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**Appendixes**  
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1.0 Executive Summary

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Aleknagik City Hall Building located in Aleknagik, Alaska. During the field visit the Health Clinic and Fire Department Garage, Maintenance Garage, and Future Washeteria were also reviewed and discussed.

The following tables summarize the current fuel use and the potential wood fuel use:

<table>
<thead>
<tr>
<th>Building</th>
<th>Fuel Type</th>
<th>Avg. Use (Gallons)</th>
<th>Average Annual Cost</th>
<th>Average Cost/Gal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall</td>
<td>Fuel Oil</td>
<td>1,300</td>
<td>$7,371</td>
<td>$5.67</td>
</tr>
<tr>
<td>Health Clinic / Fire Dept. Garage</td>
<td>Fuel Oil</td>
<td>2,350</td>
<td>$13,325</td>
<td>$5.67</td>
</tr>
<tr>
<td>Maintenance Garage</td>
<td>Fuel Oil</td>
<td>1,127</td>
<td>$6,390</td>
<td>$5.67</td>
</tr>
</tbody>
</table>

Table 1.2 - Annual Wood Fuel Use Summary

<table>
<thead>
<tr>
<th>Building</th>
<th>Fuel Oil (Gallons)</th>
<th>Cord Wood (Cords)</th>
<th>Wood Pellets (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall (C)</td>
<td>1,300</td>
<td>11.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Heath Clinic (H)</td>
<td>2,650</td>
<td>23.2</td>
<td>21.1</td>
</tr>
<tr>
<td>Future Washeteria (W)</td>
<td>1,000</td>
<td>8.7</td>
<td>8.0</td>
</tr>
<tr>
<td>C + H</td>
<td>3,950</td>
<td>34.5</td>
<td>31.5</td>
</tr>
<tr>
<td>C + H + W</td>
<td>4,950</td>
<td>43.3</td>
<td>39.4</td>
</tr>
</tbody>
</table>

Note: Wood fuel use assumes offsetting 85% of the current energy use.

Based on the potential wood use the cord wood boiler option was investigated and results are as follows:

Cord Wood Boiler Options:
- C.1: City Hall and Health Clinic.
- C.2: City Hall, Health Clinic, and Future Washeteria.

The table on the following page summarizes the economic evaluation for each option:
A small district heating system connecting city buildings appears to be a poor candidate for the use of a wood biomass heating system. With the current economic assumptions, the economic viability of all the options is poor and none of the options meet the minimum requirement of the 20 year B/C ratio exceeding 1.0. Each building individually does not spend enough on heating fuel to be able to pay for a project through potential savings. Combining multiple buildings increases the project costs without substantially increasing the annual fossil fuel use.

### Table 1.3 - Economic Evaluation Summary

<table>
<thead>
<tr>
<th>Project Cost</th>
<th>Year 1 Operating Cost</th>
<th>NPV at 3%</th>
<th>NPV at 3%</th>
<th>20 Yr B/C Ratio</th>
<th>30 Yr B/C Ratio</th>
<th>ACF YR 20</th>
<th>ACF YR 30</th>
<th>ACF=PC YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.1 $346,000</td>
<td>$797</td>
<td>$264,465</td>
<td>$125,334</td>
<td>0.36</td>
<td>0.76</td>
<td>$186,695</td>
<td>$486,354</td>
<td>27</td>
</tr>
<tr>
<td>C.2 $439,000</td>
<td>$4,173</td>
<td>$416,227</td>
<td>$212,664</td>
<td>0.48</td>
<td>0.95</td>
<td>$310,839</td>
<td>$748,746</td>
<td>24</td>
</tr>
</tbody>
</table>
2.0 Introduction

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Aleknagik City Hall Building located in Aleknagik, Alaska. During the field visit the Health Clinic and Fire Department Garage, Maintenance Garage, and Future Washeteria were also reviewed and discussed.

3.0 Existing Building Systems

Aleknagik City Hall

The Aleknagik City Hall is a single story wood framed building constructed in 1980 that is approximately 3,315 square feet. The space is divided 5 separate uses: the City Hall, Post Office, Rental Office Space, Village Public Safety Officer Program (VSPO) Office, and a Garage / Storage Space. Each space is heated by a single Toyo Stove. In the City Hall Offices plug-in personal electric heaters are used to provide supplemental heat. The table below indicates the current system outputs:

<table>
<thead>
<tr>
<th>Building</th>
<th>Heat System</th>
<th>BTU/hr Output</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall</td>
<td>Toyo Stove</td>
<td>40,000</td>
<td>Good</td>
</tr>
<tr>
<td>Rental Office</td>
<td>Toyo Stove</td>
<td>40,000</td>
<td>Good</td>
</tr>
<tr>
<td>Post Office</td>
<td>Toyo Stove</td>
<td>40,000</td>
<td>Good</td>
</tr>
<tr>
<td>VSPO</td>
<td>Toyo Stove</td>
<td>14,800</td>
<td>Good</td>
</tr>
<tr>
<td>Garage / Storage</td>
<td>Toyo Stove</td>
<td>22,000</td>
<td>Poor / Inoperable</td>
</tr>
</tbody>
</table>

There is also an existing fuel oil furnace located in the central mechanical room. The system has been decommissioned; however the ductwork and furnace are still in place.

