The Potential for Biomass District Energy Production in Port Graham, Alaska

November 7, 2007
Department of Energy Tribal Energy Program
Port Graham Tribal Council
Involvement

- Pat Noman, Chief
- Olga Foman, Second Chief
- Fran Norman, Tribal Administrator
- Charlie Sink, Technical Representative
Port Graham Tribal Council and Port Graham, Alaska

- Port Graham Tribal Council is the village administrator
- There are approximately 150 Tribal Members
- ANCSA formed Port Graham Village Corporation owns a majority of land in the area that contains largest volume of woody biomass
- Native allotment owners have the second largest volume of woody biomass
The Potential for Biomass District Energy Production in Chugachmiut Communities

Native Energy and Economic Development Symposium

Kerryanne Leroux
Kirk Williams, Erick Zacher, and Sheila Hanson

June 15, 2007
Project Partners

- Energy & Environmental Research Center
- Chugachmiut – A Tribal Organization Serving the Chugach Native People of Alaska
- U.S. Department of Energy (DOE) Tribal Energy Program
Purpose

• To provide the heating and power needs of Port Graham, Alaska utilizing local biomass resources that would create local jobs and provide an economic return to local landowners.
Assumptions

- Assuming that biomass energy applications cheaper than replacing power line from Bradley Lake.
- Cost of purchasing wood would be nominal. May assume small value-added sawmill located on local land.
- Assumes biomass harvest plan and agreement between landowners and tribe to utilize their resources.
- Does not include bio-energy needs of Nanwalek, Alaska.
Port Graham

- Accessible only by air or water.
- Current population is about 200.
- Electricity supplied from Homer Electric Cooperative using single phase hydropower.
- Heat is supplied by fuel oil (diesel) delivered by barge.
Village Interest in Biomass

• Utilization of Land
  – Port Graham Tribal members wish to preserve cultural traditions and traditional use of their lands.
  – Would like to support subsistence through optimal utilization of their lands.

• Help prevent sale of Native allotments
  – Allotments are generally underutilized.
  – Owners and new gift deeded owners occasionally have monetary need.
  – Tribe desires to maintain cultural association with the land and the owners.
Additional Motivation

• Limited accessibility makes traditional energy sources expensive to deliver.

• The dramatic rise in the prices of petroleum fuels have been a hardship to the village of Port Graham.

• There is a significant potential for biomass heat and power within the region by utilizing low-value forest residue and timber depleted from spruce beetle activity and windthrow.
Goals and Objectives

• The goal is to determine the economic and technical feasibility for implementing a biomass energy system to serve the Chugachmiut community of Port Graham.

• The objectives are as follows:
  – Evaluate Port Graham energy loads
  – Analyze biomass resource availability and suitability
  – Evaluate energy and cogeneration technologies
  – Determine engineering economics of proposed technologies
Project Approach

• A visit to Port Graham was conducted to obtain pertinent information concerning energy loads in the village.
• Wood and fish oil resources were quantified to determine annual supply and cost of procurement.
• Technologies studied
  – Wood combustion
  – Wood gasification
  – Fish oil
• Engineering economic feasibility analysis was performed to evaluate the technologies and various applications.
Port Graham Energy Needs

- Heating and electricity
  - Residential
  - Community buildings
- Processing – cannery
- Basis for current energy expenses
  - Diesel @ $3.00 per gallon
  - Electricity averaging $0.12/kWh
Total Village Energy Load

<table>
<thead>
<tr>
<th>Structure</th>
<th>Heating Power Required, MMBtu/hr*</th>
<th>Diesel, gal</th>
<th>Annual Heating Cost</th>
<th>Electrical Power Required, kW</th>
<th>Electricity Usage, MWh/yr</th>
<th>Annual Electricity Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Sector</td>
<td>4.6</td>
<td>41,000</td>
<td>$120,000</td>
<td>260</td>
<td>1,000</td>
<td>$140,000</td>
</tr>
<tr>
<td>Community Buildings</td>
<td>1.3</td>
<td>12,000</td>
<td>$35,000</td>
<td>260</td>
<td>300</td>
<td>$39,000</td>
</tr>
<tr>
<td>Cannery</td>
<td>4.5</td>
<td>25,000</td>
<td>$75,000</td>
<td>560/260</td>
<td>660</td>
<td>$53,000</td>
</tr>
<tr>
<td><strong>Total Village Load/Energy Expenses</strong></td>
<td>5.9</td>
<td>78,000</td>
<td><strong>$230,000</strong></td>
<td>560/260</td>
<td>2,000</td>
<td><strong>$230,000</strong></td>
</tr>
</tbody>
</table>

