs. The system at CCSC is located in a forested area with few close neighbors, except for the science center building itself. Important factors influencing system performance can include length of heating season, amount of wood used, form of wood (e.g., split vs. round), fuel moisture content, and prevailing wind directions.

Covered storage can also help with air quality issues. For example, at CCSC, wood that has iced over can lead to increased smoke (vs. clean, ice-free wood). At other times, brief periods of smoke can be experienced immediately after loading (i.e., at the beginning of the combustion cycle). At CCSC, it would be desirable to have a covered storage building (fig. 8) large enough to house most or all of the cordwood for a given heating season, so that restocking during winter months could be minimized.

General features of low-efficiency cordwood burners (outdoor wood boilers) include:

- They are manually fed (with roundwood, firewood, slabwood, or cordwood).
- They have relatively low boiler efficiencies (35 to 45 percent efficiency).
- They are typically sized from 0.115 to 3.2 million Btu per hour (with most systems being less than 1 million Btu per hour) (NESCAUM 2006).
- Many have water-storage capacities ranging from 150 to 550 gal.
- They can have high particulate emissions and be characterized by smoky operating conditions when operated at low-combustion efficiencies.


David Nicholls

Figure 8—Covered storage of wood fuel at the Campbell Creek Science Center near Anchorage, Alaska.

Wood Energy Site: Community of Craig, Alaska

Overview

A wood heating project for the Craig, Alaska, public schools was dedicated with a groundbreaking in August 2006, and began full operations in 2008 (Bolling 2008). The city of Craig will use wood byproducts from local mills to heat two schools and the community aquatic center. This wood-fired boiler system will supplement the existing diesel/propane-fueled system and is expected to save the city at least $90,000 per year by displacing about 35,000 gal of fuel oil per year (Western Forestry Leadership Coalition 2008). Funding partners for this wood energy system include Alaska Energy Authority, Denali Commission, U.S. Department of Agriculture Forest Service, U.S. Department of Agriculture Natural Resources Conservation Service, and U.S. Department of Energy (Fermann and Crimp 2006).

This represents the first school wood heating system in Alaska, and is modeled after the successful Fuels for Schools program in the Western United States. The first full year of operation at Craig will tell much about workings of the system, including energy cost savings potential, labor requirements, and maintenance needs. Based on this information, decisions can be made whether to expand wood energy use to heat additional buildings.

Facts and Figures

Location:

- Craig, Alaska (southeast Alaska, Prince of Wales Island), about 60 mi west of Ketchikan

Type of system:

- Hot water boiler system using chips or hog fuel

Wood energy startup date:

- 2008

Host facility:

- City of Craig, Alaska

Capacity:

- 4 million Btu per hour (maximum rated capacity)
- During the startup phase, system will be run at about 1 million Btu per hour

Energy use:

- Provides heating needs for Craig aquatic center, Craig elementary school, and Craig middle school (system generates hot [185 °F] water)

Labor required:

- About 0.5 full-time equivalent (20 hours per week) during system startup
- Net increase of zero full-time employees (after startup), since chip-fed system requires little labor

Wood fuel parameters:

- Startup with wood chips only
- Will attempt to transition to primarily hog fuel (including Sitka spruce, western hemlock, and western redcedar) during second year of operation
- Wood fuel moisture content: 60 percent (green basis), as delivered
- Wood fuel moisture content: target of 30 percent (green basis), as burned
- An in-floor system blows hot air through wood storage bin, reducing moisture content somewhat during storage

Wood fuel consumption:

- 2 green tons per day (peak usage)

Combustion equipment:

- Two-stage combustion using a Chip-Tec gasifier

Wood Energy Feature: Automated, Chip-Fired Wood Energy Systems

The system in Craig, Alaska, has the distinction of being the first fully automated, chip-fired wood energy system in Alaska. Features include below-grade, indoor wood chip storage bins, hydraulic rams and augers to automatically feed wood chips to the boiler, and hot water piping systems to deliver hot water to several buildings (Bolling 2007). Much of this process requires little or no manual labor, except for routine maintenance such as ash removal.

An important advantage of chip-fired systems is that little or no labor is needed for fuel handling, a significant cost savings over the life of a wood energy system.

Because chip-fired systems are usually much more expensive than cordwood systems, they are usually reserved for larger facilities having higher energy demands. Bulk fuelwood systems burning chips, sawdust, bark, hog fuel, and other fuel types are generally found where the maximum heating demand exceeds 1 million Btu per hour. An important 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. It is often desirable to maintain a backup system for use during downtime of the wood energy system (a propane backup system is in use in Craig).