Domestic hot water is provided by one electric water heater rated at 4.5 KW input and 30 gallons of storage.

Facilities Added to Feasibility Study

Health Clinic and Fire Department Garage

The Aleknagik Health Clinic and Fire Department Garage were designed in 2006 and were added to the feasibility study during the field visit. The Health Clinic is approximately 2,563 square feet and the Fire Department Garage is approximately 952 square feet. The facilities share a common 159,000 Btu/hr output hot water boiler.

Domestic hot water is provided by a 148,000 Btu/hr fuel oil fired hot water heater with 5.1 gallon storage tank. The existing boiler and heating system infrastructure is original to the building and is in good condition but in need of commissioning to improve performance. During the visit one of the zone valves appeared to be stuck open, causing the boiler to run continuously, causing the temperature in the Health Clinic to be higher than desired.
Future Washeteria

Although a Washeteria is not currently located at the north village, a desire to construct a new facility adjacent to the Health Clinic and City Hall was discussed. If it could be located in the vicinity of the Health Clinic and City Building it would be a potential candidate for integration into a small district heating system. Since there currently is no plan or schedule for this work an estimated case was included in the assessment. The fuel volumes were calculated based on the typical washeterias constructed in villages of similar size.

Additional Facilities Reviewed but not added to Feasibility Study

Maintenance Garage

The Maintenance Garage that is adjacent to the City Hall building was reviewed as part of the field visit. This facility was constructed during the 1980’s and is a manufactured metal building. The existing Garage is heated by 2 fuel oil unit heaters, however only one is currently in operation. A 142,000 btu/hr waste oil heater has also been recently added to the space. Domestic hot water is provided by one electric water heater rated at 4.5 KW input and has 32 gallons of storage. With the relatively small heat demand of the building and the recent addition of the waste oil heater it was determined that the building would not be incorporated into a district system.

4.0 Energy Use

Fuel is delivered to a 10,000 gallon tank located on site. Each individual building has a smaller 500-1000 gallon tank that is refilled from the 10,000 gallon tank. Fuel use summaries for the facilities were provided and the following table summarizes the data:

<table>
<thead>
<tr>
<th>Building</th>
<th>Fuel Type</th>
<th>Avg. Use (Gallons)</th>
<th>Average Annual Cost</th>
<th>Average Cost/Gal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall</td>
<td>Fuel Oil</td>
<td>1,300</td>
<td>$7,371</td>
<td>$5.67</td>
</tr>
<tr>
<td>Health Clinic / Fire Depart. Garage</td>
<td>Fuel Oil</td>
<td>2,350</td>
<td>$13,325</td>
<td>$5.67</td>
</tr>
<tr>
<td>Maintenance Garage</td>
<td>Fuel Oil</td>
<td>1,127</td>
<td>$6,390</td>
<td>$5.67</td>
</tr>
</tbody>
</table>

Electrical energy consumption will increase with the installation of the wood fired boiler system because of the power needed for the biomass boiler components such as draft fans and the additional pumps needed to integrate into the existing heating systems. The cash flow analysis accounts for the additional electrical energy consumption and reduces the annual savings accordingly.
5.0 **Biomass Boiler Size**

The following table summarized the connected load of fuel fired boilers and domestic water heaters:

<table>
<thead>
<tr>
<th>Table 5.1 - Connected Boiler Load Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Likely Peak System Output Load MBH</strong></td>
</tr>
<tr>
<td>City Hall (C) Toyo A Fuel Oil 40 MBH 0.66</td>
</tr>
<tr>
<td>Toyo B Fuel Oil 40 MBH 0.66</td>
</tr>
<tr>
<td>Toyo C Fuel Oil 40 MBH 0.66</td>
</tr>
<tr>
<td>Toyo D Fuel Oil 15 MBH 0.66</td>
</tr>
<tr>
<td>Toyo E Fuel Oil 22 MBH 0.66</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>Heath Clinic (H) Boiler Fuel Oil 159 MBH 1.00</td>
</tr>
<tr>
<td>Future Washeteria (W) Fuel Oil 80 MBH 1.00</td>
</tr>
<tr>
<td><strong>Total Of All Buildings</strong></td>
</tr>
<tr>
<td><strong>262</strong></td>
</tr>
</tbody>
</table>

Typically a wood heating system is sized to meet approximately 85% of the typical annual heating energy use of the building. The existing heating boilers would be used for the other 15% of the time during peak heating conditions, during times when the biomass boiler is down for servicing, and during swing months when only a few hours of heating each day are required. Recent energy models have found that a boiler sized at 50% to 60% of the building peak load will typically accommodate 85% of the boiler run hours. Because of the small scale of the heating system, the output will be based on the smallest cordwood boiler size available, or approximately 170,000 Btu/hr.