*Assumes energy required to heat community buildings and homes in winter months is available for cannery processing in summer months
Residential Energy Requirements

- Average home:
  - ~1000 sq ft each
  - 600 gal diesel annually
  - $2000 annual heating cost
  - 65,000 Btu/hr load

- Total residential sector
  - 70 homes
  - 41,000 gal diesel annually
  - $120,000 collective annual heating cost
  - 5 MMBtu/hr load
## Community Buildings

<table>
<thead>
<tr>
<th>Structure</th>
<th>Heating Area, sq ft</th>
<th>Est. Diesel, gal/yr</th>
<th>Annual Est. Heating Cost</th>
<th>Power Required, MMBtu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>8,000</td>
<td>5,000</td>
<td>$14,000</td>
<td>0.5</td>
</tr>
<tr>
<td>Clinic</td>
<td>4,000</td>
<td>2,000</td>
<td>$7,000</td>
<td>0.3</td>
</tr>
<tr>
<td>Tribal Council Building</td>
<td>3,600</td>
<td>2,000</td>
<td>$6,000</td>
<td>0.2</td>
</tr>
<tr>
<td>Native Corporation Office</td>
<td>1,600</td>
<td>1,000</td>
<td>$3,000</td>
<td>0.1</td>
</tr>
<tr>
<td>Grocery Store</td>
<td>2,800</td>
<td>2,000</td>
<td>$5,000</td>
<td>0.2</td>
</tr>
<tr>
<td>Community Buildings</td>
<td>20000</td>
<td>12000</td>
<td>$35,000</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Cannery

- Canning salmon
- Operational in summer months
- 25,000 gal diesel annually
- $75,000 annual cost operation
- 4.5 MMBtu/hr processing need
Village Electricity

- Homer Electric Cooperative
  - Diesel generators
  - Power plant in village for outages
- Peak requirements
  - 560-kW Cannery
    - Supplied by Cannery diesel generators for 3-phase
    - Needed for daytime operation (use HEC during nighttime/downtime)
  - 260-kW, 1-phase for community buildings and residences (and cannery downtime)
- 2 million kWh annually
- Estimated $230,000 annually
Port Graham Energy Resources

• Wood
  – Land is either Native allotment or Port Graham Native Corporation owned
  – 40,000 acre forest resource accessible by old timber harvest road network

• Fish oil
  – Salmon is a significant component to subsistence
  – Use for wastes generated, e.g., from cannery operations
Wood Resource

- 250,000 tons available within ¼-mi preexisting roadway requiring maintenance upgrade.
- 5,000 tons wood annually on 50-year rotation.
- Wood moisture is 39% “green” and 12% seasoned.
Fish Oil Options

• Biodiesel
  – Small or transportation applications (must comply with ASTM International standards).
  – No processing facilities currently exist in Alaska.
  – Requires importation of catalyst and methanol, as well as a market for glycerin by-product.

• Fish oil (straight)
  – Large applications, such as boiler fuel.
  – Maximum blend of 50% fish oil because of high cold-flow properties (cloud point ~0°C).
  – Energy of salmon oil is about 124,000 Btu/gal, or 96% diesel energy by volume.
Technologies Considered

• Wood combustion
• Wood gasification
• Fish oil (utilization of existing infrastructure)
Combustion Systems

- Indoor wood boilers
- Outdoor wood furnaces
- Full-scale systems
Gasification

- Cogeneration opportunities
- Converts solid fuel into low-Btu syngas for
  - Steam production in existing fire-tube boiler.
  - Electricity generation using a microturbine.
Fish Oil

• Considered only straight fish oil because of the economics of biodiesel.
• Maintains existing energy infrastructure.
• A portable processing facility could be available from the Alaska Energy Authority (AEA), processing up to 50 tons of fish waste per day.
# I. Wood Combustion Scenarios