The Craig system has the advantage of being able to use residues from nearby sawmills. Given the high moisture content of this wood (especially western hemlock), Craig has developed an air-drying system that forces hot air (at about 185 °F) through the floor of the wood fuel storage area (Pemberton 2008).

In many school facilities in the Western United States, forest residues (i.e., slash) are used for fuel. This material must be harvested, chipped, and transported to wood energy sites (Fuels for Schools 2008). An important consideration for bulk fuel systems is that wood chips are often generated as part of larger production facilities (e.g., large sawmills and biomass export facilities). In many of the isolated regions of Alaska, chip-fired systems might not be well suited to the scale required. However, the Craig system is ideally located within 10 mi of one of Alaska's largest sawmills, and within about 5 mi of another wood products facility.

Wood Energy Site: Regal Enterprises, Copper Center, Alaska

Overview

Regal Enterprises is a manufacturer of lumber, cants, house logs, and siding (Parrent 2004) located in interior Alaska, south of Glennallen (fig. 1). Their initial system was damaged in a fire, rebuilt, and started soon afterwards. This system as it exists today was further redesigned and enhanced to the present form (Hardmann 2008). In this application, sawmill residuals are used to heat a school, a washhouse, and four greenhouses. The system runs 12 months per year, and most days operates at less than one-half of system capacity. The heaviest loads are typically in the spring, when all four greenhouses are being heated. In the future, Regal hopes to use wood energy for residential heating in addition to its current uses. A key lesson learned by Regal Enterprises is the importance of building flexibility into system design. The current system is their third attempt at wood energy and includes a professionally designed system customized to their operating conditions.

Facts and Figures

Location:

- Near Copper Center, Alaska (interior Alaska), about 75 mi north of Valdez

Type of system:

- Hot water boiler fueled by sawmill residuals (sawdust, chips, planer shavings)

Wood energy startup date:

- December 2007

Host facility:

- Regal Enterprises, Copper Center, Alaska

Capacity:

- 1.5 million Btu per hour at maximum capacity
- Most days runs at less than 50 percent capacity
- Runs 12 months per year

Energy use:

- Hot water used to heat four greenhouses
- Domestic hot water consumption for several buildings (including a school and washhouse)

Labor required:

- About 8 hours per week (0.2 full-time equivalents)

Wood fuel parameters:

- Mixture of sawdust and chips from sawmill
- Moisture content: green (from freshly cut white spruce); note that the system will not work for dry, light planer or molder shavings

Wood fuel consumption:

- The system is run at one-third to one-half capacity most days; however, in the spring, it can be run at full capacity when heating four greenhouses
- The system is operated year-round, primarily so that fire tubes do not contract if shut down

Fuel storage:

- Covered shed with a cement floor and three enclosed sides

Fuel handling:

- Skid steer loader and conveyors
- Auger to convey fuel into burner
- One wood chipper (90 horsepower), with plans to purchase a second unit (250 horsepower)

Combustion equipment:

- Forced-air direct combustion system (Decton)

Wood Energy Feature: Providing Heat for Multiple Buildings

When heating several buildings with a single wood energy system, an important consideration is the cost of the distribution system needed to circulate hot water between buildings. At Regal Enterprises, the buildings include a school, washhouse, and four greenhouses.

Several important variables can influence heat delivery between buildings, especially in cold climates (Nicholls and Miles 2008):

- The number of buildings to heat
- The total volume of buildings
- Distance between buildings
- The presence of permafrost
- The choice of piping materials
- Cost of piping materials
- Whether piping materials are aboveground or (buried) underground

Wood Energy Site: Icy Straits Lumber and Milling, Inc., Hoonah, Alaska

Overview

Icy Straits Lumber and Milling is located in Hoonah, Alaska, on Chichagof Island in southeast Alaska, about 25 air mi west of Juneau (see fig. 1). They produce log cabin materials, timbers and beams, and timberframe structures primarily for local and regional use (Icy Straits Lumber and Milling, Inc. 2008). Their lumber production includes about 70 percent western hemlock and 30 percent Sitka spruce, which they process with their sawmill, planer/molder, and lumber dry kiln.

Icy Straits Lumber and Milling produces a variety of lumber products including 1- and 2-in dimension lumber, 1¼- and 1½-in shop lumber, and larger members for timber and log home construction (Nicholls et al. 2004). Their operating season is typically about 40 weeks per year (with the mill being closed during mid-winter months). Estimated mill output in calendar year 2005 and 2006 was 500 mbf and 700 mbf, respectively (Scribner C log scale) (Brackley and Crone 2009).