<table>
<thead>
<tr>
<th>Table 5.2 - Proposed Biomass Boiler Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Likely Peak System</strong></td>
</tr>
<tr>
<td><strong>System</strong></td>
</tr>
<tr>
<td><strong>Output MBH</strong></td>
</tr>
<tr>
<td>City Hall (C) 103 MBH 0.6</td>
</tr>
<tr>
<td>Heath Clinic (H) 159 MBH 0.6</td>
</tr>
<tr>
<td>Future Washeteria (W) 80 MBH 0.6</td>
</tr>
<tr>
<td>C + H 262 MBH 0.6</td>
</tr>
<tr>
<td>C + H + W 342 MBH 0.6</td>
</tr>
</tbody>
</table>
6.0 Wood Fuel Use

The fuel source that is available in the area consists entirely of seasoned cord wood cut and gathered locally. At the time of this report there is not an infrastructure in place to transport wood pellets or chipped/ground wood fuel. The estimated amount of wood fuel needed of each wood fuel type for each building was calculated and is listed below:

### Table 6.1 - Annual Wood Fuel Use Summary

<table>
<thead>
<tr>
<th>Building</th>
<th>Fuel Oil (Gallons)</th>
<th>Cord Wood (Cords)</th>
<th>Wood Pellets (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Hall (C)</td>
<td>1,300</td>
<td>11.4</td>
<td>10.4</td>
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<td>Future Washeteria (W)</td>
<td>1,000</td>
<td>8.7</td>
<td>8.0</td>
</tr>
<tr>
<td>C + H</td>
<td>3,950</td>
<td>34.5</td>
<td>31.5</td>
</tr>
<tr>
<td>C + H + W</td>
<td>4,950</td>
<td>43.3</td>
<td>39.4</td>
</tr>
</tbody>
</table>

Note: Wood fuel use assumes offsetting 85% of the current energy use.

The moisture content of the wood fuels and the overall wood burning system efficiencies were accounted for in these calculations. The existing fuel oil boilers were assumed to be 80% efficient. Cord wood was assumed to be 20% moisture content (MC) with a system efficiency of 65%. Wood pellets were assumed to be 7% MC with a system efficiency of 70%. Chipped/ground fuel was assumed to be 40% MC with a system efficiency of 65%.

The unit fuel costs for fuel oil and the different fuel types were calculated and equalized to dollars per million Btu ($/MMBtu) to allow for direct comparison. The Delivered $/MMBtu is the cost of the fuel based on what is actually delivered to the heating system, which includes all the inefficiencies of the different systems. The Gross $/MMBtu is the cost of the fuel based on raw fuel, or the higher heating value and does not account for any system inefficiencies. The following table summarizes the equalized fuel costs at different fuel unit costs:

### Table 6.2 - Unit Fuel Costs Equalized to $/MMBtu

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Units</th>
<th>Gross Btu/unit</th>
<th>System Efficiency</th>
<th>Net System Btu/unit</th>
<th>Delivered $/MMBtu</th>
<th>Gross $/MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil</td>
<td>gal</td>
<td>134500</td>
<td>0.8</td>
<td>107600</td>
<td>$5.00</td>
<td>$46.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$5.67</td>
<td>$52.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$6.00</td>
<td>$55.76</td>
</tr>
<tr>
<td>Cord Wood</td>
<td>cords</td>
<td>16173800</td>
<td>0.65</td>
<td>10512970</td>
<td>$200.00</td>
<td>$19.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$250.00</td>
<td>$23.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$300.00</td>
<td>$28.54</td>
</tr>
</tbody>
</table>
7.0 **Boiler Plant Location and Site Access**

None of the existing boiler rooms are large enough to fit a new biomass boiler so a new standalone boiler plant would be required. The existing gravel parking lot south of the Fire Department Garage has been identified as the preferred location for a central heating plant.

Any type of biomass boiler system will require access by delivery vehicles, typically a truck or truck and trailer. There is ample room on the site for both a standalone boiler plant and additional wood storage. The location is also under ¼ mile to the Aleknagik north village landing. This would allow cord wood to be delivered by barge or boat in the summer reducing the cost of overland hauling.

8.0 **Integration with Existing Heating System**

Integration of a wood fired boiler system would be relatively straight forward at the Health Clinic and Fire Department Garage. The field visit confirmed the location of each boiler room in order to identify an approximate point of connection from a district heating loop to each existing building. Connections would typically be achieved with arctic pipe extended to the face of each building, and extended up the exterior surface of the building in order to penetrate exterior wall into the boiler room. Once hot supply and return piping enters the existing boiler room, they would be connected to existing supply and return pipes in appropriate locations in order to utilize existing pumping systems within each building.

The integration of a wood fired boiler system to the City Building would be more challenging. Currently the facility is heated by individual Toyo Stoves. A new heating system would have to be installed to distribute the hot supply water. The existing fuel oil furnace in the mechanical room could be removed and the room could be used for the distribution system including a heat exchanger and pumping system. New radiators would be needed throughout the facility. The existing furnace could also possibly be replaced with a fan coil unit with at heating coil served by the new biomass boiler system, and this connected to the existing ductwork, if the ductwork is in good condition.

