The Lake and Peninsula Borough Regional Energy Plan

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Lake and Peninsula Borough
Regional Energy Plan

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CONTENTS

List of Figures ii
List of Tables..... ii

Executive Summary..... 3

Introduction..... 10

Electric 12

Heating 35

End-Use 44

Transportation 51

Pebble Mine Considerations 53

Appendices..... 58

LIST OF FIGURES

Figure 1 Lake and Peninsula Borough Long Run Forecast - Electric Utility Rate.....14
Figure 2 Lake and Peninsula Borough Electric Generation Screening Study Options.....17
Figure 3: Annual Average U.S. Consumer Electronic Electrical Consumption (2006).....18
Figure 4 PCE Utilities - Aggregate Average Cost of Utility Diesel Fuel (1982-2008).....23
Figure 5 AHFC Weatherization Regions – Lake and Peninsula served by ACDC (DEFINE) and Bristol Bay Housing Authority.....46

LIST OF TABLES

Table 1 Regional hydroelectric projects - Rank order.....24
Table 2 Wind Class - Project cost and performance, HOMER modeling.....27
Table 3 Individual community preliminary reconnaissance level resource assessment - Wind.....28
Table 4 Wind project benefits to communities.....29
Table 5 Wind project preliminary cost estimates.....30
Table 6 Long run cost of wood for space heating – Lake and Peninsula communities.....36
Table 7 Equivalent delivered cost per end-use heating requirement - Fuel oil versus wood.....37
Table 8 Fuel oil versus wood cost per unit by community.....39
Table 9 Estimated project cost components: Wood boiler, connections and support systems.....41
Table 10 School energy consumption - Fuel oil versus wood cost.....42
Table 11 Potential community savings - Weatherization.....48
Table 12 Potential household savings - Weatherization.....48
Table 13 Energy use per year – by BEES energy ratings.....49
Table 14 Runway extensions - Estimates of fuel cost savings.....51
Table 15 Small scale fuel delivery system – Cost of fuel transportation legs from Kenai.....52
Table 16 Large scale fuel delivery system – Cost of fuel transportation legs from Kenai.....52
Table 17 Pebble project potential impacts.....56

EXECUTIVE SUMMARY

The price of energy in the Lake and Peninsula Borough, as in other rural remote locations in Alaska, increased rapidly over the past four years, peaking during this past summer's fuel barge delivery season, raising the specter that extraordinarily high rural energy costs may drive population to migrate to communities with lower energy costs.

This spring the Legislature appropriated hundreds of millions of dollars for efficiency and conservation measures at the household level and development of renewable energy sources on the local and regional level. This summer the Legislature approved a resource "dividend" of $1,200 per person to share the wealth from high oil prices and help households with high energy and related costs.

In response to the rapid increase in energy costs, the Lake and Peninsula Borough contracted with the project team to assist in evaluating energy opportunities in the region and development of a Borough energy plan.

The project team conducted a screening study for the Borough that considered the economics of a range of options in electric generation, space heating and transportation. This screening study identified the projects with the highest potential for reducing energy costs and developed the recommendations described in this report. Development of renewable resources offers attractive projects for many communities in the region but will take considerable time and money. Demand side management, energy efficiency and conservation can offer more immediate relief in every community in the Borough.

The primary source of imported energy in the Borough is diesel. A community's ability to obtain reasonable pricing for diesel fuel drives space heat affordability and the cost of electric generation. It is worth noting that many entities within the Borough are working together and actively pursuing opportunities for joint purchasing. Joint fuel purchasing is occurring in many communities – driving down the unit price of fuel and helping to ensure regular delivery.

The Borough could take an active role in creating the structure under which <u>all</u> fuel purchases in the region occur in a coordinated way, creating larger volume and lower unit cost. The Alaska Village Electric Cooperative (AVEC) along with several school districts in its Western Alaska region, provides a successful model for cooperative fuel procurement. Consolidating fuel purchases in an area could save smaller buyers on the order of 25 cents per gallon.

For the purposes of outlining the energy needs and potential solutions for the Borough, this report is presented in five sections: electric generation, space heating, energy efficiency and conservation, transportation, and the Pebble Mine project. An appendix provides technical backup and details of the analysis. A brief summary of opportunities and findings is outlines below.

- **Electric generation:** Despite its high cost, diesel with secondary heat recovery, a.k.a. "waste heat," remains competitively priced compared to many other electric generation alternatives. In some communities, diesel prices have become high enough to warrant serious investigation of alternative generation resources.

  The most promising alternative electric generation opportunities are: hydro/wind/intertie serving the three Chignik communities and wind development in other communities in the region including: Pedro Bay, Port Alsworth, Egegik, Iliamna, Newhalen, Nondalton, Port Heiden and Pilot Point. These alternatives have the potential to reduce the cost of electricity by as much as 15c/kWh.

  In-stream turbines and geothermal electricity may be technically feasible, but small scale remote rural developments may not be economic without further sustained increase in the cost of imported diesel and identification of high quality local resources. Two communities, Igiugig and Port Alsworth, are exploring potential in-stream resources in the hopes of identifying a reliable energy source with environmental benefits and price stability.

  Since the PCE program covers a significant portion of household electric bills, most of the monetary savings associated with electric generation alternatives will be shared between commercial/government customers and the State of Alaska through a reduction in PCE support to the utility serving that community. Median households will not see a significant decrease in their energy bills. Thus, the Borough should continue to work with the Alaska Energy Authority to finance projects that will reduce the cost of electricity and reduce the need for PCE support.

- **Heating:** The Lake and Peninsula Borough has a high penetration rate of high efficiency direct vent heating units relative to other rural areas. These units offer such dramatic improvement over older less efficient heating units that it is worth continued efforts to ensure that these units are utilized in homes and small businesses where they are not currently utilized.

  Where wood is, or can be made available, Alaskans are turning to wood as an

alternative to fuel oil. The Borough should continue to support the Bristol Bay Housing Authority's initiative to provide wood stoves in new housing and explore whether opportunities exist to retrofit wood stoves and wood boilers for existing houses.

In addition, the schools in the Lakes area may be able to utilize high efficiency wood boilers to supplement their existing heating systems which rely on a combination of fuel oil and secondary heat from diesel electric generation sets. Initial screening suggests that at least seven communities may have the local wood resources necessary to provide supplemental space heat with estimated net savings of $18,000 per year.

Even with oil as low as $70/bbl and heating oil prices in the $4 per gallon range (equivalent to $340 per cord), wood remains an attractive option at $200 to $250 per cord. The biggest savings can be found by applying new wood burning technology to larger buildings in the community, e.g. schools.

- **Energy efficiency and conservation:** The least expensive unit of energy is the one that is never used. Not only are energy efficiency and conservation cheaper than other options, but they also are the fastest to implement. Rural Alaskans already practice conservation in many ways and on average use considerably less energy than their urban counterparts.

  There are, however, significant potential savings in energy efficiency measures that will have little impact on delivery of the energy-end-product, i.e. heat, light, and other consumer uses. Energy efficiency options are evaluated for electric, space heat and transportation. The Borough can play a lead role in encouraging the adoption of energy efficiency and conservation measures.

  End-use efficiency measures offer opportunities for savings at any price level. State sponsored programs such as the Home Energy Rebate and Weatherization programs run through the Alaska Housing Finance Corporation offer assistance in determining the best measures and paying for their implementation. Housing stock in the Lake and Peninsula Borough that is more than five years would likely benefit from the energy efficiency measures these programs offer. Potential household savings range from $927 to $1,718 depending on consumption and the price of fuel.

  Opportunities to save electricity can be found in almost all households, businesses, schools, government buildings and commercial facilities. Measures to reduce electric consumption include: lowering the temperature on hot water heaters, replacing old

light fixtures with new efficient lighting (T-12 to T-8 fixtures and incandescent to compact florescent bulbs), and replacing old refrigerators with efficient models.

It is recommended that the borough lead by example and implement energy efficient procurement policies as well as support the development of commercial and residential building energy codes.

- **Transportation:** In the long run, improvements in the transportation infrastructure in the region can make a significant reduction in the cost of importing energy and other goods.

  The potential savings of the Pile Bay Road on delivered fuel costs in seven Lake and Peninsula Borough communities may range from $1.23 in Nondalton to $1.82 per gallon in Igiugig compared to flown-in fuel. Annual estimated savings for the villages are substantial, totaling between $1.3 million to $1.5 million depending upon future economic growth in the area.

  The communities of Igiugig, Kokhanok, Nondalton and Pedro Bay have limited barge service and would benefit from reduced unit costs for fuel if their local runways were extended to accommodate larger aircraft.

- **Pebble mine:** Regardless of whether Pebble Mine is developed, many energy initiatives, including energy efficiency, implementation of a building energy code, weatherization, and wood space heating should help reduce the cost of energy in the Borough.

  If Pebble continues with the exploration and preconstruction phases, there may be opportunities for the cooperative purchasing of diesel for electric generators, space heating and transportation fuels that may lower prices for Borough residents.

  If Pebble proceeds to construction and operations, the Borough may benefit from a combination of importing power from the Railbelt and further development of local larger scale hydro resources. In addition, the lower cost of generation associated with imported power and larger scale hydro may be sufficient to justify the development of a regional electric grid providing power from Port Alsworth all the way over to Dillingham and Manokotak, up to Koliganek and down to Egegik.

Recommended Action Plan

The price of basic fuels in the Lake and Peninsula Borough, as in other remote rural locations in Alaska, has increased by more than a factor of three over the past five years, peaking late this summer at levels as high as $9 per gallon for heating oil (crude oil peaking at $147/bbl). Unfortunately the fuel price peak occurred at the same time as the summer fuel delivery season and many communities filled their tank farms with diesel and heating oil priced based on those record oil prices.

While crude oil has rapidly declined and is now trading around $50/bbl, roughly comparable to the summer of 2005, the residents and businesses in the Borough face three main energy challenges:

1. The immediate short term challenge of heating their homes and businesses with extremely expensive heating oil purchased during this summer's peak
2. Next summer's challenge of buying heating oil and diesel utility fuel while the US and world economy cools rapidly and Alaska's economy adjusts to the rapid decline in oil prices
3. The long term challenge of highly volatile fuel prices that could very well run back up to $85/bbl to $120/bbl by 2015.[1]

Immediate Short Term Action Plan

The Alaska resource dividend of $1200 per person that arrived in September may have provided short term relief from high energy prices this fall, but the high price of fuel from this summer's delivery is likely to persist throughout the winter and into next spring. To help provide relief to residents and businesses this winter the Borough should:

1. Identify a local lead person to sign up at least a dozen local households to participate in the AHFC weatherization/energy grant program and schedule a village visit by a home energy auditor as soon as practical
2. Work with the Bristol Bay Housing Authority to identify people who can accompany the home energy auditor(s) and provide, at a minimum, *immediate* caulking, sealing, furnace, toyo or wood stove tune-ups and chimney cleaning for households, commercial and government facilities
3. Identify a local lead person to quickly assess whether the local wood supply is adequate to meet local demand for supplementary wood heat. Where additional wood supply may be of high value, seek quotes from wood supply vendors to import wood and relay the quotes back to the local lead who can then attempt to round up enough orders to make a winter wood delivery worthwhile.

