Notes From The Field

Sustainable wood-biomass energy systems: climate and development solutions for forest communities

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Key Messages

- A rural energy crisis in many indigenous communities in Alaska, Canada and elsewhere in the North is contributing to crippling disinvestment, poverty, and outmigration.
- The carbon emissions associated with different energy sources need to be considered, to balance socio-economic development with climate change mitigation.
- One solution may be biomass-energy, a traditional source of heat energy for northern peoples. This study used a 'triple bottom line' analysis to determine the value of transitioning from oil to wood-pellets for heat or electricity in Southeast Alaska.
- The study revealed the potential for substantial benefits of such a transition, but this needs Government support, , including appropriate social development policies, financial incentives and public-private partnerships.

People around the world have long depended on biomass energy, mainly from wood. In the 20th century, however, cheap fossil fuels rapidly eclipsed biomass, which came to be viewed as inefficient and environmentally degrading – an impediment to development. Now, with increasing insecurity due to the high prices of fossil fuels, the vulnerability of supplies, and climate change linked to greenhouse gas (GHG) emissions from fossil-fuel consumption, it is time to reconsider biomass energy as a climate and development solution.

Oil-dependent indigenous communities in remote regions of Alaska face an unprecedented crisis as a result of reliance on fossil fuels. With fuel prices often triple those found in urban areas, energy costs are crippling local economies, leading to increasing outmigration and dim prospects for the future.

This policy brief assesses the potential to develop sustainable biomass-energy industry in the region of Southeast Alaska. Specifically, it evaluates the 'triple bottom line' of sustainability – the economic, environmental and social impacts of a wood-pellet industry. Efforts by Alaska Native corporations (Box 1) to convert local forest residue into wood-pellets for affordable and sustainable energy constitute a case study that reveals opportunities and barriers in transitioning from oil to biomass. The policy brief draws on this case study to suggest that additional government support measures may be necessary for a sustainable transition.

Global climate change mitigation and forests

Forests act as carbon ‘sinks’ to mitigate climate change. Burning wood-biomass releases the carbon once stored in forests into the atmosphere, which makes it important to consider the climate change-related impacts of promoting this energy source. The Intergovernmental Panel on Climate Change (IPCC, 2007: p.543) has concluded, “In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre, or energy from the forest, will generate the largest sustained mitigation benefit.”

The life cycle carbon accounting approach provides insights into the relative impacts of fossil-fuel and biomass energy on emissions. While fossil-fuel emissions flow only one way, from deep reserves into the atmosphere, carbon emitted by burning biomass can be absorbed by regenerating forests, making biomass a renewable source of energy (Lippke et al., 2011).

Background to the Alaska case study

Communities in Southeast Alaska rely primarily on hunting, fishing, timber, mining, and tourism for their livelihoods. The region has more than a dozen communities, with populations ranging from just 50 people to over 30,000 (Juneau, the state capital) spread across the coastal forest archipelago. These communities draw energy either from local hydro-power stations or fossil-fuels (oil/diesel-oil) imported by sea. While hydro is a major source of electricity in the region, most communities rely on oil for their heating.

The high cost of energy has hampered the local economy and is a major roadblock to community sustainability and regional development. Beyond high oil prices, the environmental risks of shipping, handling and storing petroleum products, and especially of oil spills on the area’s fragile ecosystem, pose a continuous threat (Alexander et al., 2010).

Nathan Soboleff, a young Tlingit business leader, displaying Sealaska Corporation’s wood-pellet based boiler, which has significantly lowered the firm’s heating costs and carbon emissions. (Photo Credit: Munish Sikka)

Biomass potential in the region

Alaska's Tongass National Forest covers nearly 17 million acres, about 500,000 of them designated for commercial timber harvest. Based on a conservative estimate, 174,400 tons of wood-pellets can be produced annually from local biomass residue associated with timber harvest and other operations on these lands, and without cutting a single new tree, solely to produce biomass energy (Mater and Miles, 2009). This would meet up to 65% of the region's demand for heating fuel.

Wood-pellets have lower moisture content and higher combustion efficiency than firewood, and their standard size and high density makes them easy to store and transport over long distances. At present, however, saw-mill and logging residue in Alaska is an un-used waste product. Eventually it decays, emitting carbon dioxide (CO_2) as it does so (a major GHG). Using these residues to displace oil for heating would avoid this waste and reduce the GHG emitted through the burning of fossil-fuels.