9.0 **Air Quality Permits**

Resource System Group has done a preliminary review of potential air quality issues in the area. The meteorological conditions of Aleknagik do not create thermal inversions very often, which it good because inversions are unfavorable for the dispersion of emissions. The proposed boiler size at this location is small enough, that the boiler is not likely to require any State or Federal permits. See the air quality memo in Appendix D.

10.0 **Options**

The technologies available to produce heating energy from wood based biomass are varied in their approach, but largely can be separated into three types of heating plants: cord wood, wood pellet and wood chip/ground wood fueled. See Appendix E for these summaries.
Based on the potential wood use the cord wood boiler option was investigated and results are as follows:

Cord Wood Boiler Options:
- C.1: City Hall and Health Clinic.
- C.2: City Hall, Health Clinic, and Future Washeteria.

Option C.1 and C.2 would be installed in a freestanding building with interior cordwood fuel storage.

11.0 Estimated Costs
The total project costs are at a preliminary design level and are based on RS Means and recent biomass project bid data. The estimates are shown in the appendix. These costs are conservative and if a deeper level feasibility analysis is undertaken and further design occurs, the costs may be able to be reduced.

12.0 Economic Analysis Assumptions
The cash flow analysis assumes fuel oil at $5.65/gal, electricity at $0.65/kwh, and cord wood delivered at $200/cord. The fuel oil, electricity, and cord wood costs are based on the costs reported by the facility.

It is assumed that the wood boiler would supplant 85% of the estimated heating use, and the existing heating systems would heat the remaining 15%. Each option assumes the total project can be funded with grants and non obligated capital money. The following inflation rates were used: O&M - 2%, Fossil Fuel – 5%, Wood Fuel – 3%, Discount Rate for NPV calculation – 3%. The fossil fuel inflation rate is based on the DOE EIA website. DOE is projecting a slight plateau with a long term inflation of approximately 5%. As a point of comparison, oil prices have increased at an annual rate of over 8% since 2001.

The analysis also accounts for additional electrical energy required for the wood fired boiler system, as well as the system pumps to distribute heating hot water to the buildings. Wood fired boiler systems also will require more maintenance, and these additional maintenance costs are factored into the analysis.

13.0 Results of Evaluation
The following table summarizes the economic evaluation for each option:

<table>
<thead>
<tr>
<th>Table 13.1 - Economic Evaluation Summary</th>
<th>Aleknagik Biomass Heating System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Operating NPV NPV 20 Yr 30 Yr B/C B/C ACF ACF YR 20 YR 30 ACF=PC</td>
<td></td>
</tr>
<tr>
<td>Cost Savings 30 yr 20 yr at 3% at 3% Ratio Ratio YR 20 YR 30</td>
<td></td>
</tr>
<tr>
<td>C.1 $346,000 $797 $264,465 $125,334 0.36 0.76 $186,695 $486,354 27</td>
<td></td>
</tr>
<tr>
<td>C.2 $439,000 $4,173 $416,227 $212,664 0.48 0.95 $310,839 $748,746 24</td>
<td></td>
</tr>
</tbody>
</table>

The benefit to cost ratio (B/C) takes the net present value (NPV) of the net energy savings and divides it by the construction cost of the project. A B/C ratio greater than or equal to 1.0 indicates an economically advantageous project.
Accumulated cash flow (ACF) is another evaluation measure that is calculated in this report and is similar to simple payback with the exception that accumulated cash flow takes the cost of financing and fuel escalation into account. For many building owners, having the accumulated cash flow equal the project cost within 15 years is considered necessary for implementation. If the accumulated cash flow equals project cost in 20 years or more, that indicates a challenged project. Positive accumulated cash flow should also be considered an avoided cost as opposed to a pure savings.

14.0 **Project Funding**

The City of Aleknagik may pursue a biomass project grant from the Alaska Energy Authority. The City of Aleknagik could also enter into a performance contract for the project. Companies such as Siemens, McKinstry, Johnson Controls and Chevron have expressed an interest in participating in funding projects of all sizes throughout Alaska. This allows the facility owner to pay for the project entirely from the guaranteed energy savings, and to minimize the project funds required to initiate the project. The scope of the project may be expanded to include additional energy conservation measures such as roof and wall insulation and upgrading mechanical systems.

15.0 **Summary**

A small district heating system connecting city buildings appears to be a poor candidate for the use of a wood biomass heating system. With the current economic assumptions, the economic viability of all the options is poor and none of the options meet the minimum requirement of the 20 year B/C ratio exceeding 1.0. Each building individually does not spend enough on heating fuel to be able to pay for a project through potential savings. Combining multiple buildings increases the project costs without substantially increasing the annual fossil fuel use.

