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Community Energy Management in Sitka, Alaska

What Strategies Can Help Increase Energy Independence?

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Abstract

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This report summarizes practical energy management strategies that could help communities in southeast Alaska move closer to energy independence while utilizing local resources more effectively. Our analysis focuses primarily on Sitka, Alaska, yet could be relevant to other communities having similar energy structures that rely primarily on hydroelectric power. We consider how community energy capacity and locally abundant resources can help communities move toward energy independence. Our recommendations focus on energy conservation, appropriately scaled renewable energy project development, and adoption of new technologies, including electric vehicles. We also identify key stakeholder elements that could be important for successful collaborative projects in southeast Alaska. Last, we consider broader implications for southeast Alaska, including communities having energy resources different from those of Sitka.

Keywords: Energy conservation, renewable energy, community energy management, hydroelectric power, biomass, sustainable communities.

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Introduction

Why Is Community Energy Management Important?

Community energy management is a strategy that combines planning concepts with energy management, and which can be implemented at the scale of neighborhoods, cities, and even small regions (Jaccard et al. 1997). A key aspect of community energy planning is that local actions that prove successful at small scales can become integrated into the fabric of increasingly larger efforts. In this way, community energy planning, if replicated forward, could become an essential feature of reaching the global carbon dioxide (CO_2) emission reduction goals articulated by Pacala and Socolow (2004) (table 1).

Community energy management is dynamic and constantly evolving to keep step with changing population patterns, construction practices, energy technologies, and social awareness. Further, regulatory issues can greatly influence the energy planning process, especially when long planning horizons are involved (e.g., with some hydroelectric projects). Community energy planning often assumes that future energy consumption is largely determined when land use decisions are made, and therefore is directed at residential, commercial, and urban transportation energy

Table 1—Proposed areas that could reduce global carbon dioxide emissions by 1 billion metric tons per year

	Global emission reduction area	Proposed action
1	Vehicle fuel economy	Increase to 60 miles per gallon
2	Vehicle miles driven	Lower to 5,000 miles per year
3	Energy efficient buildings	Reduce energy consumption by 25 percent
4	Coal plant operation	Increase to 60-percent efficiency
5	Coal plant infrastructure	Replace 1,400 GW generated from coal with natural gas
6	Coal plant—carbon capture/storage	Sequester carbon from 800 GW of coal plants
7	Coal plant—hydrogen generation	Capture and use hydrogen from 800 GW of coal plants
8	Synfuels from coal	Capture and store carbon from 30 million barrels per day
9	Coal power	Displace 700 GW of coal power with nuclear power
10	Wind energy	Add 2 million wind turbines (each 1 MW in size)
11	Solar energy	Displace 2,000 GW of coal energy with solar energy
12	Wind energy	Produce hydrogen from 4 million wind turbines (each 1 MW in size)
13	Biomass	Liquid fuels to displace oil (100 times current biofuel capacity)
14	Forestry	Stop deforestation; reestablish 300 million ha in new plantations
15	Crop management	Apply conservation tillage to crop lands (10 times current level)

Source: Pacala and Socolow (2004).
GW = gigawatts; MW = megawatts.

Perhaps most important in implementing a successful energy plan is the ability to bring about behavioral change, and to identify the elements needed to catalyze this change within the community at large.

use (Sadownik and Jaccard 1999). Aspects of community planning that relate to sustainable energy planning can include net-zero energy homes, advanced vehicles, and innovative utility energy management, among others (Carlisle et al. 2008). Perhaps most important in implementing a successful energy plan is the ability to bring about behavioral change, and to identify the elements needed to catalyze this change within the community at large.

In southeast Alaska, energy issues are at the heart of the economic viability and sustainability of many communities. However, a complicating factor in energy management strategies is the two-tiered nature of energy generation, in which some communities in Alaska enjoy relatively low-cost hydroelectric power while other, often smaller, communities depend exclusively on the costly use of diesel generators. With generally increasing fossil fuel prices, interest in renewable energy and energy conservation has never been greater. In many respects, Alaskan communities are more vulnerable than similar communities in the continental United States owing to Alaska's remoteness and longer heating seasons, among other factors. In this report we address some of these issues, discussing themes of interest to Sitka, Alaska, and southeast Alaska as a whole. We hope that this will be useful information for municipal officials and other energy users whose actions influence community energy planning decisions.

Objectives

Our aim is to evaluate Sitka's energy needs and management, assessing local resource availability. We identify the role that increased energy efficiency and energy conservation could play in community energy management strategies. We also emphasize the importance of community participation and the need for "project champions" when implementing projects. Finally, we consider the broader role of community energy management throughout southeast Alaska, including other communities dependent on hydroelectric power as well as communities having different energy sources.

This research attempts to answer the following questions relevant to community energy management in Sitka:

1. What are the opportunities for Sitka to expand its renewable energy project infrastructure?
2. What energy management strategies can assist with steps toward energy independence?
3. What technologies can assist in diffusion of renewable energy at the community level?

Hydroelectric Power in Southeast Alaska—An Abundant Resource?

Most communities in southeast Alaska are characterized by remote island locations with rugged topography and high rainfall—conditions often conducive to hydroelectric power generation. Abundant hydroelectric power provides about 208 megawatts (MW) of installed capacity to southeast Alaska communities (table 2). Statewide, Alaska derives close to 21 percent of its electricity demand from hydroelectric power (REAP 2011).

Table 2—Hydroelectric power projects in southeast Alaska (completed and proposed)

Location	Name	Size	Status
		Megawatts	
Juneau	Annex Creek	3.6	Completed (in operation)
Ketchikan	Beaver Falls	5.4	Completed
Klawock	Black Bear Lake	4.5	Completed (1995)
Petersburg	Blind Slough	2.0	Completed (1920s)
Sitka	Blue Lake	6.0	Completed (1961)
Metlakatla	Chester Lake	1.0	Completed
Skagway	Dewey Lakes	0.94	Completed (early 1900s)
Gustavus	Falls Creek	0.8	Completed (2009)
Skagway/Haines	Goat Lake	4.0	Completed (1997)
Juneau	Gold Creek	1.6	Completed (1950s)
Sitka	Green Lake	18.6	Completed (1979)
Haines/Skagway	Kasidaya Creek	3.0	Completed
Ketchikan	Ketchikan Lakes	4.2	Completed (1957)
Juneau	Lake Dorothy	14.3	Completed (2009)
Pelican	Pelican	0.7	Completed (1988)
Petersburg	Petersburg	2.0	Completed
Metlakatla	Purple Lake	3.9	Completed
Juneau	Salmon Creek	6.7	Completed (1984)
Ketchikan	Silvis Lake	2.1	Completed (1968)
Juneau	Snettisham	78	Completed (1979)
Prince of Wales Island	South Fork Black Bear	2.0	Completed (2005)
Ketchikan	Swan Lake	22.4	Completed (1983)
Wrangell	Tyee	20.0	Completed
Total installed capacity (completed)		207.74	
Ketchikan	Mahoney Lake	9.6	Proposed
Prince of Wales Island	Reynolds Creek	5.0	Proposed
Ketchikan	Whitman Lake	4.6	Proposed
Total capacity (proposed)		19.2	

Source: REAP 2011; http://alaskarenewableenergy.org/alaskas-resources/projects-in-alaska/.