[1] $85/bbl – NYMEX Crude Oil Contract, 2015 Delivery (Week of November 17-21, 2008); $120/bbl – IEA World Energy Outlook (November 12, 2008).

4. Apply for low interest loans from the AHFC and AEA where appropriate to enable up-front funding of weatherization, heating, and energy grant efforts (raters and contractors) for households and businesses and leverage equity participation by government facilities
5. Contact Steve Osborne, Alaska Inter-Tribal Council, to coordinate delivery of 100 gallons of free heating fuel for those communities in the Lake & Peninsula Borough who wish to participate in the free fuel program.

Next Summer's Fuel Supply Action Plan

Convene a meeting this winter with fishing, mining, tourism, government, native and tribal entities, other interested parties and local residents to explore a cooperative fuel purchase arrangement for next spring/summer. Engage Roger Kemppel to talk about lessons learned from other fuel cooperative purchase arrangements and his assessment of when it might make sense to buy a fixed price long term fuel supply or other fuel price hedging strategies.

Long Term Action Plan

1. Support the AHFC weatherization/energy grant program (funding + training of front line auditors and contractors) to ensure local residents have an opportunity to participate in the program in a timely manner
2. Support funding for the Williamsport-Pile Bay road to reduce the cost of delivering fuel to the villages in the Lakes region; this could save on the order of $1-2 per gallon compared to flown-in fuel
3. Support funding for lengthening runways out to 4000 feet where possible; this could save on the order of $1.50 per gallon by enabling DC-6 vs. C-46 fuel deliveries
4. Support grant applications to explore the feasibility of supplemental wood heat for schools in the Lakes Region[2]
5. Support grant applications to explore feasibility of hydro/wind power and electrical interties in the Chigniks[3]
6. Support funding for roads in the Chignik area to reduce the cost of transportation and reduce the cost of electrical interties to enable the area to share high value hydro and wind resources
7. Support grant applications to explore the feasibility of wind power opportunities in Pedro Bay, Port Alsworth, Egegik, I-N-N, Port Heiden and Pilot Point[4]
8. Support grant applications for in-stream vertical axis turbine demonstration projects in Igiugig and Port Alsworth

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[2] Grant application filed with AEA Renewable Energy Program

[3] Grant application filed with AEA Renewable Energy Program

[4] Grant application filed with AEA Renewable energy program

9. Monitor the development of energy supply options for the Pebble Mine to ensure that those options enable local residents and businesses to participate. Continue to explore the potential for development of the Newhalen River hydroelectric project to complement power imported via high voltage interties and provide local employment opportunities. Continue to explore the potential for a regional electric grid to enable reliable cost effective sharing of regional hydro and wind resources from the Lakes region down to Egegik and over to Manokotak and Aleknagik.
10. Continue to seek regional partnerships to provide cost effective and reliable operations, maintenance and management support to local utility and fuel supply operations

INTRODUCTION

The purpose of this project is to provide the Lake and Peninsula Borough with an energy plan that will serve the needs of Borough residents, offer relief from high energy costs and facilitate a more sustainable future. A sustainable energy future is one in which individuals, businesses and industries have access to reliable and affordable energy. Sustainable energy forms a key component of an atmosphere in which businesses can thrive, and it is an essential piece of the infrastructure of a healthy community.

Energy prices in the Lake and Peninsula Borough have risen dramatically during the past five years and are poised to continue to rise in the future. The median household income in the Lake and Peninsula Borough is roughly 40 percent lower than the statewide median- yet the cost of living is considerably higher. In addition to higher heating and electricity prices, the high cost of fuel affects all consumer goods transported to the Borough.

Diesel is the dominant energy source for the Lake and Peninsula Borough communities. The price of energy in the Lake and Peninsula Borough is primarily driven by the price of crude oil that provides feedstock for diesel, heating oil, gasoline and aviation fuels. Over the past five years, the price of crude oil has ranged from $30/bbl to $147/bbl and has recently fallen to below $70/bbl. Over the past six months, the Alaska Energy Authority (AEA) has been using long term oil price forecast values of $100 to $110/bbl as a benchmark for economic studies.

Oil Price Assumptions

The price of energy in the Lake and Peninsula Borough is primarily driven by the price of crude oil that provides feedstock for diesel, heating oil, gasoline and aviation fuels. Over the past five years, the price of crude oil has ranged from $30/bbl to $145/bbl. Over the past twelve months the price has gone from roughly $60-$70/bbl in the summer of 2007 up to a peak of $145/bbl in mid-summer 2008, and has fallen back down to below $70/bbl in October 2008 and remained below $70/bbl despite OPEC commitments to reduce supply .

While many energy analysts have revised their price outlook for crude oil as financial and commodity markets have deflated and become highly volatile over the past 60 days, this same set of analysts still see supply constraints becoming a prominent consideration over the next several years after the current recessionary trends abate, lending continued support for a *long-term* price forecast of around $110/bbl.[5]

[5] While in mid-October, Merrill Lynch, Citigroup, Deutsche Bank and Goldman Sachs had revised their 2009 oil price outlooks down to $75-$90, they were still predicting supply constraints and demand from emerging economies will lend support to $100-$110/bbl oil on the five year planning horizon.

Thus, for the purpose of considering long-term infrastructure investments with useful lives typically ranging from 10 to 40 years (or potentially even longer in the case of hydroelectric)

The screening study for this energy plan uses a long-term oil price benchmark of $110/bbl for screening energy resource options.

All of the utility scale capital investments that appear economically attractive in this screening study should be reviewed prior to financing and final commitment of capital funding to ensure that they continue to provide net benefits to local residents based on the best information available at the time concerning the range of future oil and delivered energy prices in Alaska and capital cost projections.[6]

Consistent with AEA and UAA ISER fuel supply studies in 2008, we used the historic relationship between the price of crude oil and the price of refined fuels delivered to individual communities as the basis to estimate the long run delivered price of fuels to the local communities in Lake and Peninsula Borough. Based on a **benchmark price of $110/bbl oil**, the delivered price for ***utility*** **diesel fuel ranges from $4.50 to $7.00 per gallon** across the Lake and Peninsula Borough.

The delivered price for fuel *within individual communities* varies depending upon whether the fuel was delivered by barge or airplane, the extent to which the cost of local storage and handling is included in price (or is subsidized), and the subsequent handling and administration associated with local fuel delivery. Within an individual community, the price for diesel/heating oil can vary from $1 to $2 per gallon – and the electric utility and school experiencing the lowest prices with the highest posted prices for heating oil for residences and small commercial and government facilities. The Alaska Rural Energy Plan, based on 2002 fuel costs, indicated widespread opportunities for cost-saving measures from end use efficiency, diesel generation efficiency, diesel combined heat and power, and wind energy.[7] Renewable energy resources, available in some form throughout Alaska,[8] hold potential for displacing diesel fuel, reducing and stabilizing energy costs, stimulating local economic development, reducing fuel spills, and decreasing air pollution and greenhouse gas emissions.

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[6] We note that if one of the major energy infrastructure projects were ready to advance to finance and construction phases today, we would encourage the project sponsors to consider the risk/reward profile of the project under $50, $110 and $150/bbl oil (2008$) scenarios. It would also be appropriate to adjust the capital cost estimates to reflect energy project infrastructure costs consistent with each of those oil price scenarios. For example, as oil prices have returned to $70/bbl this past week, many capital cost estimates for projects to be built in 2009 and beyond are being adjusted to reflect lower material, equipment, labor costs and higher financing costs. Conversely, in a $150/bbl high oil price scenario, capital cost estimates may have to be increased even higher to reflect both higher construction and higher finance cost outlooks.

[7] Foster, Mark A. in collaboration with Northern Economics, Inc. Alaska Rural Energy Plan, Initiatives for Improving Efficiency and Reliability. Anchorage: Alaska Energy Authority, 2004.

[8] Crimp, Peter and Reuben Loewen, Mia Devine, David Lockard (Alaska Energy Authority), Project), Chris Rose and Hannah Willard (Renewable Energy Alaska and Inc.), and Dan Rathert and Matthew Johnson (Resource Data. Renewable Energy Atlas of Alaska. Anchorage: Alaska Energy Authority and Renewable Energy Alaska Project, 2007.

ELECTRIC

The results of the electric energy screening study support the following energy project initiatives:

1. Chigniks Hydro/Wind Feasibility Study
    a. Chignik Bay, Chignik Lagoon, Chignik Lake
2. Regional Wind Recon/Feasibility Study
    a. Pedro Bay
    b. Port Alsworth
    c. Egegik
    d. Iliamna-Newhalen-Nondalton
    e. Port Heiden
    f. Pilot Point
3. Lakes Region School Supplemental Wood Heat Design Project
    a. Pedro Bay
    b. Kokhanok
    c. Nondalton
    d. Newhalen
    e. Port Alsworth

Electric section Outline

- Screening Study Introduction
- Cost of Power – Remote Rural
- Price of Power – Power Cost Equalization (PCE)
- Tipping Point for Commercial/Government Customers without PCE to go "off-grid" and self-generate
- Forward Looking Electric Utility Options
    - Economic screening, including operational support
    - Supply Side: Generation and Transmission
    - Regional Systems vs. Island Systems
    - Newhalen Falls Diversion Project with Regional Grid
        - With and without industrial load
    - Industrial load served by Intertie with Railbelt + Regional Grid
    - Island Systems
        - End-use efficiency
        - Diesel with secondary heat recovery
        - Hydroelectric
        - Wind
        - Wood Boilers in combined heat and power applications
        - Geothermal
        - Tidal
        - Others
- Candidates for Further Development