16.0 **Recommended Action**

Revisit the viability of a wood heating project if after the Washeteria and/or other buildings are constructed and the campus of City buildings end up using over 10,000 gallons of fuel oil for heating.
APPENDIX A

Preliminary Estimates of Probable Cost
## Preliminary Estimates of Probable Cost
### Biomass Heating Options
#### Alegnagik, AK

### Option C.1 - City Hall + Health Center

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass Boiler Building Including Wood Storage Area</td>
<td>$55,000</td>
</tr>
<tr>
<td>Wood Boiler System</td>
<td>$32,000</td>
</tr>
<tr>
<td>Stack</td>
<td>$4,200</td>
</tr>
<tr>
<td>Mechanical/Electrical within Boiler Building</td>
<td>$20,200</td>
</tr>
<tr>
<td>Underground Piping</td>
<td>$45,000</td>
</tr>
<tr>
<td>City Hall Integration</td>
<td>$32,000</td>
</tr>
<tr>
<td>Health Clinic Integration</td>
<td>$13,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$201,400</td>
</tr>
<tr>
<td>30% Remote Factor</td>
<td>$60,420</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$261,820</td>
</tr>
<tr>
<td>Design Fees, Building Permit, Miscellaneous Expenses 15%</td>
<td>$39,273</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$301,093</td>
</tr>
<tr>
<td>15% Contingency</td>
<td>$45,164</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$346,257</td>
</tr>
</tbody>
</table>

**Total Project Costs** $346,257

### Option C.2 - City Hall + Health Center + Future Washeteria

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass Boiler Building Including Wood Storage Area</td>
<td>$55,000</td>
</tr>
<tr>
<td>Wood Boiler System</td>
<td>$32,000</td>
</tr>
<tr>
<td>Stack</td>
<td>$4,200</td>
</tr>
<tr>
<td>Mechanical/Electrical within Boiler Building</td>
<td>$20,200</td>
</tr>
<tr>
<td>Underground Piping</td>
<td>$75,000</td>
</tr>
<tr>
<td>City Hall Integration</td>
<td>$32,000</td>
</tr>
<tr>
<td>Health Clinic Integration</td>
<td>$13,000</td>
</tr>
<tr>
<td>Future Washeteria Integration</td>
<td>$24,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$255,400</td>
</tr>
<tr>
<td>30% Remote Factor</td>
<td>$76,620</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$332,020</td>
</tr>
<tr>
<td>Design Fees, Building Permit, Miscellaneous Expenses 15%</td>
<td>$49,803</td>
</tr>
<tr>
<td>Subtotal</td>
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<tr>
<td>15% Contingency</td>
<td>$57,273</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$439,096</td>
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</table>

**Total Project Costs** $439,096
EXISTING CONDITIONS

<table>
<thead>
<tr>
<th>City Hall</th>
<th>Health Clinic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Type</td>
<td>Fuel Type</td>
<td>Fuel Type</td>
</tr>
<tr>
<td>Fuel Units</td>
<td>Fuel Units</td>
<td>Fuel Units</td>
</tr>
<tr>
<td>Current Fuel Cost</td>
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<td>Current Fuel Cost</td>
</tr>
<tr>
<td>$5.70</td>
<td>$5.70</td>
<td>$5.70</td>
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<tr>
<td>Estimated Average Annual Fuel Usage</td>
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<tr>
<td>1,300</td>
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<tr>
<td>Annual Heating Costs</td>
<td>Annual Heating Costs</td>
<td>Annual Heating Costs</td>
</tr>
<tr>
<td>$7,410</td>
<td>$13,395</td>
<td>$20,805</td>
</tr>
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</table>

ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)

<table>
<thead>
<tr>
<th>Fuel Heating Value (Btu/unit of fuel)</th>
<th>Current Annual Fuel Volume (Btu)</th>
<th>Assumed efficiency of existing heating system (%)</th>
<th>Net Annual Energy Produced (Btu)</th>
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</thead>
<tbody>
<tr>
<td>138500</td>
<td>180,050,000</td>
<td>80%</td>
<td>144,040,000</td>
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WOOD FUEL COST

<table>
<thead>
<tr>
<th>Cord Wood</th>
<th>$/cord:</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.00</td>
<td></td>
</tr>
</tbody>
</table>

PROJECTED WOOD FUEL USAGE

Estimated Btu content of wood fuel (Btu/cord) - Assumed 20% MC, 6,700 Btu/lb x 28.4 lb/cf x 85 cf

| Cords of wood fuel to supplant net equivalent of 100% annual heating load. |
| 38                        |

| Cords of wood fuel to supplant net equivalent of 85% annual heating load. |
| 33                        |

| 25 ton chip van loads to supplant net equivalent of 85% annual heating load. |
| N/A                       |

Project Capital Cost -$346,000

Project Financing Information

<table>
<thead>
<tr>
<th>Percent Financed</th>
<th>Est. Pwr Use</th>
<th>Amount Financed</th>
<th>Other</th>
<th>First 2 Year Learning</th>
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<tbody>
<tr>
<td>0.0%</td>
<td>Type Hr/Wk</td>
<td>$0</td>
<td>$0</td>
<td>$20.00</td>
</tr>
<tr>
<td></td>
<td>Total Hr/Yr</td>
<td>$0</td>
<td>$0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Capital Cost - Principal and Interest</th>
<th>Displaced System Replacement Costs (year one only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Net Annual Cash Flow 797 1,256 3,412 3,971 4,567 5,202 5,879 6,599 7,366 8,181 9,047 9,968 10,946 11,984 13,086 19,676 28,461 40,096