In contrast, communities that rely on fossil-fuel-derived electricity (i.e., diesel generators) can experience very high electricity costs, sometimes greater than $0.50 per kilowatt-hour (kW-hr) (table 3). This creates completely different energy conservation imperatives and energy use patterns versus communities (such as Sitka) that enjoy electrical rates closer to $0.10 per kW-hr. When diesel generators are used for backup generation in hydroelectric-dependent communities, short-term energy cost spikes can result. For example, in Sitka, four diesel generators can produce 11.4 MW of backup electricity, at a cost of about $0.33 per kW-hr (more than three times the cost of the hydroelectric power normally supplied) (CBS ED 2008a). Sitka's diesel generating capacity would cover only about 71 percent of the summer peak requirements (estimated to be 16 MW), and just over 50 percent of the winter peak demand (22.5 MW). However, it is estimated that, under certain circumstances during winter weather, the diesel backup would be able to provide only about 25 percent of Sitka's electrical needs (Brewton 2012). These factors illustrate a strong vulnerability in Sitka's current electrical use patterns. If transmission lines were disabled, isolating all of the hydroelectric power generation from use, sudden and significant energy conservation would be needed.

Other communities in southeast Alaska have developed their own hydroelectric power resources. A total of 23 hydroelectric power projects are in operation in southeast Alaska with three more projects proposed (table 2). Additional hydroelectric projects are likely in the near future (Black and Veatch 2011). Several other recent developments reflect increased dependence on renewable energy projects in southeast Alaska.

- Increased hydroelectric power capacity, including a planned expansion of the Blue Lake facility near Sitka
- Increased use of alternative-fuel vehicles (vegetable oil, electricity)
- Wood fuel initiatives (including the Coast Guard base in Sitka)
- Other funded renewable energy projects for southeast Alaska (tables 4 and 5)

Among the most important elements of successful community projects are community activism and stakeholder participation.

Among the most important elements of successful community projects are community activism and stakeholder participation. Sitka is characterized by high levels of community involvement, in part with such wide-ranging environmental causes as energy conservation and renewable-energy project development. Several recent examples of community participation in energy-related activities in Sitka are noted:

- Completion of a climate action plan for municipal operations (CBS 2010)
- Power Supply Status (green light/yellow light/red light) system to indicate level of hydroelectricity production
- Local foods network, where residents can share or sell locally grown foods
- Active recycling program; recently expanded to a new location

Table 3—Electric power costs in southeast Alaska communities

Community	Population in 2009 (age 16 and older)	Energy provider	Primary power source	Electrical generating capacity	Average electricity cost
				Megawatts	*Cents per kilowatt-hours*
Haines	1,884	Alaska Power Company	Diesel	7.45	21.2
Angoon	344	Inside Passage Electric Coop.	Diesel	1.83	54.7
Gustavus	355	Gustavus Electric Company	Hydroelectric and diesel	0.80	26.0
Hoonah	662	Inside Passage Electric Coop.	Diesel	3.06	54.0
Pelican	110	Pelican Utility Company	Hydroelectric and diesel	2.66	16.8
Elfin Cove	25	Elfin Cove Utility Commission	Diesel	0.35	52.0
Klukwan	72	Inside Passage Electric Coop.	Diesel	1.17	54.0
Juneau	23,184	Alaska Electric Light and Power Co.	Hydroelectric	214.61	9.0 to 12.0
Ketchikan	5,708	Ketchikan Public Utilities	Hydroelectric	64.05	9.6
Kake	395	Inside Passage Electric Coop.	Diesel	3.39	54.0
Petersburg	2,353	Petersburg Municipal Power & Light	Hydroelectric	10.60	11.8
Coffman Cove	138	Alaska Power Company	Diesel	0.74	39.0
Craig	838	Alaska Power Company	Hydroelectric	5.00	19.2
Hydaburg	254	Alaska Power Company	Hydroelectric	1.02	19.2
Kasaan	43	Alaska Power Company	Hydroelectric	0.25	19.2
Klawock	598	Alaska Power Company	Hydroelectric	1.38	19.2
Thorne Bay	368	Alaska Power Company	Hydroelectric	2.03	19.2
Metlakatla	1,036	Metlakatla Power and Light	Hydroelectric	8.24	9.2
Naukati Bay	118	Alaska Power Company	Diesel	0.53	48.4
Sitka	6,231	Sitka Electric Department	Hydroelectric	34.84	14.2
Skagway	740	Alaska Power Company	Hydroelectric and diesel	4.84	21.2
Wrangell	1,727	Wrangell Municipal Light and Power	Hydroelectric	32.70	12.6
Yakutat	500	Yakutat Power	Diesel	3.51	41.1

Source: U.S. Department of Commerce Economic Development Administration (2010).

- Increased use of electrically powered vehicles
- High level of environmental issue awareness in local print and broadcast media
- Installation of residential-scale solar and wind energy systems
- Proactive municipal electric department, with various outreach activities encouraging responsible energy use (energy use estimator, energy savings tips, energy conservation brochures, etc.)