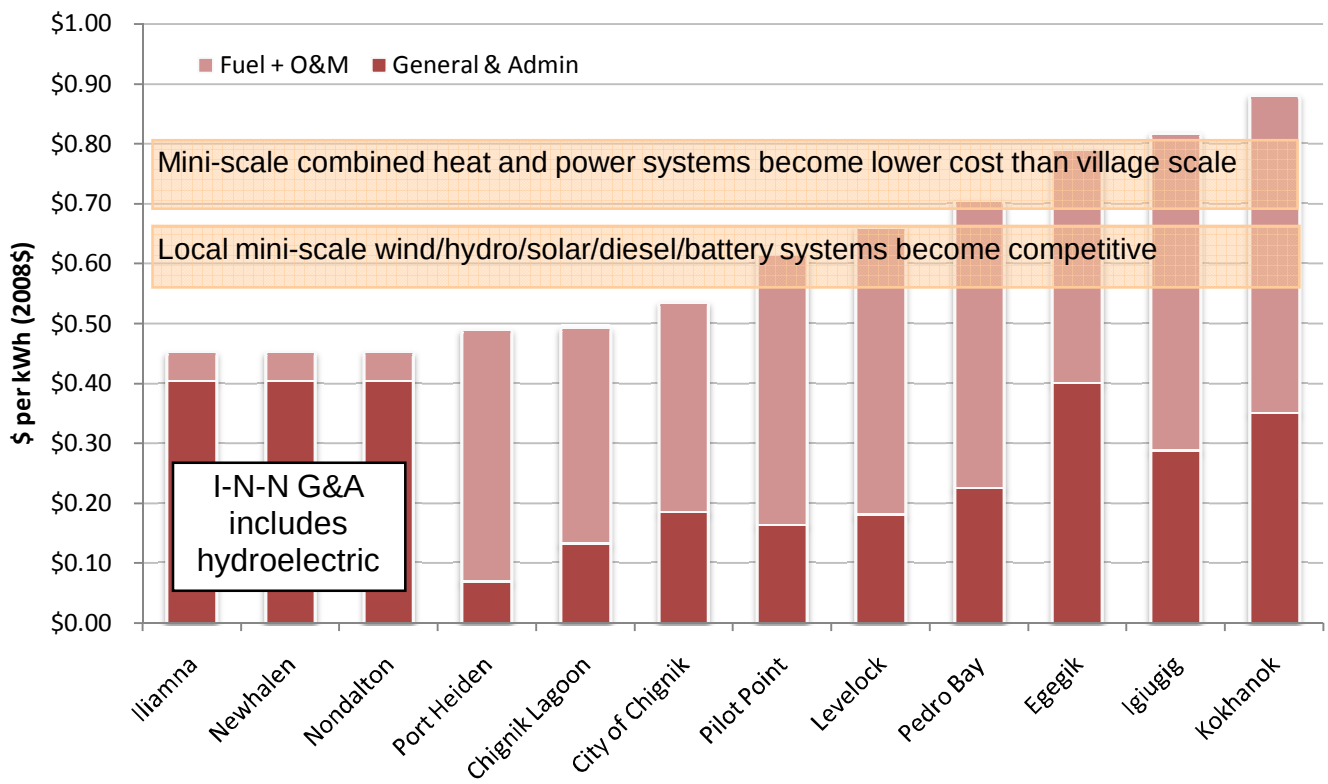
Introduction

This screening study compares the forward-looking costs of electric service in Lake and Peninsula Borough communities using various generation technologies, including diesel, hydro, wind, biomass, geothermal, household and neighborhood scale micro wind/solar/hydro hybrid systems, solar PV and end use efficiency.

Cost of Power – Remote Rural Communities

The total cost to provide electric service in remote rural communities includes the costs associated with electrical generation plus the cost of general and administrative activities and distribution system maintenance. Figure 1 below shows the total cost for electric energy generation by fuel and operations and maintenance cost as well as general administrative costs. For six communities in the region local mini-scale systems appear to be currently competitive.

Figure 1 Lake and Peninsula Borough Long Run Forecast - Electric Utility Rate



Price of Power – Power Cost Equalization (PCE) Program

PCE program provides 95 percent of difference between cost of power and "urban average" for up to 500kWh per month for residential customers and up to 70kWh/mo/person for community facilities (water, sewer, outdoor lighting, charitable education organization not funded by state or federal funds, public non-profit, etc.)

The apparent price for residential customers frequently approaches 20c/kWh, taking into account the net effect of the PCE credit and monthly consumption that exceeds 500kWh.

The apparent price for commercial/government facilities tends to more directly reflect actual cost and runs from 45c/kWh up to 90c/kWh across Lake and Pen communities.

Tipping Point for Commercial/Government facilities without PCE Support

As the cost to provide central small scale power in remote rural communities increases above $0.50 to $0.60 per kWh, there appears to be a point at which the cost and performance of central station diesel fired power becomes less attractive than the cost and performance of small scale systems that take advantage of the combination of wind/solar/diesel and/or micro-hydro hybrid systems at individual buildings, e.g., schools, clinics, fish processing plants, and remote resorts.

While in theory the local utility could attempt to reduce its general and administrative overhead allocation to these prospective self-generators in order to price electricity at a point where they are motivated to stay on the system, it appears more likely that these small central station diesel based utilities have two practical choices. One, they can find a locally practical alternative that is less expensive than diesel or, two, they can lose customers to less costly self-generation alternatives. With the loss of any significant customer, small utilities are quickly exposed by having relatively fixed general and administrative costs spread over fewer and fewer kWhs.

Thus, as the price of power increases above $0.50 per kWh, we recommend that the Borough and its local community and utility examine whether it might make more sense to 1) allow the development of more cost effective small household and small commercial systems, or 2) find a *local generation resource* that is less costly than diesel in order to keep the price of electricity under the price where customers are motivated to self-generate. (See Figure 1 for the total price of electricity in Lake and Pen communities that may still have a local central station diesel plant)

In Kokhanok, Igiugig, Egegik, and Pedro Bay, where the long run cost of diesel-generated electricity ranges from $0.70 to $0.85 per kWh, the Borough should proceed to quickly explore the cost of practical locally available alternative generation resources in order to avoid rapid loss of government and commercial customers who do *not* receive PCE support to self-generation.

For Levelock and Pilot Point, where the long run cost of diesel-generated electricity is in the $0.60 per kWh range, the hurdle rate of changing to a new unfamiliar system may slow the loss of non-PCE customers to self-generation. Nonetheless, the Borough should proceed to investigate the cost of practical locally available alternative generation resources in order to avoid loss of non-PCE customers to self-generation and to reduce the overall cost of service compared to continued reliance on diesel.

Electric Utility Alternatives

When comparing energy resource alternatives *for an existing electric utility*, we focus on the long run forward-looking cost of each type of electrical generation system and assume that the general and administrative costs of the utility remain unchanged by the choice of generation systems.

We have developed estimates for the forward-looking long run cost of several technologies that appear at least potentially attractive for remote rural Alaska to ascertain which resource options appear the most promising and to estimate their potential value relative to the existing primary reliance on diesel fired electricity and secondary heat recovery.

The economic screening analysis takes into consideration of long-term operational support for various systems. First, it is useful to keep in mind that diesel systems have considerable installed base and operational support systems and as a result have lower incremental capital and operating costs compared to most other alternatives.

New capital-intensive systems face the daunting challenge of finding and sustaining effective operational support in remote rural markets where adequate maintenance of well-known and robust energy systems can be problematic. Some systems are relatively low maintenance and will run indefinitely with modest maintenance. Other systems may not survive the many challenges of remote rural Alaska.

Neil Davis Energy Alaska cites the short-term proliferation of wind turbines in the 1980s and subsequent disappearance in the 1990s. In contrast, Skagway has a hydroelectric power plant operated by Alaska Power and Telephone that has been in essentially continuous operation for just over 100 years.

While a particular solution may appear promising, it may not be ready for widespread commercial deployment in remote rural Alaska. Thus, while wind may have sufficiently matured to warrant further investigation and potential investment at this time, several technologies that are in development, e.g., tidal, in-stream hydro, may not be ready for more than selective demonstration projects at this time. Other technologies like geothermal might be promising, but the cost to prospect or the cost to move a community to a high quality geothermal site can quickly overwhelm the potential cost savings.

Thus in this analysis we have tried to focus on energy solutions that are economic, which includes consideration of the risk of being able to sustain successful operations of relatively new technologies to a particular region where the established base of experienced operators may be limited.