Box 1: Alaskan Native Corporations negotiating sustainable development

The Alaska Native Claims Settlement Act (ANCSA) of 1971 enabled indigenous peoples to maintain ownership over a portion of their traditional territories while creating nearly 200 regional and village corporations to manage these lands (44 million acres, about 10% of Alaska) and capital ($962 million as compensation for lands taken). Native corporations were envisioned as an institutional means to give communities capital, natural resources and incentives to manage their own futures (Thornton, 2007).

Sealaska Corporation, headquartered in Juneau, the state capital is among the most successful regional corporations under the ANCSA, with nearly 16,000 shareholders of mainly Tlingit and Haida descent. The corporation owns 279,000 acres of land within America's largest national forest: the Tongass. After initial local investment in timber harvesting, Sealaska created a subsidiary, *Haa Aaní* ('Our Land') LLC in 2009, to promote sustainable development that would support rural community shareholders.

Sealaska recently replaced its oil-based heating system with a wood-pellet based heating system in its 50,000 sq. ft. corporate headquarters as a first step toward demonstrating the benefits of biomass energy. *Haa Aaní* is taking further steps to develop a regional wood-pellet industry by:

- spreading awareness of the benefits of switching to wood-pellets to heat buildings, including immediate operational savings (Sealaska recorded savings of $16,137.15 in the first six months of using pellet-based heating)
- building the capacity of existing sawmills to begin wood-pellet production using local biomass residue.

Native villages dependent on expensive diesel power plants are considering their replacement with wood-powered electrical generators to extend biomass energy to electrification.

The economic, environmental and social benefits of switching to bio-mass energy: a triple bottom line analysis

One way to assess sustainable development is through the triple bottom line (TBL) approach focusing on three elements of sustainability: economic, social and environmental (Elkington, 1997). TBL is already a popular framework to conceptualise and assess corporate social responsibility. Under this approach, corporations that create environmental and social value alongside economic value are considered to have a sustainable bottom line. TBL can help to develop and support sustainability goals by focusing on the interrelated dimensions of profits (economic), the planet (environment) and people (social). This study used TBL to determine the value of a transition from oil to wood-pellets for heat or electricity in Southeast Alaska.

Economic benefits:

First, the price per unit of energy paid to use oil, versus the price per unit to use wood pellets as a fuel was compared to estimate the economic benefit of biomass energy. The cost of energy is estimated at various oil prices; alongside the price of the wood-pellets that would be needed to produce the same amount of energy (Table 1).

Oil ($/gallon)	Equivalent wood-pellet price in $/tonnes
4.50	518.40
4.00	460.80
3.50	403.20
3.00	345.60
2.00	230.40
Derived from Brackley et al. (2010, p.19)	
Green arrow: prevailing market price of wood-pellets ***Red arrow***: current market price of oil **Black arrow**: price range at which operational savings could be achieved by replacing oil-based heating with a pellet-based system at prevailing cost.	

Table 1: Oil versus wood pellets – price comparisons, based on amount of energy produced

Wood-pellets cost around $300/ton and oil about $4.17/gallon in Southeast Alaska. The two fuels would be equal in cost if oil were priced at $3.00/gallon and wood-pellets at $345.60/ton. Therefore, with current oil prices over $4.00/gallon, huge operational savings could be achieved by switching to wood-pellets for heating. While the cost of oil has risen precipitously over the past five years, the price for wood-pellets remains competitive, demonstrating a clear economic advantage.

Environmental benefits:

Second, emission factor values can be used to estimate the carbon emissions that would be avoided by switching to pellet-based heating (Obernberger and Thek, 2010). The total avoided emission is calculated for a potential supply capacity of 174,400 tons of wood-pellets (Table 2). This shows a clear advantage in terms of reducing carbon dioxide (CO_2) emissions and, therefore, mitigating climate change**.** However, current pellet-based systems yield more carbon monoxide (CO) and nitrogen oxide (NOx) than oil-based heating, which also has negative environmental impacts. These emissions could be reduced by deploying recent technological innovations.