Accumulated Cash Flow 797 2,053 5,464 9,435 14,002 19,204 25,083 31,682 39,048 47,229 56,276 66,244 77,190 89,175 102,261 186,695 310,436 486,354

Simple Payback: Total Project Cost/Year One Operating Cost Savings: 5

Net Present Value (30 year analysis): Net Present Value (20 year analysis):
## EXISTING CONDITIONS

### City Hall
- **Estimated Fuel Type:** Fuel Oil
- **Fuel Units:** gal
- **Estimated Average Annual Fuel Usage:** 1,300 gal
- **Annual Heating Costs:** $7,410

### Health Clinic
- **Estimated Fuel Type:** Fuel Oil
- **Fuel Units:** gal
- **Estimated Average Annual Fuel Usage:** 2,350 gal
- **Annual Heating Costs:** $13,395

### Washateria
- **Estimated Fuel Type:** Fuel Oil
- **Fuel Units:** gal
- **Estimated Average Annual Fuel Usage:** 1,127 gal
- **Annual Heating Costs:** $6,424

## ENERGY CONVERSION

### Projected Wood Fuel Usage
- **Estimated Btu content of wood fuel (Btu/cord):** 16,173,800
- **Cords of wood fuel to supplant net equivalent of 100% annual heating load:** 50 cords
- **25 ton chip van loads to supplant net equivalent of 85% annual heating load:** N/A

## Project Capital Cost
- **Amount Financed:** $439,000
- **Amount of Grants:** $439,000
- **Interest Rate:** 5.00%
- **Term:** 10 years
- **Annual Finance Cost (years):** $0

## Net Annual Cash Flow
- **Year Accumulated Cash Flow > 0:** #N/A
- **Year Accumulated Cash Flow > Project Capital Cost:** 24 years

## Operation and Maintenance Costs
- **Electric Rate:** $0.650 /kWh
- **Biomass System 1st 2 Year Learning:** O&M Inflation Rate: 2.0%

## Simple Payback:
- **Total Project Cost/Year One Operating Cost Savings:** 0.48

## Financials
- **Financed Project Costs - Principal and Interest:** 0
- **Displaced System Replacement Costs (year one only):** 0

## Discount System Replacement Costs (year one only)
- **Net Annual Cash Flow:**
  - Year 1: $4,173
  - Year 2: $4,841
  - Year 3: $7,218
  - Year 4: $8,010
  - Year 5: $8,852
  - Year 6: $9,747
  - Year 7: $10,698
  - Year 8: $11,708
  - Year 9: $12,779
  - Year 10: $13,916
  - Year 11: $15,122
  - Year 12: $16,401
  - Year 13: $17,756
  - Year 14: $19,193
  - Year 15: $20,714
  - Year 16: $29,769
  - Year 17: $41,757
  - Year 18: $57,545

## Accumulated Cash Flow
- **Year Accumulated Cash Flow > 0:** #N/A
- **Year Accumulated Cash Flow > Project Capital Cost:** 24 years

## Net Present Value (30 year analysis)
- **Net Present Value:** 0.48

## Net Present Value (20 year analysis)
- **Net Present Value:** 0.48

## Additional Power Use
- **Additional Maintenance**
  - **Electric Rate:** $0.650 /kWh
  - **Biomass System 1st 2 Year Learning:** O&M Inflation Rate: 2.0%

## Additional Fuel Use
- **Additional Operation and Maintenance Costs**
  - **Electric Rate:** $0.650 /kWh
  - **Biomass System 1st 2 Year Learning:** O&M Inflation Rate: 2.0%

## Simple Payback:
- **Total Project Cost/Year One Operating Cost Savings:** 0.48

## Financials
- **Financed Project Costs - Principal and Interest:** 0
- **Displaced System Replacement Costs (year one only):** 0

## Discount System Replacement Costs (year one only)
- **Net Annual Cash Flow:**
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  - Year 16: $29,769
  - Year 17: $41,757
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## Accumulated Cash Flow
- **Year Accumulated Cash Flow > 0:** #N/A
- **Year Accumulated Cash Flow > Project Capital Cost:** 24 years

## Net Present Value (30 year analysis)
- **Net Present Value:** 0.48

## Net Present Value (20 year analysis)
- **Net Present Value:** 0.48

## Additional Fuel Use
- **Additional Operation and Maintenance Costs**
  - **Electric Rate:** $0.650 /kWh
  - **Biomass System 1st 2 Year Learning:** O&M Inflation Rate: 2.0%

## Simple Payback:
- **Total Project Cost/Year One Operating Cost Savings:** 0.48

## Financials
- **Financed Project Costs - Principal and Interest:** 0
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## Net Present Value (30 year analysis)
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## Net Present Value (20 year analysis)
- **Net Present Value:** 0.48