Figure 2 Lake and Peninsula Borough Electric Generation Screening Study Options

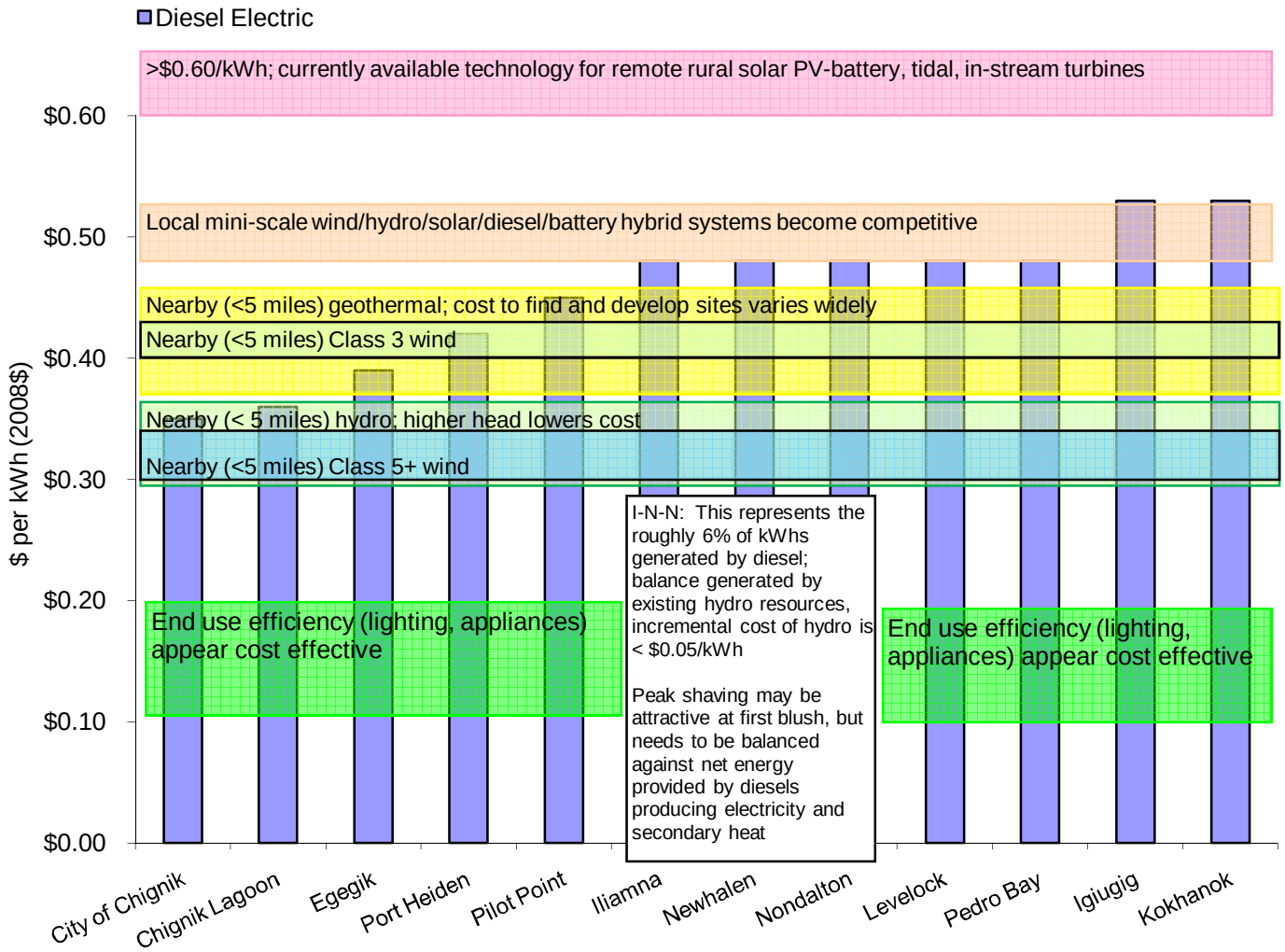


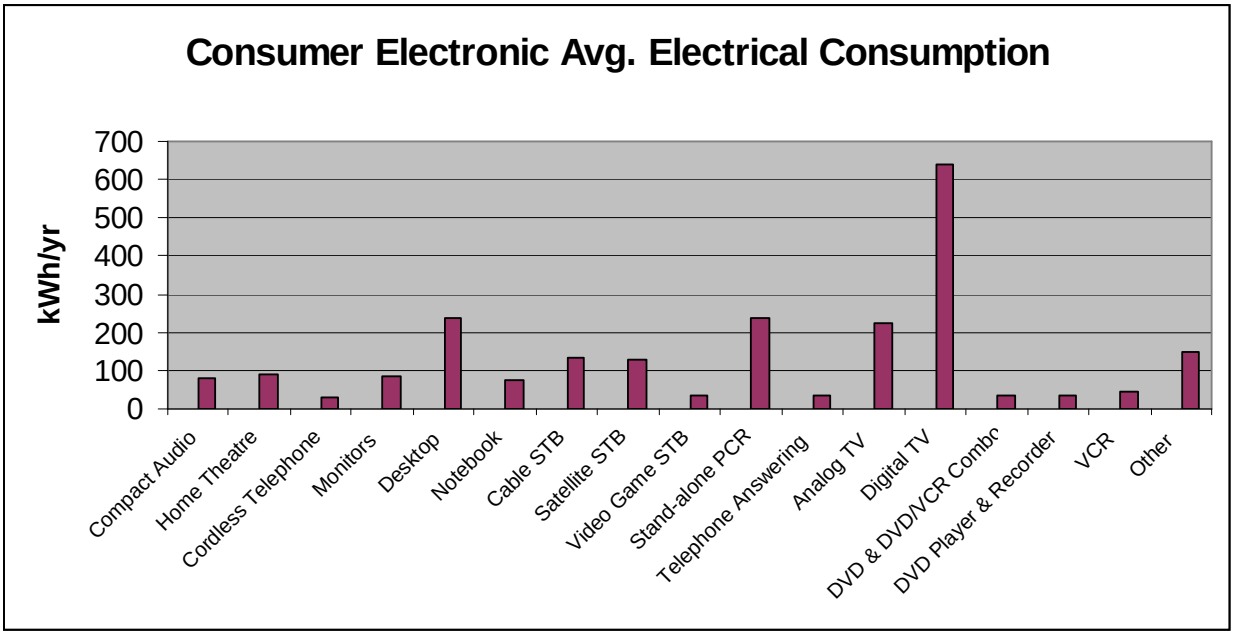
Figure 2 summarizes the projected cost of providing electricity using existing systems, which are predominantly diesel engine generator sets with secondary jacket water heat recovery to offset heating oil requirements. Iliamna-Newhalen-Nondalton (I-N-N) Electric Cooperative uses a small (920kW) in-river hydro plant to provide over 90 percent of its energy needs, using diesel to back-up and supplement the hydro.

In those communities served by diesel engines, end-use efficiency measures, e.g., converting lights to compact fluorescents (CFLs), replacing old inefficient electric appliances (refrigerators, freezers) with new efficient appliances, remains a very cost effective resource – costing somewhere on the order of 10c/kWh to 20c/kWh depending largely on the cost to procure, mobilize, distribute and install efficient appliances and lighting community wide programs.[9]

[9] We note that the economic case for the replacement of incandescent lights with CFLs in Iliamna, Newhalen and Nondalton, which receive 94% of their electricity from run of river hydropower, may not be compelling where the

We also note that end-use efficiency measures have the potential to reduce the demand for electricity in the short term. However, over the intermediate and long term, even with increased penetration of more efficient lighting and appliances, electrical demand tends to grow, particularly as people become *relatively* wealthier.

Figure 3: Annual Average U.S. Consumer Electronic Electrical Consumption (2006)



Source: MAFA Analysis of Electronics Industry Survey Data, 2007

A recent micro illustration of these macro phenomena can be found in the proliferation of consumer electronics, *see* Figure 3 *above*, especially big screen televisions and entertainment centers. Even while the efficiency, as measured in energy required per square inch of screen has improved by a factor of 2, the overall size of the TV has increased by a factor of 4 or more, resulting in an increase in power demand on the order of 2 over previous types of TVs. And the old TVs tend to remain in the home providing service to other rooms. The proliferation of increasingly energy efficient gaming systems (as measured by speed/graphics resolution per watt of power) has also resulted in a net increase in power demand.

At some point people's interest in lighting, home appliances and home entertainment devices may be satiated and their electrical demand may plateau and end-use efficiency measures may result in net energy conservation per household. But given current market trends, it appears that most rural communities, like their suburban and urban counterparts, have households who are continuing to purchase household appliance and entertainment systems as their budgets allow.

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reduced heat contribution from the incandescent bulb may be made up with expensive heating oil and the incremental cost (and price) savings on electricity is modest. *Switching* to *exterior* LED Christmas lights on the other hand, may be worth considering during the low water winter months to avoid the need for diesel-fired electrical generation to meet winter peak load requirements.

So, for this screening study, we find that end-use efficiency is a very attractive approach to providing more value for each dollar spent on electricity. We also do not anticipate that end-use efficiency measures will have a significant impact on the overall demand for electricity since most of the households in the region do not appear to have reached a point where they believe they have too many electrical devices in their homes and we assume they will continue to purchase new and improved electrical devices and use them as their disposable incomes allow.

Regional vs. Individual Island Electric Systems

I-N-N Electric Cooperative provides an example of the beginnings of a regional electric system with a central power generation plant and a multi-community distribution system. It pursued the successful development of the $11.6 million 920 kW Tazimina run of river hydroelectric project and interconnected the hydro project with the three communities of Iliamna, Newhalen and Nondalton.[10] Over the years the Tazimina hydro project has supplied as much as roughly 95 percent of the energy supply requirements of I-N-N Electric Cooperative.[11]

A prominent example of a larger scale potential regional project is the Newhalen River Diversion Project (16MW, <10% of stream flow) with a Bristol Bay regional grid (including Dillingham) that was found to be the most cost effective electrical project in a 1982 Stone and Webster regional feasibility study. It was estimated to have a life cycle cost on the order of 65 percent of diesel and 71 percent of Tazimina hydro (1MW) plus diesels for the balance of the region. [12] In other words, using the assumptions of the day (circa 1982), a large hydro project with a regional transmission grid was projected to be roughly 30 percent to 35 percent *less costly* than diesel or small hydro mixed with diesel alternatives.

Newhalen River Diversion Project + Regional Grid (2008 Update)

To illustrate the potential for an efficient large-scale electrical generation plant and regional grid to serve the area, we reviewed the project file on the Newhalen Diversion Project and Regional Grid (Alternative B-14) identified in the 1982 Stone and Webster Study and updated its cost assumptions based on:

1. Current trends in
    a. Capital and operating cost quotes for civil, electrical, mechanical, and transmission costs on hydro projects,
    b. Project procurement structure where the design and build phase have become consolidated into an Engineering, Procurement, and Construction (EPC) contract package,

[10] See http://www.arctic.net/~newhalen/Tazfolder/Tazimina.html for additional details.

[11] PCE Statistics

[12] Bristol Bay Regional Power Plan Interim Feasibility; Stone and Webster Engineering Corporation, for Alaska Power Association; July 1982; Executive Summary, Volumes 1 and 2, DOE Library.

c. Environmental assessment and permitting,

d. Cost of right of way acquisition, and

2. Consultations with engineers with Alaska hydro experience as to cost effective modifications they might make in the design now that we have collectively accumulated over two decades of experience since the previous conceptual design and estimate.[13]

The updated estimate of the total project cost of the Hydro project and Regional Grid is roughly $290 million, $150 million for hydro and $140 million for a regional transmission grid.[14] Based on an aggregate average long run cost of diesel fuel throughout the region of $4.50 per gallon, a 16MW hydro + regional grid project appears to yield a benefit/cost ratio of 0.83 – a result driven in part by excess capacity in the early years combined with the loss of roughly 2.2 million in high priced diesel kWhs that have subsequently been replaced by the Tazimina hydro project.[15]

The project can be rescaled to 8MW with corresponding increases in unit cost to roughly $12,000 per kW to achieve a break-even with the existing mix of diesel and hydro generation facilities.[16]

If additional industrial loads could be attracted to connect to the grid, e.g., fish processing, fish freezer facilities, Pebble Mine, a 16MW project appears economically attractive, achieving a benefit/cost ratio of 1.13 assuming diesel at $4.50.[17]

Depending upon the potential for industrial loads to be added, the hydrology of the river may allow for additional capacity and output to be utilized, especially at high water flows that were associated with making the Newhalen Falls impassible for fish migration in previous studies. The appropriate balance between hydroelectric capacity, river flows and diversionary flows is beyond the scope of this screening study.[18]

Thus, at a reconnaissance level it appears that the Newhalen River + Regional Grid has the potential to provide lower cost power to the region. Those benefits may be enhanced if additional loads can be signed up to enable the hydro development to achieve greater economies of scale.