Table 2: Total emission savings in tonnes through the consumption of 174,400 tons of wood-pellets and the displacement of oil

Emission Type	Carbon dioxide (CO_2)	Carbon monoxide (CO)	Hydro-carbons (C_xH_y)	Nitrogen oxides (NOx)	Sulphur dioxide (SO_2)	Dust
Wood-pellets	12590.28	388.82	72.60	443.32	53.15	93.73
Oil	276986.25	152.91	169.01	313.88	250.50	18.78
Emission avoided (tonnes)	**264395.96**	**-235.91**	**96.41**	**-129.44**	**197.35**	**-74.95**

Note: The Emission Factor (EF) values are in mg/MJ (milligrams per Mega-Joule of Energy, *Adapted from Obernberger and Thek, 2010: 305*). The final emission quantity is in tonnes.

The formula generated for this conversion is:
Emission (tonnes) = Quantity of Fuel (oil/wood-pellets) in Tons x 19.23 x 10^{-6} x EF of gas

This formula could be used for conservative calculation of the environmental benefits of promoting wood-pellets over oil elsewhere in Alaska and beyond.

Social benefits:

Third, the development of a regional biomass industry is expected to generate jobs and income. But these depend on how much wood-pellet production can be captured locally. At present Sealaska corporation estimates that it can profit only by *distributing* imported wood-pellets, benefiting rural communities through reduced dependence on oil and vulnerability to its volatile prices and environmental risks, but employing only a modest workforce. Greater potential lies in *manufacturing* pellets, but the current economics are not favourable, given limited local demand, 'lock-in' to oil-based heat systems, and comparatively high production costs. To showcase the benefits of transitioning to biomass energy, Sealaska (Box 1) took the high profile step of converting its own headquarters from oil to wood-pellet heating.

Limitations of biomass energy

The large-scale use of biomass-energy faces many risks and constraints: environmental, technical and socio-economic. Decision-makers need to consider four factors in particular.

- **Environmental impacts:** Possible degradation of local forests and ecosystem services as a result of increasing commercial harvest and removal of residues. The present study does not propose cutting any new trees to produce wood-pellets, and a balance is needed between forest conservation and harvesting, based on principles of ecosystem management (Rosillo-Calle et al., 2007).
- **Demand constraints:** Whether people will use efficient biomass fuel depends largely on their knowledge of the benefits versus costs. This is complex, and fuel-price itself may not be the deciding factor (Brackley et al., 2010). To stimulate demand, consumers must be informed about the multiple benefits of a regional wood-pellet industry and be given concrete incentives to switch to biomass energy. Sealaska (Box 1) is promoting its conversion project to showcase the climate and sustainability benefits of biomass heat over oil, but others following their lead need incentives and access to capital.

- **Supply constraints:** A sustained local supply of raw-materials to make wood-pellets is imperative to achieve benefits and justify investments in regional production. It is important to avoid the potential pitfalls associated with large-scale importation (e.g. carbon footprints from transport, displaced environmental impacts, and limited local job creation). A clear, long-term forest policy is important to maintain wood supply, mobilise private investment, and ensure wood-biomass energy does not jeopardise important forest ecosystem services and management objectives.
- **Economic constraints:** High capital investment costs and other economic constraints often hinder conversion from oil to biomass energy. In Alaska, for example, Sealaska's wood-pellet boiler system cost $539,000 to install and relied on co-financing from an emerging energy technology grant from the Denali Commission, a federal-state partnership supporting cost-shared infrastructure projects. Carbon taxes, investment subsidies and feed-in tariffs are proven policy instruments that can be adapted to facilitate biomass energy transition (JEDC, 2011) (see Box 2).

Box 2: Lessons from Europe

State policy support has been a key driver for increased wood-pellet demand in Northern Europe (Obernberger and Thek, 2010). In the Netherlands, for example, a system of feed-in premiums (tariffs) for renewable electricity has made the co-firing of clean woody biomass with coal an economically attractive alternative. Belgium has introduced a quota system of green certificates requiring suppliers of electricity to reach a certain share of renewable electricity, which has led to conversion from coal to wood-pellets. Sweden has imposed a tax on fossil-fuel use for heating, leading to more use of wood-pellets for district heating and Combined Heat and Power production. Finally, initiatives in Finland, including a CO_2 tax, investment subsidies, and investment in research and development have contributed to large-scale adoption of wood-pellets (Nicholls et al., 2009).