Their wood energy system uses wood products manufacturing residues from the host sawmill facility. Construction of the wood energy system has been recently completed, followed by startup and testing (Tyler 2008). During trial runs, it was noted that the wood fuel moisture content was too high for efficient combustion. The facility has not been used on a regular basis, but is expected to provide energy pending solution of the moisture problem. A fuel-oil system acts as a backup energy system, but generally is not needed under normal operation with the wood burner. The wood energy system will be used to dry lumber (in a 20-mbf dry kiln) and to heat a lumber storage building. Wood residue production at Icy Straits Lumber and Milling typically averages nearly 10 green tons per day under high-production conditions, according to the sawmill owner.

Facts and Figures

Location:

- Hoonah, Alaska (southeast Alaska; Chichagof Island), about 20 mi west of Juneau

Type of system:

- Hot water boiler converted to sawmill residuals (sawdust, planer shavings)

Wood energy startup date:

- System is in place and currently under repair (as of May 2008)

Host facility:

- Icy Straits Lumber and Milling, Hoonah, Alaska
- http://www.alaskawoodproducts.com

Energy use:

- Heat dry kilns (20 mbf capacity)
- Heat lumber storage building (40 by 24 ft)
- Two separate energy systems are maintained (wood-fired and oil-fired)

Wood fuel parameters:

- Wood residue type: green sawdust with dry molding shavings (about 50/50)
- Wood fuel moisture content: 35 to 40 percent (green basis)
- Fuel storage conditions: covered roof, dry storage
- Fuel-handling methods: front-end loader
- Wood residues include bark, sawdust, hog fuel, and planer shavings (only dry residue)

System capacity:

- 3 million Btu per hour maximum capacity

Combustion equipment:

- Fire-tube boiler

Wood Energy Feature: Managing and Burning High-Moisture-Content Fuel

In Hoonah and other locations in southeast Alaska, special considerations might be needed when trying to burn high-moisture fuel, especially if fuel has been exposed to rainfall.

Moisture content is an important concern when burning wood wastes because it affects combustion efficiency and available energy. In Hoonah and other locations in southeast Alaska, special considerations might be needed when trying to burn high-moisture fuel, especially if fuel has been exposed to rainfall. Because boiler efficiency is reduced with wet fuel, covered storage is essential to minimize rain absorption.

Western hemlock is a species noted for its high moisture content (up to 170 percent, ovendry basis or 63 percent, green basis) (USDA FS 1999), and is one of the primary species processed at Icy Straits Lumber and Milling. Typically, sawdust picks up too much moisture (rainwater) during storage, resulting in poor burn conditions and possible clogging damage to fuel auger systems. Another disadvantage of high moisture fuel of any species is that extra labor may be needed to mix dryer wood into the fuel stream to reduce overall fuel moisture content to an acceptable level.

It should be noted that green sawdust can burn satisfactorily at Icy Straits Lumber and Milling if it is fired directly into the boiler shortly after sawing (i.e., with little or no outdoor storage). Also, sawdust mixed with dry planer shavings burns very well. Icy Straits Lumber is exploring possible solutions to the problem of high-moisture-content fuel, including storing high moisture content fuel in an enclosed building or silo and then transferring fuel directly from the storage building to the wood energy system using a front end loader. This way, various types and ratios of fuel (i.e., bark, sawdust, chips, hog fuel, planer shavings) could be mixed in a commercial mixing bin before being conveyed into an enclosed storage silo. A secondary storage bin (already in place at Icy Straits Lumber and Milling, fig. 9)

Daniel Parrent

Figure 9—Wood fuel storage bin at Icy Straits Lumber, Hoonah, Alaska.

conveys fuel into the boiler. Materials handling and fuel mixing are also important considerations (i.e., mixing dry and wet fuel together in a consistent way would be important). A simpler alternative would be to burn only one fuel type (perhaps green sawdust) with no fuel mixing, and stored inside before burning (i.e., lowest capital cost). Material size is also an important consideration. Because Icy Straits Lumber and Milling does not have a chipper or wood-hog, oversized material (i.e., slabs and edgings) must be handled separately from small particles (i.e., sawdust) that can be handled with augers.