Table 4—Alaska renewable energy fund ranking for Round 3 (current February 2010)

Project title	Energy user	Project	Renewable energy
Hoonah-IPEC Hydroelectric Project	Inside Passage Electric Cooperative	Utility	Hydroelectric
Neck Lake Hydroelectric Project	Alaska Power and Telephone Company	Utility	Hydroelectric
Biomass Fuel Dryer Project	City of Craig	Government	Biomass
Reynolds Creek Hydroelectric Transmission Line	Alaska Power Company	Utility	Transmission
Indian River Hydroelectric Project	City of Tenakee Springs	Utility	Hydroelectric
Whitman Lake Hydroelectric Project	Ketchikan Public Utilities Electric Division	Utility	Hydroelectric
Connelly Lake Hydroelectric Project	Alaska Power Company	Utility	Hydroelectric
Takatz Lake Hydroelectric Feasibility Analysis	City and Borough of Sitka Electric Department	Utility	Hydroelectric
Thayer Lake Hydroelectric Power Development	Kootznoowoo Inc.	Independent power producer	Hydroelectric
Elfin Cove Hydroelectric Project	Elfin Cove Utility	Utility	Hydroelectric
Gastineau Elementary School Geothermal	City and Borough of Juneau	Government	Geothermal
Spur Road Distribution Line Extension	City and Borough of Wrangell	Government	Hydroelectric
Schubee Lake Hydroelectric Project	Alaska Power and Telephone Company	Utility	Hydroelectric
Port Frederick Tidal Power Project	Alaska Power and Telephone Company	Utility	Ocean/River
Hoonah Schools Biomass Heating System	Hoonah City School District	Government	Biomass
Metlakatla-Ketchikan Intertie	Metlakatla Indian Community (MIC)	Government	Transmission
Yakutat Wave Energy Pilot Demonstration	City and Borough of Yakutat	Government	Ocean/River
Tenakee Inlet Geothermal	Inside Passage Electric Cooperative	Utility	Geothermal
Ruth Lake Hydroelectric Project	City of Angoon	Government	Hydroelectric
Scenery Lake Hydroelectric Project	City of Angoon	Government	Hydroelectric
Angoon Tidal Power Project	Blue Energy Canada, Inc.	Independent power producer	
Triangle Lake Hydroelectric Project	Metlakatla Indian Community	Government	Hydroelectric
Sunrise Lake Project	City and Borough of Wrangell	Government	Hydroelectric
Wrangell Downtown Revitalization	City and Borough of Wrangell	Government	Transmission
Wrangell Street Light Conversion	City and Borough of Wrangell	Government	Other
Alaska–British Columbia (AK-BC) Intertie Project	City and Borough of Wrangell	Government	Transmission

Table 5—Summary of projects listed in table 4 (Alaska Renewable Energy Fund Ranking)

	Government	Utility	Independent power producer	Total
		Number of projects		
Project type	13	11	2	26

	Hydroelectric	Geothermal	Transmission	Biomass	Ocean/river	Other	Total
			Number of projects				
Renewable energy	14	2	4	2	2	2	26

Source: Alaska Energy Authority (2010).

Renewable Energy Profile for Sitka, Alaska

Sitka is a remote island community with few direct ties to urban centers, and has a limited road system and transportation infrastructure (with less than 20 miles of primary paved roads). Although there are more than 9,800 registered vehicles in Sitka (ADA DMV 2012) many residents drive just a few thousand miles per year. Much of the road system is flat, and this lack of hills bodes well for less-powerful vehicles, including electric vehicles. Sitka's relatively mild maritime climate results in essentially no air-conditioning needs in the summer, and, by Alaska standards, a relatively mild winter heating season. Sitka is renowned for its concerned and proactive citizens, who could likely garner community support on a broad scale. Almost all of Sitka's electricity is generated from sources of hydroelectric power, including the Blue Lake facility (6-MW capacity, established in 1961) and the Green Lake facility (18.6-MW capacity, established in 1979) (CBS ED 2011) (fig. 1). Within the past decade, increasing electric load growth has created a strong need to explore options for increasing generating capacity.

Community Energy Management—From Theory to Practice

Community energy management combines planning concepts with energy management concepts, and can be implemented at the scale of neighborhoods, cities, and even small regions (Jaccard et al. 1997). This multidisciplinary field can encompass land use planning, transportation management, and site design, as well as energy supply and management. Aspects of community planning that relate to sustainable energy planning can include net-zero energy homes, advanced vehicles, innovative utility energy management, and other sustainable living practices (Carlisle et al. 2008). Community energy planning has become central to communities for establishing renewable energy goals, setting emission reduction targets, and providing affordable energy to residents. For example, the city of Banff, Alberta, Canada, has developed a community energy plan to reduce household energy costs by 7

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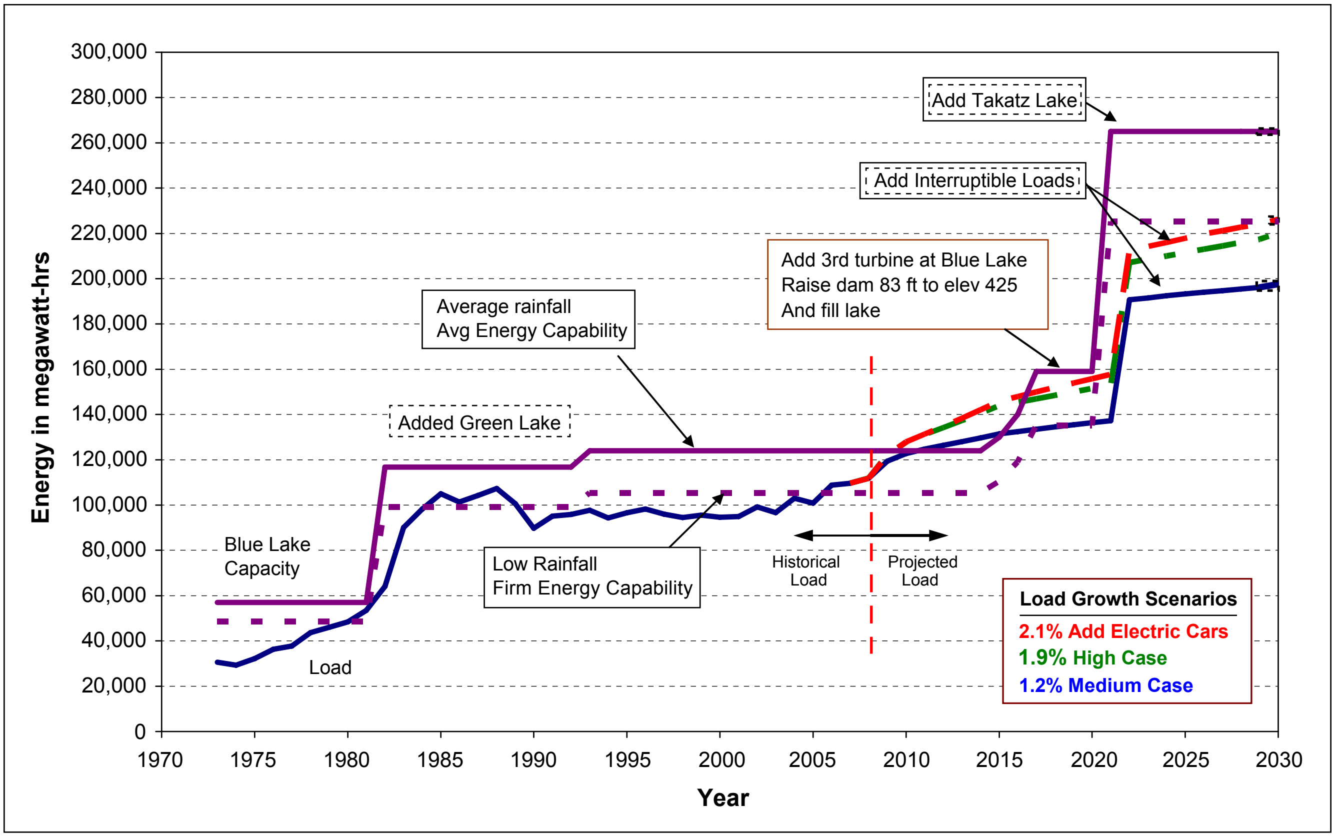