The Northern European experience also reveals key social and ecological conditions required for a sustainable biomass industry, including: 1) large forestry operations and the potential to use biomass to meet energy needs, 2) low population densities with little conflicting use of forest lands, and 3) large forests that could meet biomass requirements sustainably without harming ecosystems services or requiring major importation beyond the bioregion (an issue in Europe). These conditions exist in Alaska and may also hold true for remote forested regions in Canada, Russia, and elsewhere.

Recommendations

Locally available biomass can be an affordable, green energy alternative, especially among remote forest communities that are vulnerable to rising oil prices. However, successful development of the sector requires support from governments and the private sector (Box 2). Policy-makers need to consider:

- **The potential of local sources of biomass to meet energy needs**. In Southeast Alaska, forest residue can meet up to 65% of heating energy demand. A local, renewable energy source of this magnitude can deliver sustainable economic, environmental and social benefits.

- **The impact of the development of a wood-biomass energy sector on the forest ecosystem**. Policy-makers need to consider not only the supply of wood residue but how it is accessed, transported and processed, and how it is used by other species, all of which affect the ecosystem.

- **The key economic thresholds for transition to biofuels**. The formulae used in this study can be applied to calculate benefits of wood-pellets over oil in any region, using local price configurations (economic) and fuel-quantity consumption (environmental).

- **The public-private partnerships and policies that are needed to promote the transition to sustainable biomass energy**. Biomass processing facilities and the installation of wood-pellet heating systems require high capital investment. Supportive policies and co-financing to help underwrite transition costs can be critical. Carbon taxes, investment subsidies and feed-in tariffs are proven policy instruments that can be adapted to facilitate biomass energy transition.

- **What communities need to support biomass energy.** Alaska Native corporations in the Tongass National Forest are important catalysts in the transition to biomass energy because they have recognised energy security as a challenge in their communities. They also possess strong networks, clear land rights and significant natural, financial and human capital to support a new energy infrastructure. These may be lacking among other rural indigenous and forest communities, where community investment may need to be strengthened through the development of community-based initiatives and enterprises to invest in local renewable energy. In this way people can come to understand and manage the values and impacts of their energy system.

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References

Alexander, S. J., Henderson, E. B., and Coleman, R. (2010). *Economic Analysis of Southeast Alaska: Envisioning a Sustainable Economy with Thriving Communities,* Juneau: Forest Service, Alaska Region Publication R10-MB-725.

Brackley, A. M., Barber, V., and Pinkel, C. (2010). *Developing Estimates of Potential Demand for Renewable Wood Energy Products in Alaska,* Portland: USDA - Forest Service.

Elkington, J. (1997). *Cannibals With Forks: the Triple Bottom Line of 21st Century Business*. Capstone: Oxford.

IPCC (2007). *Climate Change 2007 Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC.* IPCC.

Juneau Economic Development Council (2011). *Southeast Alaska Action Initiatives For Key Economic Clusters,* Juneau: Juneau Economic Development Council (JEDC).

Lippke, B., Oneil, E., Harrison, R., Skog, K., Gustavsson, L., and Sathre, R. (2011). 'Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns', *Carbon Management*, pp. 303-333.

Mater, C. M., and Miles, T. (2009). *Feasibility Assessment of Producing a Wood Waste Alternative Fuel Product on Prince of Wales Island.* MATER Ltd.

Nicholls, D., Monserud, R. A., & Dykstra, D. P. (2009). 'International bioenergy synthesis—Lessons learned and opportunities for the western United States', *Forest Ecology and Management*, pp. 1647-1655.

Obernberger, I., and Thek, G. (2010). *The Pellet Handbook: The Production and Thermal Utilisation of Pellets,* London: Earthscan.

Rosillo-Calle, F., Hemstock, S., Groot, P., and Woods, J. (ed.). (2007). *The Biomass Assessment Handbook: Bioenergy for a sustainable environment,* London: Earthscan.

Sealaska Corporation. (n.d.) *Sealaska - Who We Are,* [Online], Available: http://www.sealaska.com/page/who_we_are.html [11 March 2011].

Thornton, T. F. (2007) 'Alaska Native Corporations and Subsistence: Paradoxical Forces in the making of sustainable communities', in Maida, C. A. (ed.) *Sustainability and Communities of Place* (pp. 41-62), New York - Oxford: Berghahnbooks.