Wood Energy Site: Ionia Ecovillage, a Residential Mental Health Treatment Center, Kasilof, Alaska

Overview

The Ionia Ecovillage, a Residential Mental Health Treatment Center (on the Kenai Peninsula in south-central Alaska) has decided to save energy by installing two separate wood-fired hot water boiler systems. Completed in early 2008, their wood energy system has already resulted in energy savings of about $1,000 per month in propane costs and about $150 per month in fuel oil costs. Projected annual energy savings are 1,500 gal of fuel oil and 8,200 gal of propane (Western Forestry Leadership Coalition 2008). Several buildings are connected to the wood energy system with 120 ft of superinsulated pipe, buried to a depth of 10 ft. During winter months, both cordwood units are typically in operation (and also being double-fired).

A typical firing pattern would be to start with a normal "dosage" of about 100 lb of wood in each burner (with doses of about 100 lb 1 to 2 hours later) (Eller 2008). By having two separate burners, Ionia community is able to regulate their heating load based on the number of burners (one vs. two), and dosage level of wood fuel (high vs. low). This can be especially beneficial during autumn and spring shoulder seasons when heating loads may be unpredictable, and typically only one burner is used. An advantage of operating only one burner is that only 2,000 gal of water needs to be heated (vs. 4,000 gal when operating both burners). Six solar panels are also used to heat water, supplementing the wood energy system.

The Ionia community practices good stewardship by planting about 1,000 trees per year (primarily lodgepole pine (*Pinus contorta* Douglas ex. Loud.) and western larch (*Larix occidentalis* Nutt.)) on their property for future use in wood energy and other forest products.

Facts and Figures

Location:

- Near Kasilof, Alaska (south-central Alaska; Kenai Peninsula), about 150 mi south of Anchorage

Type of system:

- Wood-fired hot water boiler system (fueled with firewood)

Wood energy startup date:

- January 2008

Host facility:

- Ionia Ecovillage, a Residential Mental Health Treatment Center
- http://www.ionia.org

Capacity:

- 800,000 Btu per hour (each unit rated at 400,000 Btu per hour)

Energy use:

- Heat about 7,000 ft^2 of living and meeting space
- Heat about 2,000 gal per day of water for domestic use (to 120 °F)
- Wood masonry heaters (used in addition to cordwood boilers) heat about 5,000 ft^2 of space

Labor required:

- About 1 hour per day (about 0.125 full-time equivalent)
- Typically two stokings per day are required

- Fuel-handling methods: tractors haul 20-ft logs to building housing wood burners, cut logs to 30-in lengths, stored inside for less than 1 month before burning

Wood fuel parameters:
- Currently—slabs and edgings from construction activities
- Over the next several years—beetle-killed spruce
- Long term—cordwood from planted trees
- Moisture content—slab wood is 20 to 25 percent (green basis)

Wood fuel consumption:
- 400 lb per day (moderate heating needs)
- 800 lb per day (peak heating needs)

Wood fuel storage:
- Up to 10 cords of wood fuel is stored inside the building that houses the wood burners

Combustion equipment:
- Two GARN 2000 units
- Each unit includes approximately 2,000 gal of water for heat storage
- During the summer, only one unit is operated (while one remains idle)

Wood Energy Feature: Energy From Beetle-Killed Wood

Over the past few decades, spruce bark beetles have devastated extensive forested areas within the Kenai Peninsula. Although much of this material is no longer suitable for lumber production, small-scale wood energy production has remained an economically viable option for this biomass (Nicholls and Crimp 2002). However, highly deteriorated biomass that is not sound enough to be removed from the forest floor might not be suitable even for energy. Use of beetle-killed material, if feasible and the integrity of the material is sufficient to allow harvesting and handling, has the benefit of reducing wildfire risk, an important consideration near communities.

The Ionia community is located on the southern part of the Kenai Peninsula, an area that was particularly hard hit by the bark-beetle epidemic. They plan to burn beetle-killed spruce as wood fuel over the next several years. However, they recognize that this is not a viable long-term source, and eventually plan to sustainably harvest trees planted onsite for energy. Over the short term, they also plan to use slabs and edgings from onsite construction activities.

Discussion

Recent wood energy developments in Alaska have been significant and are already resulting in greater energy independence for several communities. Widespread interest in wood energy has been apparent from all regions of the state, across different scales of use, and among many classes of end users. One driving force is the high cost of fossil fuel. Some rural Alaska communities have seen dramatic increases in the cost of heating fuel, and in some cases, fuel must be delivered long distances by air.

Within the past few years, several new wood energy installations in Alaska have come online, providing heat to school buildings, community centers, forest products firms, and lumber dry kilns.