Figure 1—Electrical energy requirements and power resources for Sitka, Alaska (1973–2030). Source: City and Borough of Sitka Electric Department (2008a).

percent, reduce CO_2 emissions by 20 percent below 1998 levels, and realize aggregate savings of about $20 million over a 12-year period (Sheltair Group Resource Consultants Inc. 2000). Other researchers have indicated the importance of community energy management (Jaccard et al. 1997), community energy planning (St. Denis and Parker 2009), community-owned energy production (Walker 2008), and sustainable energy for rural communities (Banister 2005, Byrne et al. 1997, Carlisle et al. 2008, Hillring 2002, Marsden and Smith 2005, Smith 1998).

Many communities in southeast Alaska already have substantial hydroelectric resources and could benefit from a comprehensive community energy plan, integrated into existing community practices, to further reduce their carbon footprints. Of particular interest is how secondary renewable technologies (e.g., wood, wind, and solar) could supplement hydroelectric power. Because Sitka is an island community, certain unique issues need to be considered, including transportation energy needed to import most of its consumer goods as well as construction materials. Community energy planning could have several important ramifications, including encouraging energy conservation and awareness of energy issues. For example, hydroelectric resources in Sitka are characterized by a red, yellow, and green "traffic-light" system that reflects the city's current power supply. When lake levels are low, and generating capacity is limited, public awareness of a "red light" status can serve to stimulate conservation.

One approach that could be used for diagramming planned greenhouse gas (GHG) emissions is based on "Socolow's wedge." Conceptually, each stabilization wedge can be thought of as one component in reducing climate change. The triangular wedges can be added together to form a larger wedge, signifying the total effect. In practice, Socolow's wedges can depict diagrammatically how climate change can be reduced over time versus "business as usual." Although the original development (Pacala and Socolow 2004) was applied to a global scale, it can be adapted to much smaller scales, including the community level. The rationale behind reduction wedges is that each wedge, once realized, would represent one aspect of GHG reductions. In Sitka, four primary wedges have been identified as having strong potential for reducing GHG emissions: (1) residential energy conservation; (2) increased use of wood energy for home heating; (3) increased use of alternative fuel vehicles, such as electric cars; and (4) increased use of electricity for home heating (Nicholls 2010). In practice, however, any number of GHG reduction areas could be identified, each representing a wedge.

Community Energy Themes—Practical Planning Considerations for Managers

In the following section, we review a number of themes that could be of interest to community energy planners. We attempt to identify practical examples and lessons learned for different geographic regions, including southeast Alaska, the United States, and internationally.

Theme: New energy sources and technologies—
Community energy management strategies are likely to become more significant as new energy types become integrated into mainstream energy use to displace fossil fuels. Integration of several renewable energy forms (wind, solar, and hydroelectric power) into small, village-scale energy systems is sometimes possible. In some cases, it may be desirable to have integrated hybrid energy systems, with diesel generators meeting baseload needs and renewable energy providing peak power. This energy delivery strategy is sometimes used in rural western Alaska, using hybrid diesel-wind systems (Baring-Gould 2008), and has been used in combination with battery systems to manage diesel fuel use more efficiently (Flowers et al. 2000).

Community energy management strategies are likely to become more significant as new energy types become integrated into mainstream energy use to displace fossil fuels.

A coherent strategy for sustainable energy management could be especially important for communities that are on isolated grid systems, including many in southeast Alaska. For example, Stirling engine technologies,[1] although not widely adopted, have been considered for meeting the electricity needs of rural villages (Podesser 1999). Other strategies could include incrementally reducing demands for a primary energy source by gradually "phasing in" one or more secondary sources. For example, although Ketchikan, Alaska, is highly dependent on hydroelectric power, at least four wood pellet systems are in development (including the city's federal building, Discovery Center, public library, and fire station). Similarly, Juneau, Alaska, primarily uses hydroelectric power; however a wood pellet heating system recently was installed to heat a downtown office building, burning close to 300 tons of pellets per year and displacing 35,000 gallons per year of heating oil (Soboleff 2011). Kodiak, Alaska, made significant strides to reducing its carbon footprint by installing three large wind turbines (each 1.5 MW in capacity) (Tetra Tech 2011), adding to its abundant hydroelectric power resources.

The "learning curve" for the first renewable energy systems in a given community could present challenges, although successful examples will make it easier to implement subsequent projects. For example, on Prince of Wales Island, the first chip-fired wood energy system in Alaska was recently established in the town of Craig (Bolling 2007). This pioneering facility has spawned a great deal of interest in wood energy locally and statewide. More recently, interest in wood pellet production on Prince of Wales Island could lead to new wood energy opportunities while strengthening wood products firms located near Thorne Bay, Alaska (Pedersen 2011). Although the diffusion of new renewable energy technologies can be a slow process, such as use of wood energy in southeast Alaska, innovation among participating firms can help lead this process (Jacobsson and Johnsson 2000).

In Sitka, hydroelectric power meets most of the community's energy needs, although use of fossil fuels for transportation (on land, air, and water) is substantial. A new renewable energy product, the all-electric vehicle, could see broad-scale adoption once commercially produced vehicles become available and recharging stations are established. Throughout Alaska, a grant program administered by the Alaska Energy Authority is providing grant funding for renewable energy systems across different technologies. This is apparent in the growth of the wind energy

[1] A Stirling engine is an external combustion reciprocating engine having an enclosed working fluid that is alternately compressed and expanded to operate a piston (The FreeDictionary 2012). Because Stirling engines are not powered by combustion, there is no exhaust, and they can therefore be used in specialized applications, such as submarines or auxiliary power generators, where quiet operation is important. In other applications, the energy to heat the working fluid can be supplied by wood or other forms of biomass.

sector, with at least seven communities in Alaska having wind energy systems (Alaska Energy Authority 2011).