## Additional Fuel Use
- **Additional Operation and Maintenance Costs**
  - **Electric Rate:** $0.650 /kWh
  - **Biomass System 1st 2 Year Learning:** O&M Inflation Rate: 2.0%
APPENDIX C

Site Plan
APPENDIX D

Air Quality Report
INTRODUCTION

At your request, RSG has conducted an air quality feasibility study for a biomass energy installation in Aleknagik. Aleknagik is located in southwest Alaska at the head of the Wood River and has a population of 219 people. A cord wood boiler is planned for the Aleknagik Main City Hall. The boiler will have an estimated heat output of 205,000 Btu's per hour and a heat input of 256,250 Btu's per hour, assuming 80% thermal efficiency.

STUDY AREA

A USGS map of the study area is provided below in Figure 1. As shown, the study area is located on Lake Aleknagik in the midst of hilly to mountainous topography and very little development. Our review of the area did not reveal any significant emission sources or ambient air quality issues.

Figure 1: USGS Map Illustrating the Study Area
Figure 2 shows CTA Architects' plan of the location of the proposed biomass facility and surrounding buildings. The site is relatively flat and sparsely populated with buildings. The facility will be located in a separate building south of the fire department garage. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined.

**Figure 2: Location of Proposed Biomass Facility**
METEOROLOGY

Aleknagik is located relatively close (approximately 40 miles) to the ocean and therefore has a mostly maritime climate. Meteorological data from Bethel, AK, was reviewed to develop an understanding of the weather conditions. Bethel is approximately 150 miles away, but also located in the same climactic region of Alaska and therefore experiences similar weather patterns. As shown in the bottom of Figure 3, there is a relatively low percentage of “calms” (times when the wind is not blowing) during most of the year.\(^1\) This data indicates only 1% of the year when “calms” occur, which suggests there will be minimal time periods when thermal inversions and, as a result, poor emission dispersion conditions occur.

**Figure 3: Wind Speed Data from Bethel, AK**

\(^1\) See: [http://climate.gi.alaska.edu/Climate/Wind/Direction/Bethel/BET.html](http://climate.gi.alaska.edu/Climate/Wind/Direction/Bethel/BET.html)
DESIGN & OPERATION RECOMMENDATIONS

The following are suggested for designing this project:

- Burn natural wood, whose characteristics (moisture content, bark content, species, geometry) - result in optimal combustion in the equipment selected for the project.
- Do not install a rain cap above the stack. Rain caps obstruct vertical airflow and reduce dispersion of emissions.
- Construct the stack to at least 1.5 times the height of the tallest roofline of the adjacent building. Hence, a 20 foot roofline would result in a minimum 30 foot stack.
- Operate and maintain the boiler according to manufacturer's recommendations.
- Perform a tune-up at least every other year as per manufacturer's recommendations and EPA guidance (see below for more discussion of EPA requirements)
- Conduct regular observations of stack emissions. If emissions are not characteristic of good boiler operation, make corrective actions.

These design and operation recommendations are based on the assumption that state-of-the-art combustion equipment is installed.

STATE AND FEDERAL PERMIT REQUIREMENTS

This project will not require an air pollution control permit from the Alaska Department of Environmental Quality given the boilers’ relatively small size and corresponding quantity of emissions. However, this project will be subject to new proposed requirements in the federal “Area Source Rule” (40 CFR 63 JJJJJJ). A federal permit is not needed. However, there are various record keeping, reporting and operation and maintenance requirements which must be performed to demonstrate compliance with the requirements in the Area Source Rule. The proposed changes have not been finalized. Until that time, the following requirements are applicable:

- Submit initial notification form to EPA within 120 days of startup.
- Complete biennial tune ups per EPA method.
- Submit tune-up forms to EPA.

Please note the following:

- Oil and coal fired boilers are also subject to this rule.
- Gas fired boilers are not subject to this rule.
- More requirements are applicable to boilers equal to or greater than 10 MMBtu/hr heat input. These requirements typically warrant advanced emission controls, such as a baghouse or an electrostatic precipitator (ESP).

The compliance guidance documents and compliance forms can be obtained on the following EPA web page: http://www.epa.gov/boilercompliance/
SUMMARY & CONCLUSIONS

RSG has completed an air quality feasibility study for a new cord wood boiler for the Aleknagik Main City Hall. The boiler is not subject to state permitting requirements, but is subject to federal requirements. Design criteria have been suggested to minimize emissions and maximize dispersion.

The following conditions suggest advanced emission control devices (ESP, baghouse) are not warranted:

1. Aleknagik is a very rural area with no significant emission sources.
2. Aleknagik has favorable meteorology for emissions dispersion.
3. The wood boiler will be a relatively small emission source.
4. There are no applicable federal or state emission limits.

While not mandatory, we recommend exploring the possibility of a cyclone or multi-cyclone technology for control of fly ash and larger particulate emissions. We also recommend developing a compliance plan for the aforementioned federal requirements.