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[13] Among others, MAFA had conversations with Earl Ausman, PolarConsult and David Vogel, Bristol Environmental, on the Newhalen River

[14] See Appendix B: Newhalen River Project + Regional Grid Total Project Cost

[15] See Appendix C: Newhalen River Project + Regional Grid Local Load Scenario

[16] See Appendix D: Newhalen River Project + Regional Grid Local Load Break-Even Scenario

[17] See Appendix E: Newhalen River Project + Regional Grid – Industrial Load Scenario

[18] Please note that we have substantially increased the budget for environmental assessment over prior estimates to reflect current and projected higher standards for assessment and mitigation considerations in hydro project development.

Railbelt Intertie

Another potential means to provide power to a large regional grid is to build an Intertie to the Railbelt, tying into natural gas, hydro, coal, and large-scale fuel oil generation options.

The 1982 Stone and Webster study found a large intertie from the Chugach Electric Beluga Power Plant on the west side of the Cook Inlet that interconnected to a regional grid with local diesel back-up would cost on the order of 35 percent more than a large local hydro project providing the base load for the regional grid.

Subsequent reconnaissance studies concerning how to provide 100MW – 200MW of power to the potential Pebble Mine have included a submarine cable electrical Intertie from the Kenai Peninsula across the Inlet plus on overland transmission line to the Pebble Mine. For a first order of magnitude estimate of the cost of power delivered into the region using this approach, we updated our estimates for 230kV submarine and terrestrial transmission facilities including recent reductions in the cost of materials. Based on this analysis, we estimate that the delivered cost of power from an HEA intertie and source of supply might be on the order of 24c/kWh.[19]

While it appears that importing power from the Railbelt and distributing it via a large regional grid might be on the order of 10-15 percent less than distributing power over that regional grid from a local large scale hydro project, our estimates are preliminary reconnaissance level estimates that are not sufficiently well developed to be able to use them to definitely distinguish between alternatives that appear this close.

In either event, unless a local community has a high value adjacent generation resource, like the Indian Creek hydro project for the Chigniks mentioned below, it appears that a regional grid that distributes power from a large scale in-region hydro project or imported power from the Railbelt may be competitive with individual island electric utility systems served with diesel fired electrical generation.

Other Regional Developments

We note that Nushagak Electric has recently revived other small-scale localized hydro projects, e.g., Lake Elva and Lake Grant in the Wood Ticchik State Park, for further consideration. To the extent that these may get built to meet more localized needs, they may diminish the net total benefits available from a larger scale hydro development and regional transmission grid.

Given what appears to be a continued preference for more expensive small-scale local projects rather than a large-scale project with a regional transmission grid, we focus the balance of our attention on smaller scale (1MW and less) local hydro developments.

We have included data in Appendix G on a few of the larger projects as benchmarks against which to compare other projects.

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[19] See Appendix F: Power Supply from HEA to Pebble

Island Systems

Basic energy options include:

- Diesel with secondary Heat Recovery, Hydroelectric, Wind, Wood Boilers – electric + heat, Geothermal, Tidal, In-stream hydro, Solar PV, micro-scale hybrid systems (10kW)

Basic Diesel Generated Electricity with Secondary Heat Recovery

With the exception of the Tazimina hydro project serving Iliamna-Newhalen-Nondalton (I-N-N), the electric generation picture in the Borough is dominated by diesel engine generator sets. One of the reasons for the continued reliance on diesel is that, while it has experienced a dramatic increase in price over the last four years, if you look back roughly 25 years, the basic price pattern is two price peaks separated by roughly 25 years of relatively low, non-volatile diesel fuel prices. See Figure 4 below.

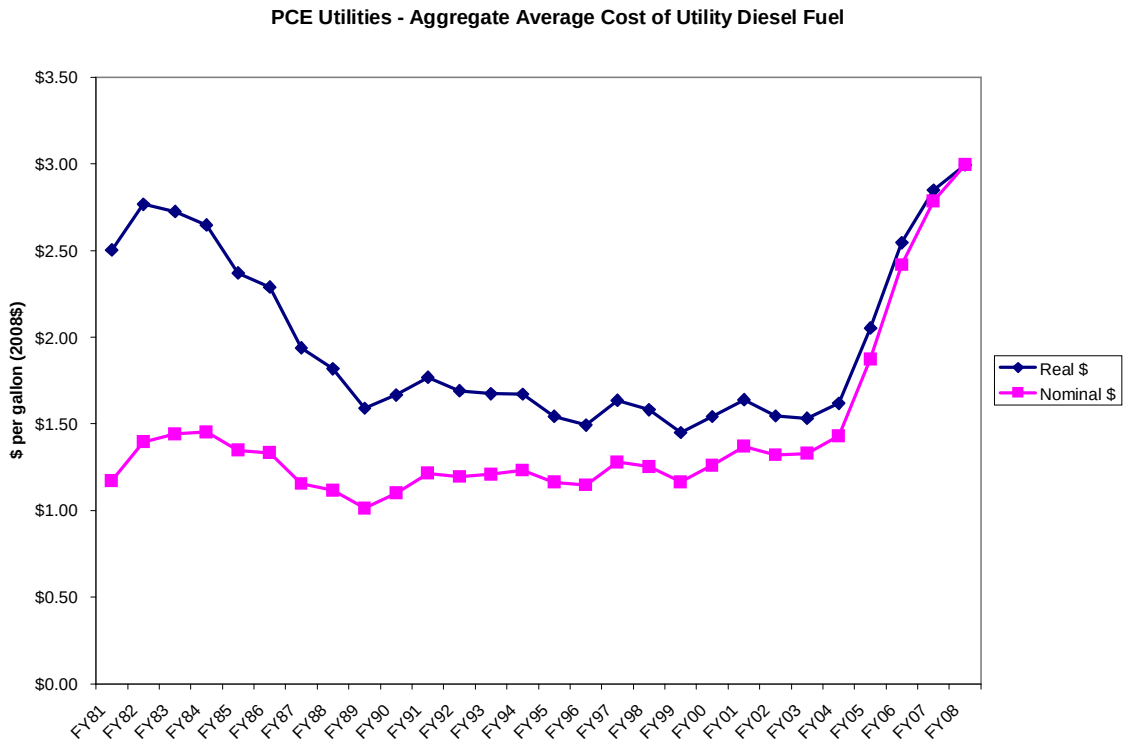
For the most part, PCE utilities over the past 25 years have improved performance through increasing fuel efficiency and generating more kWhs while managing non-fuel cost growth. A few utilities invested in alternatives to diesel where they had relatively attractive local resources – wind in Kotzebue and along the West Coast, hydroelectric in Southeast and near I-N-N.

With the recent run-up in diesel fuel prices to a level that is more than twice the apparent long term average in real terms, there is considerable interest in alternatives to diesel.

The key challenge we face in evaluating alternatives to diesel is whether we assume this most recent price spike reflects a fundamental change in the balance between supply and demand and, unlike a hundred years of prior price spikes in oil, the price of oil will remain roughly twice as high in real terms as it has over the past 140 years. For the purpose of this screening analysis, we've adopted what we would characterize as the consensus price forecast of energy industry analysts.[20] After period of depressed prices over the next few months – down to around $50-$70/bbl - due to financial shocks and softening of demand due to a flat economy (declines in U.S. and Europe offset by continued, albeit slower, growth in China), as demand re-emerges, prices will return to around $100/bbl (2008$) due to ongoing limitations on the supply side.

[20] See for example, Wall Street Journal, Financial Times, and the Oil & Gas Journal reporting on energy price movements and energy analyst price forecasts over the past three weeks (October 2008) as forecasts have been revised to reflect the financial crisis and anticipated downturn in many economies.

Figure 4 PCE Utilities - Aggregate Average Cost of Utility Diesel Fuel (1982-2008)



Crude Oil at $100/bbl amounts to $2.38 per gallon of crude. Based on historic patterns of refinery margins and delivery margins to rural Alaska communities, we've estimated the delivered price of diesel fuel to Lake and Peninsula communities will range from $4.30 a gallon on the South Coast (Chigniks) to almost $7.00 a gallon for relatively small quantities of diesel fuel flown in to Igiugig and Kokhanok.

Fuel efficiencies for the small-scale diesel utility operations typical of the Borough runs from 11 to 13 kWh per gallon. This results in a fuel cost of $0.35 to $0.56 per kWh. Add maintenance and operations, overhauls and capital replacement and the price for diesel electricity ranges from $0.40 to $0.61 per kWh.[21]

Because a significant number of the utilities recover the heat from the diesel engine jacket water and use it to reduce heating oil purchases, we've adjusted our "diesel base case" to reflect the value of the secondary heat that would be given up if an alternative to diesel is deployed. We note that this approach is consistent with the AEA's energy studies dating back to the early 1980s. The net result is a net cost of diesel electricity that ranges from $0.33 per kWh (Chigniks) up to $0.50 per kWh (Igiugig, Kokhanok). See Figure 2

It is against this diesel-fired electricity + secondary heat recovery base case that we compare various electric generation alternatives.

[21] See Excel Workbook tab "Tech Screening Electric" for detail of assumptions and calculations.

Hydroelectric Opportunities

Alaska has over a century of cost effective development of hydroelectric resources in remote rural areas. The Alaska Energy Authority archives and hydroelectric project database reference a number of potential hydroelectric projects in the Lake and Peninsula Borough. Most of the more detailed reconnaissance and feasibility studies date to the 1978-1983 timeframe when oil prices were high and oil had begun to flow in the TransAlaska Pipeline System and state tax collections followed.

The 1982 Stone and Webster Bristol Bay Regional Power Plan identified several economically attractive hydroelectric projects.[22] These projects are identified in economic rank order in Table 1 below.

Table 1 Regional hydroelectric projects - Rank order

Project	Life cycle cost of service
Newhalen 16MW Run of River + Regional Grid (RG)	$189,000,000
Alternative A-1 (Verify components)	$213,700,000
Kontrashibuna Lake (16MW Tanalian River Dam + RG)	$226,800,000
Intertie to Railbelt (Beluga Power Plant) + Regional Grid	$255,000,000
Tazimina River (16MW with regional grid)	$261,500,000
Tazimina River (1 MW with local INN grid)	$267,100,000
Base Case (Diesel w/secondary heat recovery)	$291,000,000

If the Lakes and Upper Peninsula and Dillingham region had joined together to develop the top ranked 16MW Newhalen River run of river fisheries enhancement project, electric rates might be on the order of 20c/kWh (without PCE) and electric heat could become an alternative to fuel oil consistent with the experience of the Four-Dam Pool communities[23] as the price of fuel oil has climbed in recent years. In addition, the region would be interconnected with electrical interties that would more readily enable sharing of new wind, geothermal and hydro resources throughout the region.