Statewide, wood energy has also seen significant growth, with more than nine small-industrial scale systems now operating in Alaska (Nicholls 2009). In southeast Alaska, interest in wood pellet systems has also been very high. An advantage of wood pellets in southeast Alaska is their lower cost of transportation over longer distances compared to wood chips, which are economical to transport for only relatively short distances.

Theme: Identify energy "forte"—
Communities can identify their "forte," or strong suit, for successful energy project development. For example, many communities would have at least one area of "low-hanging fruit" that would represent their most viable form of renewable energy, whether hydroelectric power, wind, solar, or biomass. In most cases, a community's energy forte would be very closely related to the community's resource availability. For example, Sitka relies heavily on hydroelectric power while Craig, with a more extensive road system and wood products infrastructure, has a stronger bioenergy focus. However, the idea of a community energy forte must be tempered by the reality that many community-scale energy projects can be very complicated, with intertwined factors. For example, in Sitka, state regulations have restricted development of an otherwise promising hydroelectric project at Lake Diana.

In some cases, communities should favor a mix of renewable energy technologies rather than rely on an energy forte. For example, Tsioliaridou et al. (2006) used sensitivity analysis and simulation to determine optimal proportions of energy technologies for the island of Crete. Their research found onshore wind energy and biomass to be leading renewable energy options (while small-scale hydroelectric and solar energy were less favorable). Perry et al (2008) and Ryden et al. (1993) emphasized the importance of integrated energy sectors that could include several types of renewable energy systems to supplement fossil fuel systems.

Theme: Community acceptance and public participation—
Community acceptance can be evaluated in the context of specific acceptance of renewable energy projects and siting decisions by local stakeholders, including residents and local authorities (Wustenhagen et al. 2007). There is some debate over the importance of NIMBY ("not in my backyard") objections to renewable energy projects (Wustenhagen et al. 2007). In Sitka, the NIMBY element for hydroelectric projects located several miles from town would perhaps not be as pronounced as for other types of renewable energy (e.g., a wood-burning facility located in town). Therefore, community acceptance of environmental impacts will need to be an important part of any renewable energy project.

Community energy management strategies should be developed with extensive public participation (Roseland 2000) and stakeholder involvement (Smith 1998). Many local governments have embraced community energy management principles; in Vermont more than 75 communities have established local energy coordinators or town energy committees (Van Hoesen and Letendre 2010). Community energy management strategies should be developed with extensive public participation (Roseland 2000). In particular, this is seen with regard to community wood energy systems, where project teams can include diverse members such as administrators, system operators, contractors, architects, and engineers (Maker 2004). For larger capital projects, public support may be required through taxpayer approval. Also desirable is having one or more "project champions" to provide local support and coordination. Sometimes project champions can spend several years setting the groundwork for a successful bioenergy project. For example, the Craig, Alaska, wood energy facility (started in 2009) had been in planning for several years.

Wustenhagen et al (2007) identified three components of social acceptance for renewable energy project development: community acceptance, market acceptance, and sociopolitical acceptance. Adoption of renewable energy projects in Sitka is likely to involve participation from a number of community stakeholders.

The Tongass Futures Roundtable is a collaborative effort established to address community resource issues on the Tongass National Forest in southeast Alaska, including renewable sources (Tongass Futures Roundtable 2011). Key members of the group include representatives of the Tongass, Sealaska Corporation, the Wilderness Society, the Audubon Society, The Nature Conservancy, Native organizations, fishing interests, and city government. Because this collaboration represents interests spanning much of the 17-million-acre Tongass, it also addresses issues of community importance.

Bergmann et al. (2006) found that rural residents place a high value on wildlife, thus any renewable energy projects with the potential to harm wildlife would need to have large offsetting benefits. The significance of this in southeast Alaska is that forest thinnings have been conducted throughout the Tongass to improve wildlife habitat (primarily to increase deer forage), while also providing the potential for biomass removals. On Prince of Wales Island, forest thinnings are being conducted that are designed to improve wildlife habitat (primarily for deer) while also providing the potential for biomass utilization. In the Staney Creek watershed, an integrated resource management plan (IRMP) has been facilitated by The Nature Conservancy, the Wilderness Society, and the U.S. Department of Agriculture (USDA) Forest Service (ConserveOnline 2011). In 2010, a series of public meetings were held to develop a shared vision among local and regional stakeholders.

Theme: Energy conservation as part of community energy management—
A desirable condition for sustainable communities is a reduction in per capita consumption of resources as communities grow (Roseland 2000). Incentives can be put in place to motivate energy conservation while providing community economic incentives. For example, Davis, California, created a program in the early 1980s to encourage residents to reduce peak energy use (Kowalczyk et al. 1983). Here, the municipal utility was rewarded $10,000 for each 1 percent of overall energy conservation during a summer season. Total electricity consumption during the study period was reduced by 7 percent, and an estimated 54 percent of residential customers participated in this program. One of the strategies employed in the Davis program was to target certain areas for energy conservation (e.g., reduced air conditioning).

Similar strategies could be employed in Sitka, such as prudent use of electric space heaters to reduce overall electric load. In Sitka, a "cost of service" model for electric rates is used. Typically, larger users are less costly for the local utility to serve on a per kilowatt-hour basis, with the added benefit of commercial users providing employment (Brewton 2012). In 2008, the largest 12 electrical users in Sitka consumed more than 19.7 gigawatt-hours (GW-hrs) (CBS ED 2008a), and 17 of the top 25 accounts (based on kilowatt hours consumed) were government entities (Brewton 2012). The Davis energy conservation program found that once programs like this are started, there can be a residual (or carryover) effect of continued conservation after the formal program ends. This was observed in Juneau during spring 2008 when an avalanche damaged a transmission line, resulting in a loss of hydroelectric power that had to be replaced with expensive diesel generation. Rates increased from $0.11 to more than $0.50 per kW-hr (Golden 2008). During the period of high energy prices in Juneau, strong conservation programs were put in place, reducing peak energy use from about 1,000 MW-hrs per day to roughly 600 MW-hrs per day, a reduction of about 40 percent (USDOE 2008).