Please contact me if you have any comments or questions.
APPENDIX E

Wood Fired Heating Technologies
WOOD FIRED HEATING TECHNOLOGIES

CTA has developed wood-fired heating system projects using cord wood, wood pellet and wood chips as the primary feedstock. A summary of each system type with the benefits and disadvantages is noted below.

Cord Wood
Cord wood systems are hand-stoked wood boilers with a limited heat output of 150,000-200,000 British Thermal Units per hour (Btu/hour). Cord wood systems are typically linked to a thermal storage tank in order to optimize the efficiency of the system and reduce the frequency of stoking. Cord wood boiler systems are also typically linked to existing heat distribution systems via a heat exchanger. Product data from Garn, HS Tarm and KOB identify outputs of 150,000-196,000 Btu/hr based upon burning eastern hardwoods and stoking the boiler on an hourly basis. The cost and practicality of stoking a wood boiler on an hourly basis has led most operators of cord wood systems to integrate an adjacent thermal storage tank, acting similar to a battery, storing heat for later use. The thermal storage tank allows the wood boiler to be stoked to a high fire mode 3 times per day while storing heat for distribution between stoking. Cord wood boilers require each piece of wood to be hand fed into the firebox, hand raking of the grates and hand removal of ash. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Cordwood boilers are manufactured by a number of European manufacturers and an American manufacturer with low emissions. These manufacturers currently do not fabricate equipment with ASME (American Society of Mechanical Engineers) certifications. When these non ASME boilers are installed in the United States, atmospheric boilers rather than pressurized boilers are utilized. Atmospheric boilers require more frequent maintenance of the boiler chemicals.

Emissions from cord wood systems are typically as follows:

- **PM2.5**: >0.08 lb/MMbtu
- **NOx**: 0.23 lb/MMbtu
- **SO2**: 0.025 lb/MMbtu
- **CO2**: 195 lb/MMbtu

**Benefits:**
- Small size
- Lower cost
- Local wood resource
- Simple to operate

**Disadvantages:**
- Hand fed - a large labor commitment
- Typically atmospheric boilers (not ASME rated)
- Thermal Storage is required
**Wood Pellet**

Wood pellet systems can be hand fed from 40 pound bags, hand shoveled from 2,500 pound sacks of wood pellets, or automatically fed from an adjacent agricultural silo with a capacity of 30-40 tons. Pellet boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from KOB, Forest Energy and Solagen identify outputs of 200,000-5,000,000 Btu/hr based upon burning pellets made from waste products from the western timber industry. A number of pellet fuel manufacturers produce all tree pellets utilizing bark and needles. All tree pellets have significantly higher ash content, resulting in more frequent ash removal. Wood pellet boilers typically require hand raking of the grates and hand removal of ash 2-3 times a week. Automatic ash removal can be integrated into pellet boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer. Pellet storage is very economical. Agricultural bin storage exterior to the building is inexpensive and quick to install. Material conveyance is also borrowed from agricultural technology. Flexible conveyors allow the storage to be located 20 feet or more from the boiler with a single auger.

Emissions from wood pellet systems are typically as follows:

- **PM2.5**: >0.09 lb/MMbtu
- **NOx**: 0.22 lb/MMbtu
- **SO2**: 0.025 lb/MMbtu
- **CO2**: 220 lb/MMbtu

**Benefits:**
- Smaller size (relative to a chip system)
- Consistent fuel and easy economical storage of fuel
- Automated

**Disadvantages:**
- Higher system cost
- Higher cost wood fuel ($/MMBtu)
**Wood Chip**

Chip systems utilize wood fuel that is either chipped or ground into a consistent size of 2-4 inches long and 1-2 inches wide. Chipped and ground material includes fine sawdust and other debris. The quality of the fuel varies based upon how the wood is processed between the forest and the facility. Trees which are harvested in a manner that minimizes contact with the ground and run through a chipper or grinder directly into a clean chip van are less likely to be contaminated with rocks, dirt and other debris. The quality of the wood fuel will also be impacted by the types of screens placed on the chipper or grinder. Fuel can be screened to reduce the quantity of fines which typically become airborne during combustion and represent lost heat and increased particulate emissions.

Chipped fuel is fed from the chip van into a metering bin, or loaded into a bunker with a capacity of 60 tons or more. Wood chip boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from Hurst, Messersmith and Biomass Combustion Systems identify outputs of 1,000,000 - 50,000,000 Btu/hr based upon burning western wood fuels. Wood chip boilers typically require hand raking of the grates and hand removal of ash daily. Automatic ash removal can be integrated into wood chip boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Emissions from wood chip systems are typically as follows:

- PM2.5: 0.21 lb/MMbtu
- NOx: 0.22 lb/MMbtu
- SO2: 0.025 lb/MMbtu
- CO2: 195 lb/MMbtu

**Benefits:**
- Lowest fuel cost of three options ($/MMBtu)
- Automated
- Can use local wood resources

**Disadvantages:**
- Highest initial cost of three types
- Larger fuel storage required
- Less consistent fuel can cause operational and performance issues