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[22] Bristol Bay Regional Power Plan Interim Feasibility; by Stone and Webster Engineering Corp; for APA; July 1982; BRI 013, Executive summary, volumes 1 and 2; DOE Library

[23] We note that Sitka's experience with the growth in hydroelectric supplied electric heat has lead them to actively explore expansions in their hydroelectric system capacity and to add new hydro projects to their generation mix. See for example, "Electric vs. Oil Heat cost" (September 2005) available at: http://www.cityofsitka.com/dept/electric/Documents/Electric%20vs%20Oil%20Cost%20Comp.pdf

and "Sitka's Power Supply Plan" (January 2008), available at: http://www.cityofsitka.com/dept/electric/PowerGeneration.html

However, the development of cost-effective hydroelectric projects has faced two key constraints - patience and capital. When oil prices declined in the mid-1980s, the rapid reduction in the availability of state grant funds caused many to retreat to smaller scale lower capital cost alternatives, most prominently diesel-fired electric generation.

I-N-N Electric Cooperative provides an example of an exception to the general retreat. It pursued the successful development of the $11.6 million (nominal $) 920 kW Tazimina run of river hydroelectric project.[24] Over the years the hydro project has been able to supply on the order of 96 percent of the energy supply requirements of I-N-N customers.

Going forward, some of the relative value of a larger scale 16MW Newhalen hydro development with a regional grid has diminished with the construction of the predominantly grant funded 920kW Tazimina run of river project (0.92MW). In addition, Nushagak has recently revived other more expensive small-scale localized hydro projects, e.g., Lake Elva and Lake Grant in the Wood Ticchik State Park, for further consideration. To the extent that these may get built to meet more localized needs, they will tend to diminish the net total benefits available from a larger scale hydro development and regional transmission grid.

Given what appears to be a continued preference for more expensive small-scale local projects rather than a large-scale project with a regional transmission grid, we have focused our attention on smaller scale (1MW and less) local hydro developments.

We have included data Appendix A on a few of the larger projects as benchmarks against which to compare other projects.

We reviewed the AEA's hydroelectric project database, archival studies, and consulted with engineers who participated in the hydro reconnaissance efforts over the past three decades. We screened out projects that were rated poorly in prior screening studies based on high cost. We then updated individual project cost estimates to ensure they reflected reasonable estimates of capacity, capacity factors, firm annual energy and did a quick reconciliation and interpolation of stream flow (cfs) and head (ft) data from various studies to ensure they reflected the most current information readily available in the archives.

Then we updated the construction cost and total project cost estimates to 2008$ using the U.S. Army Corps of Engineers Public Construction Cost Indices. We adjusted the total project cost estimates to ensure they had an adequate (42%) allowance for owner's costs, including planning, design, permitting, right of way (ROW) acquisition, legal, and regulatory.

We then benchmarked the Tazimina Falls reconnaissance and feasibility study estimates against the actual project cost of the 920kW Tazimina Falls project completed by I-N-N in 1997. It appears that the 1987 feasibility study estimated the project cost at $29,400 per kW of capacity (2008$) and that the 1997 actual project was completed for roughly $18,900 per kW of capacity (2008$) – a 33 percent reduction in the unit cost of the project due in part to installation of larger capacity turbines to better utilize available stream flows. Thus, we believe that the Stone

[24] See http://www.arctic.net/~newhalen/Tazfolder/Tazimina.html for additional details.

and Webster project cost estimates, though potentially conservative on the high side, remain reasonable first order estimates for the purpose of a screening study.

LAKES

In the absence of significant load growth or the desire to resurrect a regional transmission grid, the existing Tazimina Falls hydroelectric project provides on the order of 92 percent of the electrical energy for Iliamna-Newhalen-Nondalton and diesel use is limited to peaking requirements during periods of low water and high demand.

To the extent that the potential exists for large load growth, we note that the Taminina Falls hydro project capacity could be expanded and that the Newhalen River Project, rated as the least cost alternative in prior reconnaissance studies, appear to remain attractive cost effective candidates for expanding electrical generation.

In the meantime, in the absence of a large new load, the communities served by hydro-centric I-N-N may wish to explore peak shaving measures to avoid diesel peaking. Among other things that have been effective in these situations in Alaska are electric water heating interruptible rates.

CHIGNIKS

The Chignik Alaska Draft Small Hydropower Feasibility Report and EIS, by the Army Corps of Engineers (ACOE) (July 1984) conducted a study of the Packers Creek, Mud Bay Lake, and Indian Creek drainages around Chignik. Indian Creek, with a potential head of 409ft and modest flows on the order of 22 cfs, appeared to be the most cost effective electric project in the area. Based on the updates to the prior study to use a consistent minimum mark-up on construction cost estimates to reflect total project cost including owner's costs for planning, design, permitting, etc, and the synchronization to 2008$ construction costs, the reconnaissance level estimate for the long run levelized cost of electricity from Indian Creek is 23¢/kWh - roughly *40 percent below* the projected cost of electricity from diesel generator sets with secondary heat recovery (38¢/kWh).[25]

In addition, it appears that the cost of electricity from the Indian Creek hydro project is roughly 25 percent less than the potential cost of electricity from a Chignik area wind project (30¢/kWh; discussed in more detail in the wind section following).

We also note that the monthly correlation between rain and wind in the Chignik area raises the possibility of being able to size hydro, wind and diesel back-up resources so as to take advantage of each resource's cost and availability to optimize the system to meet both the winter and summer peak loads in addition to overall energy production requirements.[26]

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[25] See Appendix D for economic benefits and costs for the Indian Creek Hydro project for the Chigniks. See Appendix E for the electric rate impact analysis for the Indian Creek Hydro for a projected with 80% grant support.

[26] See Appendix C for initial reconnaissance on the hydro, wind and load profiles.

In addition, there is an interest in exploring whether Chignik Lagoon can be cost effectively interconnected with Chignik (approx. 5 direct map miles) in order to be able to share the wind, hydro and back-up diesel generator resources.

Thus, a feasibility study to optimize the location, generation mix and timing of hydro, wind, and diesel backup resources, taking into account the cost associated with the challenging terrain for electrical interties, would be extremely timely and could save government, commercial facilities and the PCE program on the order of 33 percent per kWh compared to the current diesel-dominated mix of generating resources.[27]

Wind

It appears that several Lake and Pen communities have sufficient wind and high enough diesel fuel prices to warrant further investigation into local wind prospects, a good location with affordable real estate, environmental assessment, permitting, and further refinement of cost and benefit estimates prior to seeking financing, if appropriate for a wind power project. Table 2 describes project costs associated with wind energy development for different classes of wind resources.

Table 2 Wind Class - Project cost and performance, HOMER modeling

Wind Class	3	4	5	6	7
Net capacity factor	18.0 %	**21.5 %**	24.5 %	**30.0 %**	40.0 %
Total project cost ($/kW)	$ 7,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500
Levelized capital cost ($/kW-yr)	$ 602	$ 602	$ 602	$ 602	$ 602
Turbine replacement cost ($/kW)	$ 2,500	$ 2,500	$ 2,500	$ 2,500	$ 2,500
Levelized capital cost ($/kW-yr)	$ 76	$ 76	$ 76	$ 76	$ 76
Total capital levelized cost ($/kW-yr)	$ 677	$ 677	$ 677	$ 677	$ 677
Fixed O&M ($/kW-yr)	$ 120	$ 120	$ 120	$ 120	$ 120
Total levelized cost (capital + O&M) ($/kW-yr)	$ 797	$ 797	$ 797	$ 797	$ 797
Net annual production (kWh-yr/kW)	1,578	1,885	2,148	2,630	3,506
Levelized cost of electricity ($/kWh)	$ 0.51	**$ 0.42**	$ 0.37	**$ 0.30**	$ 0.23

Source: MAFA Analysis of Wind Project Cost and Performance Data, HOMER Modeling (2008)

Wind Resources Review - We reviewed the National Renewable Energy Lab high-resolution wind maps, weather station wind data, wind data from met tower studies, wind data collected by the Pebble Partnership, the wind data available on the AEA web site, including the Bristol Bay Native Corporation Wind and Hydroelectric Feasibility Study (March 2007), Independence Power and Energy Consulting LLC Wind Resource Assessment Report City of Chignik Bay (March 2006), and performance data from Port Heiden micro wind turbines to identify potentially

[27] Our high level estimate of savings, assuming that the hydro resource may lose some modest amount of capital efficiency as it is scaled down to more closely match load and complementary diesel back-up resources during the feasibility study/conceptual design. We also note the existence of a micro-hydro resource near Chignik that generated roughly 10,000kWhs, or 2% of the total kWh's generated in FY2008 and similarly a micro-hydro resource near Chignik Lagoon generated roughly 7,000 kWhs in FY2008.

attractive wind resource candidates for wind power in or adjacent to Lake and Pen communities.

Wind Project Cost Updates - We updated wind power economic reconnaissance studies from the Renewable Power In Rural Alaska: Improved Opportunities for Economic Deployment, by Crimp, Colt, Foster (2007) to reflect September 2008 vendor quotes for 2009 construction year projects for engineering, permitting, procurement, construction and integration of wind power with existing diesel-fired electrical generation systems, an allowance for interties to connect the wind resource to the power plant, and testing and training of local site personnel. We also collected 2008 cost data on micro wind/pv/diesel hybrid systems.