Theme: Adopting a bottom-up approach—
Sustainable energy management models should favor a "bottom-up," or grassroots approach to ensure the involvement of all stakeholders (Roseland 2000, Ryden et al. 1993). An emerging trend is the development of community energy plans that focus on local action. St. Denis and Parker (2009) found that communities tend to focus on policies and practical programs to increase energy efficiency and conservation, and that less attention is devoted to implementing renewable energy technologies. This research also found that, for small communities in Canada, the most common renewable energy technology goal was use of biofuels for transportation. Further, a goal of many community energy programs was to set ambitious GHG reduction

targets for municipal operations while setting less-stringent targets for the community at large (St. Denis and Parker 2009). In this way, the broader community could follow the successful examples already implemented by the municipality. This has been the case in Sitka, where a community action plan has been completed (CBS 2010) that considers only municipal operations.

Small communities can become leaders in introducing renewable energy systems (St. Denis and Parker 2009). This trend is also apparent in rural Alaska, where significant strides toward renewable energy have occurred in the past decade, notably with wind energy systems (Alaska Energy Authority 2011). A central theme is that significant changes, including reductions in GHGs, can be made at the community level. A comparison of five Swedish communities working together has also illustrated the importance of a bottom-up approach as well as using a portfolio of renewable energy technologies to meet goals (Ryden et al. 1993). Many positive changes can be made at the grassroots level with little or no capital investment; for example, household actions can reduce overall energy use with little or no reduction in household well-being. These actions could potentially save up to 20 percent of household direct emissions (7.4 percent of U.S. national emissions) (Dietz et al. 2009).

Theme: Community energy and the role of climate action plans—
In 2007, statewide CO_2 emissions in Alaska were estimated to be more than 43 million metric tons (USDOE EIA 2009). Several communities across Alaska have developed climate action plans. As of July 2011, climate action plans have been completed by Sitka (CBS 2010) and by Homer (Parks et al. 2007). Juneau has completed a plan that is in public review (Bus et al. 2011), and Anchorage has a proposed plan (Kimmel and Pace 2007). Nationally, dozens of cities have developed climate action plans, ranging in size from Burlington, Vermont, to Los Angeles, California (City of Louisville 2011). Further, numerous federal agencies have adopted climate change action programs. Climate action plans are useful for identifying many grassroots efforts that could be practiced at the community level, including efficiency improvements to schools and other public buildings, as well as individual energy reductions.

An important aspect of community energy management is setting GHG emission-reduction targets, as well as having a well-defined baseline. Often, it is beneficial to first implement GHG reduction measures within municipal or other government structures, followed by diffusion to the community at large and to businesses (as is the case with Sitka's climate action plan). In Sitka, an emissions reduction goal of 25 percent for municipal operations has been set for 2020, based on a baseline year of 2003 (CBS 2010). The Homer plan recommends

GHG emission reductions of 12 percent by 2012 and 20 percent by 2020 (using a baseline year of 2000) (Parks et al. 2007).

Theme: "Island" energy technologies—
Sitka has an isolated grid system that is not shared with other neighboring communities, and therefore is entirely dependent on the energy it generates. Other communities in southeast Alaska are also characterized by isolated grid energy systems, in which all the energy users are located near the power plant. Hiremath et al. (2007) indicated a need in rural areas for greater levels of decentralized energy planning as well as a shift to greater levels of renewable energy production. This illustrates the importance of improving the cost-effectiveness of technologies for small-scale, decentralized cogeneration of heat and electricity, especially if heat requirements are concentrated (Jaccard et al. 1997). In rural Alaska, small-scale cordwood energy systems are popular for community heating where either a single building or several buildings are heated (Nicholls 2009); however, it is unlikely that cordwood energy systems could be the sole energy provider for communities in southeast Alaska.

The geographical coverage of decentralized energy models has an important impact on how energy is supplied to rural communities. Hiremath et al. (2007) considered three levels of decentralized energy planning: the village level, the block level (a cluster of villages), and the district level (a scale potentially involving several thousand villages over numerous blocks). In Alaska, the most relevant level of planning would likely be the village level (i.e., where a single village or community is self-contained in terms of its energy use and generation). However, examples of the block or cluster level to which Hiremath referred are also evident in cases where transportation corridors connect communities. Examples include communities connected by the Prince of Wales Island road system, and communities located along the Yukon or Kuskokwim River in interior Alaska. In both cases, wood fuel could easily be shared among communities (by road or by river), in effect creating a cluster relationship.

Island energy systems could become renewable energy "testbeds," with potential to become energy self-sufficient in the sense that they neither import fossil fuels to the island nor share an electrical connection to a nearby mainland (Duić and da Graça Carvalho 2004). Higher energy costs in island communities can make renewable energy more economically viable because they would be less likely to compete with large-scale fossil fuel systems found in areas connected to electrical grids providing lower cost power. This can be facilitated in part by the high cost of providing energy from mainland sources to islands (Weisser 2004). Rural communities that are connected by centralized grids (that are also shared by large cities) tend to be more vulnerable to power interruptions (Van Hoesen and Letendre 2010), a potential advantage of isolated grid systems.

Small-scale, community renewable energy systems should not be overlooked as important components of large-scale national energy goals.

Theme: Community energy management to reach broader goals—
Small-scale, community renewable energy systems should not be overlooked as important components of large-scale national energy goals. Community energy efforts, if adopted on a sufficiently broad scale, can have a significant effect on reaching national renewable energy goals (Hain et al. 2005). Small-scale systems (ranging from 100 kW to 5 MW) that closely match local electrical needs can be more stable and less expensive to operate than larger systems, under certain scenarios. Walker and Devine-Wright (2008) emphasized the importance of community energy projects with respect to mainstream energy policy. They reviewed how "process" and "outcome" can interact to influence outcomes of renewable energy projects. In particular, processes that are "open and participatory," combined with outcomes that are "local and collective," could be considered ideal community energy projects because they are carried out by community members for the benefit of the local community.

Theme: Landscape-level resource utilization—
In Sitka, community energy management actions could have implications at the forest landscape level. For example, hydroelectric power projects in southeast Alaska can have broad-ranging impacts on local resources such as fish, timber, biodiversity, and others. Local residents must weigh the benefits of site-specific renewable energy versus the anticipated impacts. Several proposed hydroelectric projects or expansions in recent years have illustrated the impact of energy use at the landscape level. For example, Lake Diana near Sitka was a proposed hydroelectric project located near a wilderness area on the Tongass National Forest. This project was not pursued, in favor of an expansion of the existing Blue Lake reservoir near Sitka. By raising the dam height at Blue Lake, this project has potential impacts owing to the increased lake size, loss of forest ecosystem, and other landscape-level considerations. However, this project will also provide potential benefits such as improved water temperatures for fish habitat and displacement of diesel fuel use (Brewton 2012).