Within the past few years, several new wood energy installations in Alaska have come online, providing heat to school buildings, community centers, forest products firms, and lumber dry kilns. In almost all cases, new wood energy projects have resulted in additional employment. Wood fuel has come from numerous sources, including sawmill residues, beetle-killed timber, and firewood harvests. Other sources, such as hazard fuel removals near communities at risk for wildfire, could potentially fuel new wood energy systems.

In rural Alaska, an important consideration is the travel distance from harvest sites to bioenergy facilities. Fresco (2007) found that 22 out of 27 sampled communities in interior Alaska could be sustainably supplied with wood fuel from travel distances of 6 mi or less. If there is a willingness to harvest wood, proximity to fuel sources would be a key consideration for most villages that are not part of Alaska's road system.

In contrast, bulk fuelwood can be transported greater distances by using established shipping methods. In the fall of 2008, one of the major sawmill owners in southeast Alaska purchased a firewood processor and now has the potential to sell 20-ft containers of split and processed wood in any location in the region serviced by barge, including Juneau (Juneau Empire 2008). This additional supply could benefit not only the residential firewood market, but also those considering high-efficiency cordwood burners.

Continued interest in wood energy is expected in Alaska, despite fluctuating fossil fuel prices. For example, between 2005 and 2008, 79 statements of interest were submitted by potential wood energy adopters to the Alaska Wood Energy Development Task Group (Alaska Department of Natural Resources, Division of Forestry 2008). Although the energy savings from wood energy can be substantial, initial investment costs for wood-burning equipment, buildings, and accessories can often be a barrier in much of Alaska. A renewable energy fund, established by the state of Alaska, has already solicited proposals for close to $100 million. Twenty-four projects classified as either biofuels or biomass have moved into stage 2 review for funding (Alaska Energy Authority 2009). Many of these are already either in the feasibility, design, or construction phases—a sign that wood energy use in Alaska is likely to continue increasing in the near future.

Glossary

board foot—A piece of lumber that is 1-ft wide, 1-ft long, and 1-in thick, or its volumetric equivalent (http://www.woodweb.com/knowledge_base/What_is_a_Board_Foot.html).

chip-fired wood energy system—A wood energy system that uses wood chips, hogged fuel, or other comminuted wood as a fuel source. Fuel handling and conveying is often at least partially automated, and can include augers, conveyors, or front end loaders.

combustion efficiency—The ratio of energy released during combustion to the potential chemical energy available in the fuel (http://www.canren.gc.ca/prod_serv/index.asp).

cordwood energy system—A wood energy system using firewood, roundwood, manufacturing residues, or similar solid woody residue as a fuel source. Fuel handling and conveying is often done manually.

fossil fuel—A hydrocarbon deposit, such as petroleum products, coal, or natural gas, derived from living matter of a previous geologic time and used for fuel (http://www.thefreedictionary.com).

hogged fuel—Fuel made by grinding waste wood in a hog; a mix of wood residues such as sawdust, planer shavings, and sometimes coarsely broken-down bark and solid wood chunks produced in the manufacture of wood products and normally used as fuel (http://forestry.about.com/library/glossary/blforglh.htm).

moisture content percent (green basis)—[(green wood weight – ovendry wood weight) / green wood weight] × 100

moisture content percent (ovendry basis)—[(green wood weight – ovendry wood weight) / ovendry wood weight] × 100

outdoor wood boiler—Wood-fired water heaters that are located outdoors or are separated from the space being heated. The fires in the large fire boxes heat water that is circulated into the heated space through underground pipes. The energy may be used to heat houses, shops, domestic hot water, greenhouses, swimming pools and spas, among other uses (State of Washington, Department of Ecology. http://www.ecy.wa.gov/programs/air/AOP_Permits/Boiler/Outdoor_Boilers_home.html#What_are_Outdoor_Wood-fired_Boilers_(OWBs)).

wood ash—The incombustible, inorganic residue remaining after combustion of wood.

woody biomass—The trees and woody plants, including limbs, tops, needles, leaves, and other woody parts, grown in a forest, woodland, or rangeland environment, that are the byproducts of forest management (USDA Forest Service Woody Biomass Utilization. http://www.fs.fed.us/woodybiomass/whatis.shtml).

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	25.4	Millimeters
Inches (in)	2.54	Centimeters
Feet (ft)	.305	Meters
Square feet (ft^2)	.0929	Square meters
Miles (mi)	1.609	Kilometers
Gallons (gal)	3.78	Liters
British thermal units (Btu)	1,050	Joules
Tons (ton)	907	Kilograms
Pounds (lb)	454	Grams
Degrees Fahrenheit	.56(F - 32)	Degrees Celsius

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