Table 3 Individual community preliminary reconnaissance level resource assessment - Wind

Community	Wind Power Class - NREL Maps	Wind Power Class - Local Met Data	Wind LCOE ($/kWh)	Diesel w/2nd heat recovery - LCOE	Wind Savings (LCOE)
Pedro Bay	7		$ 0.26	$ 0.51	**$ 0.25**
Kokhanok	7	6	$ 0.34	$ 0.56	**$ 0.22**
Newhalen, Iliamna, Nondalton (diesel peaking)	6		$ 0.34	$ 0.46	$ 0.12
Igiugig	4		$ 0.42	$ 0.56	$ 0.13
Pilot Point	5		$ 0.41	$ 0.47	$ 0.06
Port Alsworth	5		$ 0.41	$ 0.45	$ 0.05
Chigniks	5	6	$ 0.34	$ 0.37	$ 0.03
Egegik	5		$ 0.41	$ 0.41	$ 0.00
Port Heiden	5	4	$ 0.42	$ 0.45	$ 0.03
Levelock	3		$ 0.51	$ 0.51	($ 0.00)
					($ 0.04)
High value opportunity					
Good opportunity					
Investigate Wind Opportunity if other cost effective options are not available					
Marginal					

Table 4 Wind project benefits to communities

kWhs/yr	Community	Wind displaced diesel kWhs	Gal/kWh diesel efficiency	Displaced diesel fuel gallons	Long run cost of diesel	Annual value of diesel fuel avoided	Incremental diesel O&M avoided	Total annual value of avoided diesel fuel and O&M
290,000	Pedro Bay	174,000	0.0694	12,083	$6.20	$74,917	$3,480	$78,397
450,000	Kokhanok	225,000	0.0806	18,145	$6.90	$125,202	$4,500	$129,702
650,000	Newhalen, Iliamna, Nondalton [28]	325,000	0.0732	23,792	$5.60	$133,236	$6,500	$139,736
230,000	Igiugig	69,000	0.0935	6,449	$6.90	$44,495	$1,380	$45,875
400,000	Pilot Point	160,000	0.0895	14,324	$5.75	$82,363	$3,200	$85,563
640,000	Port Alsworth	256,000	0.0769	19,692	$5.50	$108,308	$5,120	$113,428
900,000	Chigniks	450,000	0.0930	41,860	$4.28	$179,163	$9,000	$188,163
640,000	Egegik	256,000	0.0769	19,692	$4.95	$97,477	$5,120	$102,597
620,000	Port Heiden	186,000	0.0833	15,500	$5.50	$85,250	$3,720	$88,970

Table 4 above shows the estimated benefits of wind projects to communities in the Lake and Peninsula Borough. Benefits include displaced diesel and the avoided cost of the fuel itself as well as the avoided operations and maintenance costs of traditional energy generation. Table 5 on the following page describes the cost estimates associated with these projects, integrates benefits data and presents simple payback and a benefit/cost ratio.

[28] (diesel peaking kWhs)

Table 5 Wind project preliminary cost estimates

kWhrs/yr	Community	Installed capacity (kW)	Capital cost ($)	Annual O&M ($)	Net annual benefit ($)	Simple payback (years)	Turbine replacement cost ($)	B/C ratio
290,000	Pedro Bay	65	$520,000	$11,700	$66,697	8	$162,500	**2.0**
450,000	Kokhanok	100	$800,000	$17,000	$112,702	7	$250,000	**1.7**
650,000	Newhalen, Iliamna, Nondalton [29]	130	$1,040,000	$22,100	$117,636	9	$325,000	**1.4**
230,000	Igiugig	65	$487,500	$7,800	$38,075	13	$162,500	**1.3**
400,000	Pilot Point	65	$520,000	$10,400	$75,163	7	$162,500	**1.2**
640,000	Port Alsworth	130	$1,040,000	$20,800	$92,628	11	$325,000	**1.1**
900,000	Chigniks	200	$1,600,000	$34,000	$154,163	10	$500,000	**1.1**
640,000	Egegik	130	$1,040,000	$20,800	$81,797	13	$325,000	**1.0**
620,000	Port Heiden	100	$750,000	$12,000	$76,970	10	$250,000	**1.1**

As demonstrated in the table above, all of the communities with identified wind energy generation potential have B/C ratios of one or greater. The communities with a simple payback period of less than 10 years include Pedro Bay, Kokhanok and Newhalen/Iliamna/Nondalton. Levelock and Nondalton (as a standalone) do not appear likely to benefit from a local wind project. Nondalton, by virtue of being intertied with the Tazimina hydro system, could benefit from wind resources developed in the Iliamna/Newhalen area.

[29] (diesel peaking kWhs)

For the most part, it appears that the wind prospects that pass our initial economic screen are likely to have a class 4 or higher wind power regime which makes them potential candidates for "high penetration" wind systems that provide for systems to store the energy from the high wind when the electrical system cannot take all of it at once. The storage of the excess wind energy is often referred to as the "dump load." In small systems, the dump load may be a battery bank. In more sophisticated systems the dump load may be an electric boiler, high temperature bricks, a flywheel, or other energy storage system.

A key challenge in these high wind locations is to find *a cost effective* way to store the extra wind that might be generated so that it can be put to productive use reducing the need to burn heating oil. It is not uncommon to find that a simple battery storage system is more cost effective than more sophisticated, and potentially more complicated to maintain, systems with newer energy storage technologies. We defer the consideration of the most appropriate dump load technology to the preliminary design and feasibility study phase.

Wood Boilers in Combined Heat and Power

We reviewed the wood biomass reconnaissance studies from the *Renewable Power In Rural Alaska: Improved Opportunities for Economic Deployment*, by Crimp, Colt, Foster (2007) and focused on refining cost estimates for smaller scale <250kW wood biomass power plants.[30]

It appears a 100kW scale wood electric + heat power plant might result in a long run life cycle cost on the order of $0.40/kWh where a substantial local wood fuel supply is available. At first blush, this alternative appears competitive with flown-in diesel with secondary heat in the Lakes region, $0.50/kWh. However, it appears that these Lakes Region communities have other alternatives, e.g., hydro, wind, that appear to be lower cost than wood boilers. In the event that the hydro and wind alternatives to not appear viable, the local wood supply should be more closely assessed to determine whether adequate supplies are available for electrical generation.

Geothermal

We relied upon two primary sources to develop a first order estimate of the cost of geothermal electricity in the Borough. The first is the SAIC Report (2005) on the Geothermal Potential for Chena Hot Springs outside Fairbanks. We used the performance parameters from that site investigation, which included drilling to characterize the geothermal resource, flow parameters, and estimated lifespan of the field, to establish a "base case" for performance parameters. We used the MIT Study on The Future of Geothermal Energy (2007) for basic assumptions about cost/performance of geothermal power plants for lower 48 locations based on specified performance parameters. We adjusted those lower 48 costs to reflect the cost challenges of remote rural Alaska and normalized them on the performance parameters SAIC estimated for

[30] See Appendix J: Wood Boilers for assumptions and calculations.

the Chena Hot Springs resource in order to develop a very rough first order of magnitude cost estimate for potential geothermal resources in the Borough.

The net result of the analysis is that **if** a community is currently sitting on top of a geothermal resource comparable to Chena Hot Springs, we estimate the cost of electricity will be on the order of $0.32 per kWh.

To that base price we need to add the cost of prospecting, drilling to confirm the quality and quantity of the geothermal resource, and the cost to build an electrical intertie from the geothermal resource to the local community (or the cost to move the local community to the geothermal resource).

Working back from the cost to build an electrical intertie from our local community to the geothermal power plant, unless the geothermal resource is located within 10 miles of one of the communities where fuel is flown in, diesel appears to remain a lower cost alternative. If one adds in the cost for prospecting including drilling to find an adequate resource, it appears that geothermal is unlikely to be more cost effective than diesel.

In those communities where fuel is barged in, unless the geothermal resource is located within four or five miles from the community, diesel appears to remain a lower cost alternative. Again, if one adds in the cost for prospecting including drilling to find an adequate resource, geothermal quickly looks more expensive than diesel.

Finally, we note that in response to inquiries concerning the potential for geothermal in the Lake & Peninsula and Bristol Bay region, we examined oil and gas exploration well log information for the purpose of reviewing data related to geothermal performance. Based on that paper prospecting and matching up the well log temperature data at depth to the performance parameters in the MIT Study on The Future of Geothermal, we believe our use of the Chena Hot Springs geothermal performance parameters as a benchmark may be optimistic. While the geothermal gradient is high as one would expect from the volcanic activity in the area, it does not appear high enough to provide an economic prospect for small remote rural communities that are not currently situated right on top of the resource.

Tidal

In addition to reviewing the proceeds of the Ocean Energy Conference held in Ketchikan last year, we relied on the "North American Tidal In-Stream Energy Conversion Technology Feasibility Study," Roger Bedard, Ocean Energy Leader, Electric Power Research Institute (EPRI), July 11, 2006, and the International Energy Agency, "Energy Technology Perspectives, Scenarios & Strategies to 2050," OECD/IEA, 2006 and 2007, to benchmark cost and performance data, bring the costs to 2008$, adjusted them to Cook Inlet Alaska and then adjusted them to reflect the added costs of small scale and remote rural construction mobilization down along the peninsula.

In the case of the EPRI Study (2006), we adjusted the estimates for the specified Cook Inlet Alaska project (15MW) to include owner's costs including site investigation and geotechnical, environmental assessment and permitting. We then adjusted the resulting cost to reflect remote rural project development and construction relative to the Cook Inlet and further

adjusted the costs to reflect the installation of two 220 kW units along the coast in the Borough rather than 66 units in the NREL Cook Inlet Project Study. We estimate the total project cost of a 15MW installation in the Cook Inlet might result in a life cycle cost of 11-12c/kWh, presuming it can get permitted in light of the potential for Beluga Whale and Salmon concerns.

The net effect of our adjustments is that we estimate the *total project cost* to develop a remote rural tidal power site in the Borough with 2 each 220kW in-stream tidal turbine units with a tidal current resource comparable to the Cook Inlet would be on the order of $0.40-0.50/kWh. Along the coastal communities where tidal would be applicable, it appears that the cost of diesel electricity from barge delivered diesel fuel remains a lower cost alternative.

In-Stream Hydro

We were asked to examine the economic prospects for in-stream hydro for Igiugig on the Kvichak River. We reviewed the NREL report on the potential for in-stream hydro at Igiugig (2007) and used the monthly stream flow data from that theoretical analysis to drive the published performance curves for a 25kW Encurrent-025-F4 in stream vertical axis water turbine.

Based on data from other Encurrent turbine quotes in Alaska and an estimate of total project cost (including environmental assessment and permitting) to develop a 25kW scale system in Igiugig that would be integrated with the local small-scale diesels, it appears that even if we assume utility diesel fuel is flown in for a total cost of $7 per gallon (FY08 PCE fuel cost reflecting prior year's inventory was $4.26), the benefit cost ratio of 0.78 indicating it is not economic at this time. Nonetheless, the theoretical potential for in-stream hydro remains promising. In light of the relatively early stage of development for this technology, it may be appropriate to consider pursuing a demonstration project for Igiugig.

Solar Photovoltaic (PV)

We reviewed solar PV cost and performance for remote rural sites in Alaska. It appears that solar PV power, on a stand-alone basis, in the Borough would result in reliable low maintenance solar electric power on the order of 80c/kWh – 100c/kWh. It still appears to be on the order of 2X as expensive as diesel assuming $100/bbl oil. Solar PV remains an attractive for installations where the noise and emissions associated with diesel may not be acceptable on a constant basis. It also remains an attractive alternative for remote locations where access by people is infrequent, e.g., remote communications mountaintops.