<table>
<thead>
<tr>
<th><strong>A. Wood Furnaces/Boilers</strong></th>
<th><strong>Feedstock: Logs, wood chips, or pellets</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indoor Wood Boilers</td>
<td>Individual homes' and village buildings' heat</td>
</tr>
<tr>
<td>2. Small Outdoor Wood Furnaces</td>
<td>Individual homes' and village buildings' heat</td>
</tr>
<tr>
<td>3. Moderate Outdoor Wood Furnaces</td>
<td>Multiple (3–4) homes' and village buildings' heat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B. Automated Combustion System</strong></th>
<th><strong>Feedstock: Wood chips</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Moderate Combustion System</td>
<td>Village buildings' heat and cannery steam</td>
</tr>
<tr>
<td>2. Large-Scale Combustion System</td>
<td>Entire village, i.e., homes and village buildings' heat and cannery steam</td>
</tr>
</tbody>
</table>
Example of Outdoor Wood Furnace Layout
## II. Gasification Scenarios

### A. Gas Production

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Feedstock: Wood chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Moderate Steam (Gas)</td>
<td>Syngas $\rightarrow$ steam boiler $\rightarrow$ cannery steam, steam heat for community buildings</td>
</tr>
<tr>
<td>2. Moderate Gas and Steam</td>
<td>Syngas $\rightarrow$ steam boiler $\rightarrow$ cannery steam Syngas $\rightarrow$ community buildings for heat</td>
</tr>
<tr>
<td>3. Large Gas</td>
<td>Syngas $\rightarrow$ steam boiler $\rightarrow$ cannery steam Syngas $\rightarrow$ community buildings, homes for heat</td>
</tr>
</tbody>
</table>

### B. Gas and Electricity Production

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Feedstock: Wood chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Moderate Steam and Electricity</td>
<td>Scenario II.A.1. + electricity generation (1-phase, 260 kW)</td>
</tr>
<tr>
<td>2. Moderate Gas, Steam, and Electricity</td>
<td>Scenario II.A.2. + electricity generation (1-phase, 260 kW)</td>
</tr>
<tr>
<td>3. Large Gas and Elect.</td>
<td>Scenario II.A.3. + electricity generation (1-phase, 260 kW)</td>
</tr>
</tbody>
</table>

### C. Electricity Production

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Feedstock: Wood chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High-Power Electricity and Heat</td>
<td>Electricity generation for power and heat (3-phase, 560 kW)</td>
</tr>
<tr>
<td>2. High-Power Electricity</td>
<td>Electricity generation for power (3-phase, 560 kW)</td>
</tr>
<tr>
<td>3. Low-Power Electricity</td>
<td>Electricity generation for power (1-phase, 260 kW)</td>
</tr>
</tbody>
</table>
Example of Cogeneration Layout
### III. Fish Oil

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Moderate Steam (Oil)</strong></td>
<td>50% fish oil–diesel blend → steam boiler → cannery steam, steam heat for community buildings</td>
</tr>
<tr>
<td><strong>B. Moderate Oil and Steam</strong></td>
<td>50% fish oil–diesel blend → steam boiler → cannery steam&lt;br&gt;50% fish oil–diesel blend → community buildings for heat</td>
</tr>
<tr>
<td><strong>C. Large Oil and Steam</strong></td>
<td>50% fish oil–diesel blend → steam boiler → cannery steam&lt;br&gt;50% fish oil–diesel blend → community buildings, homes for heat</td>
</tr>
</tbody>
</table>
Economics

- Feedstock
- Capital
- Operating
- Savings
- Simple payback
## Feedstock Costs

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Heating Value</th>
<th>Price/Cost</th>
<th>Per MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>130,000 Btu/gal</td>
<td>$3.00/gal</td>
<td>$23.00</td>
</tr>
<tr>
<td>Wood, dry</td>
<td>8,100 Btu/lb</td>
<td>$55/ton</td>
<td>$3.90</td>
</tr>
<tr>
<td>Logs, 12% moisture</td>
<td>7,100 Btu/lb</td>
<td>$97/ton</td>
<td>$6.80</td>
</tr>
<tr>
<td>Chips, 12% moisture</td>
<td>7,100 Btu/lb</td>
<td>$240/ton</td>
<td>$15.00</td>
</tr>
<tr>
<td>Pellets, 5% moisture</td>
<td>7,700 Btu/lb</td>
<td>$1.00/gal</td>
<td>$8.50</td>
</tr>
<tr>
<td>Fish Oil</td>
<td>120,000 Btu/gal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Capital Investment

• Totals range from $260,000 to $2.1 million
• Estimations included
  – Main energy system price.
  – Hot water, gas, and/or steam piping.
  – Heat exchangers for structures currently heated by forced air.
  – Refurbishing the existing fire-tube steam boiler.
  – Gas or electric boilers for gasification scenarios producing syngas or electricity for heat.
Operating

• Totals range from $1700 to $67,000 annually.