Perhaps the broadest example of landscape-level planning in southeast Alaska is the electrical intertie project, a plan to connect numerous dispersed communities with hydroelectric resources. Although several exploratory studies have been completed for possible interties, including one from Juneau to Hoonah (Emerman 2006) and one from southeast Alaska to British Columbia (Hatch Acres Corporation 2007), their high cost is a limiting factor along with numerous technical challenges (Brewton 2012).

Lessons can be learned from other regions of the Nation. In the Upper Midwest region, wind energy farms have been established over extensive rural areas. As of 2009, a total of 5,414 MW of wind energy has been installed in Minnesota and

Iowa (USDOE 2011). Additional wind farms are in operation in Indiana, including the 400 MW Fowler Ridge wind farm (the largest wind farm in the Midwest). All one has to do is fly over these regions to appreciate the landscape-level changes that are taking place. At the same time, social opposition to landscape-level changes (e.g., reduced viewscapes from wind energy projects) can hamper renewable energy project development.

Theme: Self-sufficient communities—

Communities can make a collective choice to become energy independent, deriving most or all of their energy from renewable sources. For example Gussing, Austria, (population 3,900) has established 27 separate renewable energy plants, creating employment of close to 1,000 jobs (including direct and indirect employment). In doing so, Gussing has become the first community in the European Union to reduce carbon emissions by more than 90 percent (Tirone 2007). Vaxjo, Sweden, also realizes significant contributions of renewable energy. Well-defined community energy plans can be an important step, in addition to policy measures, toward supporting renewable energy project development.

Communities can make a collective choice to become energy independent, deriving most or all of their energy from renewable sources.

Bergmann et al. (2008) found that, compared to urban residents, rural respondents placed a higher value on the creation of new permanent jobs and were more willing to tolerate negative landscape impacts resulting from renewable energy project development. This would suggest that rural areas may actually have some advantages versus urban projects despite lacking the economies of scale often associated with urban settings.

Theme: "Rainmaker" projects—

One strategy that communities can employ is to invest in large-scale projects, designed to meet their long-term energy needs, perhaps decades into the future. Here, installed energy capacity is added in "chunks" rather than incrementally. For example, the proposed Susitna hydroelectric project near Talkeetna, Alaska, could supply up to 2,600 GW-hrs of electricity per year to Alaska's railbelt—enough to allow Alaska to achieve the state energy goal of 50-percent renewable energy by 2025 (Alaska Energy Authority 2010). However, the leading proposal for the Susitna project would cost about $4.5 billion, and require construction of a 700-ft-high dam[2] (Mauer 2011). Although these projects can potentially take care of demand growth for decades in the future, they are often very expensive. In the case of the Susitna project, the cost would be roughly $7.5 million per installed megawatt. Near Sitka, the 27-MW Takatz Lake project has been proposed. If completed, this project would generate about 107 GW-hrs of electricity per year (CBS ED 2008a), almost

[2] By comparison, Hoover Dam (located on the Arizona/Nevada border) is 726.4 ft high.

doubling Sitka's current generating capacity (fig 1). However, the Takatz Lake facility is projected to have a construction cost of more than $200 million (CBS ED 2011), including expensive transmission tunnels on Baranof Island. Despite high initial costs, hydroelectric projects can offer attractive life-cycle costs owing to their long service lives (often up to 100 years) (Brewton 2012).

One advantage of "rainmaker" projects is the added local employment, especially during the construction stages. For example, the Blue Lake expansion could provide work to about 30 employees over a period of about 7 years (CBS ED 2008a), with estimates of 50 to 100 jobs during the 2- to 3-year construction phase (Brewton 2012). This is generally consistent with research by Bergmann et al. (2008), which found that rural residents tend to be highly supportive of renewable energy projects that create new permanent jobs (more so than their urban counterparts).

These two case studies illustrate that large projects can sometimes provide decades of energy security. Greater energy resources could attract new industry to regions, stimulating economic growth. Reliable, long-term energy resources can also reduce the need to "juggle" primary sources (e.g., hydroelectric) and intermittent or backup sources (e.g., diesel) as is currently being done in Sitka. On the other hand, a sudden surplus of energy could diminish energy conservation efforts or perceptions among community members that energy is a scarce resource that should be conserved (especially if accompanied by a rate decrease). Another potential disadvantage of "rainmaker" projects is that they necessarily "lock in" a given energy technology for decades, preventing the use of new and emerging technologies that could potentially cost less. For example, if cost-reducing breakthroughs were to occur in wind, solar, or geothermal energy within the next few decades, the large scale hydroelectric facilities would take precedence so that their high construction costs could be recovered.

Community Energy Management in Sitka, Alaska

Opportunities for Sitka have been identified to increase its energy independence through community energy management strategies. For Sitka, there are great opportunities to expand its utilization of hydroelectric power to displace fossil fuels for current residential heating and future transportation needs. However, this will require careful management of new electrical generating capacity, as well as a community-wide commitment to energy conservation. This commitment is illustrated by local residents' purchase of energy-efficient appliances as part of the "Energy Star Rebate Program" in 2012 and 2013. Here, a total of 194 appliances were purchased for residential use, including freezers (18), heat pumps (43), refridgerators (75), and washing machines (58) (Agne 2013). The Blue Lake hydroelectric power expansion project, which could increase Sitka's capacity by 34 GW-hrs per year (roughly 27 percent of Sitka's current electrical use) (CBS ED 2011), could provide a golden opportunity for greater energy independence. However, this assumes that successful energy practices could help limit future growth. This will be important because Sitka's energy use has been increasing dramatically since 2005. With rising prices for heating oil, more residents are switching to electric heating, causing electric demand to increase 5 percent in 2006, and 3 to 5 percent annually in 2007 and 2008. This is considerably higher than historical growth rates of about 0.8 percent per year (CBS ED 2011), but still lower than the cumulative average growth from 1973 to present of about 3 percent (Brewton 2012).

Substantial reductions in Sitka's fossil fuel use could be facilitated by new commercial technologies, including electric vehicles.

Substantial reductions in Sitka's fossil fuel use could be facilitated by new commercial technologies, including electric vehicles with a driving range of at least 20 miles (the approximate length of Sitka's road system). Electric vehicles are already starting to be used in Sitka, and in Petersburg, Alaska, about eight electric vehicles have been acquired (Viechnicki 2008). Sitka, Petersburg, and other communities in Alaska that have limited road systems and relatively low driving speeds could become early adopters of electric cars. Electric vehicle use is finding policy support as well—Senate Bill 59 has recently been passed, allowing low-speed vehicles on roads having posted speed limits of 45 miles per hour (mph) or less (AHSO 2010).