• Estimations included
  – Fuel preparation and delivery.
  – System labor requirements.
  – Ash management.
  – Utility needs.
Savings and Payback

• Total estimated savings range from incurred cost to $89,000 annually.
• Savings calculated from difference in current energy expenses and estimated feedstock, capital, and operating costs.
• Paybacks ranged 2–28 years.
• The simple payback provides estimated return on investment.
# Economic Viability (top 10)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Scenario</th>
<th>Annual Feedstock Requirement</th>
<th>Total Capital</th>
<th>Annual Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indoor Wood Boilers</td>
<td>600 tons logs</td>
<td>$270,000</td>
<td>$89,000</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>Large Oil and Steam</td>
<td>42,000 gal fish oil</td>
<td>$260,000</td>
<td>$80,000</td>
<td>2.4</td>
</tr>
<tr>
<td>3</td>
<td>Large-Scale Combustion System</td>
<td>850 tons chips</td>
<td>$1,000,000</td>
<td>$83,000</td>
<td>5.6</td>
</tr>
<tr>
<td>4</td>
<td>Moderate Outdoor Wood Furnaces</td>
<td>900 tons logs</td>
<td>$420,000</td>
<td>$64,000</td>
<td>4.0</td>
</tr>
<tr>
<td>5</td>
<td>Small Outdoor Wood Furnaces</td>
<td>900 tons logs</td>
<td>$620,000</td>
<td>$45,000</td>
<td>5.8</td>
</tr>
<tr>
<td>6</td>
<td>Large Gas</td>
<td>900 tons chips</td>
<td>$1,300,000</td>
<td>$58,000</td>
<td>6.9</td>
</tr>
<tr>
<td>7</td>
<td>Large Gas and Elect.</td>
<td>3300 tons chips</td>
<td>$1,400,000</td>
<td>$61,000</td>
<td>6.9</td>
</tr>
<tr>
<td>9</td>
<td>Moderate Combustion System</td>
<td>400 tons chips</td>
<td>$620,000</td>
<td>$20,000</td>
<td>7.6</td>
</tr>
<tr>
<td>10</td>
<td>High-Power Electricity</td>
<td>2900 tons chips</td>
<td>$870,000</td>
<td>$20,000</td>
<td>8.1</td>
</tr>
</tbody>
</table>
Conclusions

- Port Graham energy requirements
  - Heat: 9,000 MMBtu/yr (6 MMBtu/hr)
  - Electricity: 2,000 MWh/yr (560/260kW)
- Sufficient resources (5,000 tons/yr) exist for Port Graham to utilize wood as an energy fuel
- The most economically viable solution:
  - Install moderate outdoor furnaces, which could provide heat to three to four homes or village buildings per furnace.
  - Requires 600 tons logs annually for $90,000 annual savings and <3 year ROI of $300,000.
- Challenges
  - Assurance of emissions compliance
  - Coordination of wood procurement, storage, and delivery
  - Operation and maintenance of mechanical components on the remote village
Next Steps

• Chose energy scenario and derive approach plan
• A formal engineering design and quote, including guarantee or proof of emission compliance
• Secured financing
• Equipment procurement and installation
• Personnel hire and training
• Coordination of feedstock delivery and potential loading services
• Ash disposal plan
• Small or Big
QUESTIONS?
Chart Comparison of 1-, 5-, and 10-Mw Biomass Load to Supply Rotation

<table>
<thead>
<tr>
<th></th>
<th>PG 2.9kt</th>
<th>PG 2.9kt</th>
<th>PG 80kt</th>
<th>PG 80kt</th>
<th>PG+ N</th>
<th>PG+ N</th>
<th>PG+ N+A</th>
<th>PG+ N+A</th>
</tr>
</thead>
<tbody>
<tr>
<td>acres need</td>
<td>33.99</td>
<td>18.2</td>
<td>937.7</td>
<td>502.2</td>
<td>1875</td>
<td>1004</td>
<td>1875</td>
<td>1004</td>
</tr>
<tr>
<td>rotation period</td>
<td>1177</td>
<td>2197</td>
<td>43</td>
<td>80</td>
<td>32</td>
<td>60</td>
<td>36</td>
<td>68</td>
</tr>
</tbody>
</table>