As electric vehicle technologies evolve, including batteries that offer greater driving ranges, communities with more extensive road systems could benefit. Although widespread use of electric vehicles could affect electricity use, adoption on a limited scale could be done in balance with other community needs. The potential of electric vehicle use in Sitka was significant enough to be included in the 2008 electric load forecast (Dhittle and Associates 2008). In this report, a separate scenario was prepared for widespread use of electric vehicles in Sitka. Up to 3,500 all-electric cars were projected to be in operation in Sitka by 2028. Each vehicle would be driven an assumed 4,380 miles per year, using 0.2 kW-hr per mile driven (876 kW-hr per vehicle per year). Also assumed is that vehicle heating would require 1,095 kW-hr per vehicle per year) (table 6). Therefore, the total projected energy requirements for electric vehicles in Sitka would be about 6.13 GW-hr per year, based on 75 percent of all vehicles being electric. This number is significant in that it represents only about 5.6 percent of Sitka's current total retail energy sales (year 2008). Thus, it seems very plausible that, with some prudent planning and energy budgeting, Sitka could easily power an entire community of electric vehicles while using only a small fraction of its available electricity. Once electric vehicle use becomes established, the impact on electric load growth would be similar to the nonelectric car scenario (table 7).

Table 6—City and Borough of Sitka 2008 electric load forecast

	Estimated electric vehicle loads[a]						
Year	Estimated number of passenger cars (all types)	Percentage of electric cars	Estimated number of electric cars	Annual miles per electric car	Average electricity consumption	Annual vehicle space heat	Total annual electric car load
					Miles/kWh	*kWh/car*	*kWh*
2008	4,860	0	—	4,380	5.00	1,095	—
2009	4,878	0.5	24	4,380	5.00	1,095	47,304
2010	4,896	2.0	98	4,380	5.00	1,095	193,158
2011	4,894	5.0	245	4,380	5.00	1,095	482,895
2012	4,892	10.0	489	4,380	5.00	1,095	963,819
2013	4,890	15.0	734	4,380	5.50	1,095	1,388,261
2014	4,888	20.0	978	4,380	5.50	1,095	1,849,754
2015	4,886	25.0	1,222	4,380	5.50	1,095	2,311,246
2020	4,841	50.0	2,421	4,380	6.00	1,095	4,418,325
2025	4,776	75.0	3,582	4,380	6.50	1,095	6,336,007
2028	4,749	75.0	3,562	4,380	7.00	1,095	6,129,184

kWh = kilowatt-hours.
Source: Sitka 2008 Electric System Load Forecast (CBS ED 2008b).
[a] Assumptions: (1) Average vehicle daily use is 12 miles; (2) vehicle heaters require 1,500 watts per hour for an average daily heating time of 2 hours.

Table 7—Forecasted total energy requirements in Sitka, Alaska (excluding potential interruptible sales)

Year	Low	Medium	High	Electric vehicle
2008 (actual)	111,919	111,919	111,919	111,919
2010	114,380	122,730	127,820	127,870
2015	119,530	131,410	143,830	145,810
2020	121,550	136,380	151,490	155,750
2025	123,280	140,670	158,900	165,240
2029	124,180	143,590	164,860	171,420

Source: City and Borough of Sitka Electric Department (2008b).

Energy prices have been shown to have a marked impact on conservation efforts, and in some cases this has been dramatic (for example, the case of Juneau in spring 2008). In Sitka, during spring 2011, low water levels at the Blue Lake and Green Lake hydroelectric facilities created a "red light" scenario, indicating a strong need for energy conservation and increasing community awareness (KCAW Radio 2011). Sitka has among the least expensive electricity costs in the state (at about $0.09 per kW-hr for residential customers).

Community activism could also play an important role because Sitka is renowned among communities in southeast Alaska for its community activism and ability to support grassroots efforts. Conservation-oriented groups in Sitka include Bike-Friendly Sitka, Local Foods Network, Sitka Global Warming Group, Sitka Conservation Society, and Sustainable Sitka. The Sitka public transit system (Community Ride) also provides regular bus service. Community activism could lead to greater energy conservation as well as adoption of new technologies. Public outreach and education also can play an important role in community energy planning. A conservation-minded community is a strong asset. Further, in smaller communities, the diffusion of information for new renewable energy developments can occur rapidly through community newspapers, radio, and other media eager to showcase new developments. For example, in Sitka, the first private electric vehicle to be used on a regular basis generated numerous radio and newspaper stories (Ronco 2010). Similar examples in Sitka can be noted for the first wind energy system (installed at a local high school) and the first solar electric system (installed at a private residence).

Biomass energy could play an integral role in Sitka's energy planning, for both residential and "small-industrial" systems. A general increase in the use of firewood for residential heating has been observed as a result of rising heating oil prices, and firewood users in southeast Alaska consume an average of about 3.6 cords annually (Nicholls et al. 2010). Other potential wood energy users include the Coast Guard base in Sitka, which is moving forward with a project to burn wood pellets for energy (Deering 2011). This project could consume close to 900 tons of wood pellets annually when completed.

Given the momentum in wood energy development that has been spurred by recent fuel price increases, it is conceivable that regionwide bioenergy networks could soon form in southeast Alaska. Notably, recent advances in wood pellet use in Juneau and Ketchikan (systems in operation as of September 2011) and in Sitka (a planned system at the Coast Guard base) could catalyze even further wood pellet use and manufacture throughout the region. As larger wood energy systems become established, wood-chip-fired systems could take advantage of greater economies of scale, including interisland biomass shipments. The significance of this is that community energy management practices would be carried out at the local level, yet strongly influenced by regional considerations, including fuel type and availability among other factors. Perhaps the greatest element influencing community energy planning is not within the control of the residents of Sitka—namely the market price of fossil fuels. During the recent energy price surge that peaked in mid 2008, renewable energy interest skyrocketed, especially in rural Alaska where price increases were magnified. Given the strong interest in renewable energy in Alaska over the past decade, it appears that communities are taking a long-term view to develop sustainable energy solutions, while becoming less vulnerable to fluctuations in the cost of fossil fuels.

Metric Equivalents

When you know:	Multiply by:	To find:
Feet (ft)	0.305	Meters
Miles (mi)	1.609	Kilometers
Gallons (gal)	3.78	Liters
Tons (ton)	907	Tonnes or megagrams
Kilowatt-hour (kW-hr)	3.6	Megajoules

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