Micro-Scale Wind Solar PV Hybrid Systems

Based on conversations with representatives from Renewable Energy Systems (Anchorage) and informal quotes for equipment, we estimate that small-scale (18kW) wind/solar PV hybrid systems with diesel and battery back-up have life cycle costs on the order of $0.50 per kWh.

In communities where utility scale hydro, wind, wood and geothermal may not be available and diesel fuel is flown-in, the life cycle cost and relatively low maintenance profile of these systems may provide a cost effective, convenient and reliable alternative for small lodge owners,

commercial and government facilities compared to a local diesel utility, especially if the local utility has reliability and power quality issues.

Economic Analysis

BASIC ASSUMPTIONS

Real Discount Rate = 5% (State of Alaska Opportunity Cost of Public Funds)

Economic Life

Hydro	50 years
Interties	30 years
Wind	20 years
Diesel Gen Set	10 years
Wood Biomass	20 years
Geothermal	20 years
Tidal	20 years
Solar	20 years

Diesel fuel price projections $110/bbl oil

5 ¢/gallon ultra low sulfur diesel fuel market premium

25¢/gallon cost associated with CO2 emissions tax/cap and trade program

Screening Study Methodology

Estimate Long Run Levelized Cost of Electricity based on:

- Capital Cost * Annualized Capital Recovery Factor = Annualized Capital Costs
- Annual Fuel Cost
- Annual Fixed + Variable O&M Cost
- Replacement Cost * Sinking Fund Factor = Annualized Capital Costs to Replace Key Components
- = Total Levelized Cost of Electricity (LCOE)

HEATING

Based on our initial screening study of household and school heating system opportunities in the Borough, we recommend:

- Continuation of public education efforts to ensure that any remaining households that have not yet installed high efficiency direct vent "Toyo" type heating units are well aware of their benefits compared to older less efficient central oil-fired furnace or boilers

- Continuation of the Bristol Bay Housing Authority practice of installing wood stoves as a supplemental and back-up heating source in all new homes
    - Net Fuel Savings = $2,400 per year
    - Total Capital Cost = $6,000 per household

- Exploration of the use of high efficiency low emissions wood boilers to provide supplemental heating for schools and teacher housing in the Lakes region where robust wood supplies appear available
    - Net Fuel Savings = $18,000 per year
    - Total Capital Cost = $157,000 per school

Heating Oil Price Projection

Consistent with AEA and UAA ISER fuel supply studies in 2008, we used the historic relationship between the price of crude oil and the price of refined fuels delivered to individual communities as the basis to estimate the long run delivered price of fuels to the local communities in Lake and Pen. Based on a **benchmark price of $110/bbl oil**, the delivered price for ***PCE utility*** **diesel fuel ranges from $4.50 to $7.00 per gallon** across Lake and Pen communities.

The delivered price for fuel *within individual communities* varies depending upon whether the fuel was delivered by barge or airplane, the extent to which the cost of local storage and handling is included in price (or is covered by an external subsidy), and the subsequent handling and administration associated with local fuel delivery. Within an individual community, the price for diesel/heating oil can vary from $1 to $2 per gallon – with the electric utility and school experiencing the lowest prices with the highest posted prices for heating oil for

residences and small commercial and government facilities. To simplify the analysis, we adopt a benchmark cost of heating oil that is $**1.20 per gallon** above the projected cost of electric utility diesel fuel.

Wood Heating Fuel Price Projection

Wood has historically been used for heating where supplies are readily available, e.g., the Lakes Region. Communities with limited local wood resources throughout Alaska have begun to import wood by ocean and river barge where importing wood is less expensive than importing fuel oil supplies.

Where local wood is available, we estimate a market price of $200 to 250 per cord.

Where wood will need to be imported, we estimate a market price ranging from $250 to $400 per cord depending upon delivery and local storage requirements. Thus, for our initial screening study, we have adopted the cost estimates for wood and fuel oil, summarized in Table 6 below.

Table 6 Long run cost of wood for space heating – Lake and Peninsula communities

Community	Long run outlook: diesel fuel	Long run outlook: heating oil	Heating oil	Wood delivered	Wood delivered
	($/gallon)	($/gallon)	($/MMBtu)	($/cord)	($/MMBtu)
Chignik	$ 4.52	$ 5.72	$ 42.37	$ 380	$ 27.14
Chignik Lagoon	$ 4.72	$ 5.92	$ 43.85	$ 380	$ 27.14
Chignik Bay	$ 4.57	$ 5.77	$ 42.74	$ 380	$ 27.14
Ivanof Bay	$ 6.00	$ 7.20	$ 53.33	$ 400	$ 28.57
Perryville	$ 5.00	$ 6.20	$ 45.93	$ 400	$ 28.57
Port Heiden	$ 5.50	$ 6.70	$ 49.63	$ 400	$ 28.57
Pilot Point	$ 6.00	$ 7.20	$ 53.33	$ 400	$ 28.57
Ugashik	$ 6.00	$ 7.20	$ 53.33	$ 400	$ 28.57
Egegik	$ 5.17	$ 6.37	$ 47.19	$ 400	$ 28.57
Levelock	$ 6.40	$ 7.60	$ 56.30	$ 350	$ 25.00
Igiugig	$ 7.00	$ 8.20	$ 60.74	$ 350	$ 25.00
Kokhanok	$ 7.00	$ 8.20	$ 60.74	$ 250	$ 17.86
Pedro Bay	$ 6.40	$ 7.60	$ 56.30	$ 250	$ 17.86
Iliamna	$ 5.80	$ 7.00	$ 51.85	$ 250	$ 17.86
Newhalen	$ 5.80	$ 7.00	$ 51.85	$ 250	$ 17.86
Nondalton	$ 5.80	$ 7.00	$ 51.85	$ 250	$ 17.86
Port Alsworth	$ 5.75	$ 6.95	$ 51.48	$ 250	$ 17.86

Source: MAFA, Long Run Cost of Fuel, L&P Borough, 3Qtr, 2008

Table 7 below describes the heat content in a gallon of fuel oil compared to a cord of wood so that we can compare the actual cost by unit of energy. What the table shows is that $6 per gallon fuel oil it is economical to purchase a cord of wood for more than $500 – higher than the estimated cost to deliver wood to Lake and Pen region communities that lack local resources.

Table 7 Equivalent delivered cost per end-use heating requirement - Fuel oil versus wood

Fuel Oil		Wood	
Fuel oil heat content (Btu(LHV)/gallon)	135,000	Wood heat content (Btu/cord)	14,000,000
Fuel oil heating unit efficiency	85 %	Wood burner efficiency	70 %
Net fuel oil heat content (Btu delivered/gallon)	114,750	Wood system (Btu delivered/cord)	9,800,000

($/gallon)	($/MMBtu-eud)	($/MMBtu-eud)	($/cord)
$ 1.00	$ 9	$ 9	$ 85.40
$ 1.50	$ 13	$ 13	$ 128.10
$ 2.00	$ 17	$ 17	$ 170.81
$ 2.50	$ 22	$ 22	$ 213.51
$ 3.00	$ 26	$ 26	$ 256.21
$ 3.50	$ 31	$ 31	$ 298.91
$ 4.00	$ 35	$ 35	$ 341.61
$ 4.50	$ 39	$ 39	$ 384.31
$ 5.00	$ 44	$ 44	$ 427.02
$ 5.50	$ 48	$ 48	$ 469.72
$ 6.00	$ 52	$ 52	$ 512.42
$ 6.50	$ 57	$ 57	$ 555.12
$ 7.00	$ 61	$ 61	$ 597.82
$ 7.50	$ 65	$ 65	$ 640.52
$ 8.00	$ 70	$ 70	$ 683.22
$ 8.50	$ 74	$ 74	$ 725.93
$ 9.00	$ 78	$ 78	$ 768.63

Source: MAFA, Long Run Cost of Fuel, L&P Borough, 3Qtr, 2008

Thus, if you only consider the cost of fuel and ignore capital and operating costs, $3.00 per gallon fuel oil is roughly equivalent to $250 per cord of wood.

Based on our assumed long run cost of oil is $110/bbl oil, we estimate the long run cost of fuel oil for local delivery will range from $5.70 per gallon ($490/cord delivered heat equivalent) for South coast communities up to $8.20 per gallon ($700/cord delivered heat equivalent) for small remote communities that typically have to fly in their fuel.

We note that even if oil remains at recent lows of $70/bbl, the heat content equivalent cost of wood would be in the range of $300 to $450 per cord.

Analysis of Residential Heating Options

Over a wide range of assumptions, the installation of a high efficiency direct vent fuel oil heater, e.g., Toyo, Monitor, Rinnai, is very cost effective compared to reliance on an existing moderately efficient central fuel-oil fired furnace or boiler. The annual fuel savings with fuel oil at $6/gallon should be on the order of $1,000 a year for an investment of around $2,000.

The next increment of capital investment is a retrofit of a high efficiency catalytic wood stove. Even if a household already has switched to a high efficiency direct vent fuel oil heater, with oil costs of $6 a gallon and wood costs of $250 a cord it appears that a wood stove can save on the order of $2,000 a year for an investment of around $6,000. The Bristol Bay Housing Authority installs backup wood stoves in all the homes they build in communities with wood resources. The Borough could offer assistance in bulk purchasing of wood stoves for interested parties with homes that were either not built by BBHA or are in communities that would require importing wood.

Even if a household already has a high efficiency direct vent fuel oil heater, if it cannot fit a wood stove into the existing space, it still makes sense for the household to consider a capital intensive high efficiency low emissions wood boiler in an exterior enclosure. With oil costs of $6 a gallon and wood costs of $250 a cord, it appears that a wood boiler can save on the order of $2,000 a year on an investment of $15,000.[31]

[31] We note that the incremental investment in a wood boiler becomes a break-even compared to a direct vent fuel oil fired heater at a discount rate of 15% - a rate not atypical of moderate income households.

Finally, we note that the addition of a wood stove as an alternative source of heat appears attractive down to fuel oil prices in the $3.50 a gallon range. Table 8 compares the cost per unit of heating oil and wood for Lake and Peninsula Borough communities.

Table 8 Fuel oil versus wood cost per unit by community

	Heating Oil ($/gallon)	Heating Oil ($/MMBtu)	Wood ($/MMBtu)
Chignik Lake	$5.72	$33.48	$30.00
Chignik Lagoon	$5.92	$34.96	$30.00
Chignik Bay	$5.77	$33.85	$30.00
Ivanof Bay	$7.20	$44.44	$36.00
Perryville	$6.20	$37.04	$36.00
Port Heiden	$6.70	$40.74	$36.00
Pilot Point	$7.20	$44.44	$36.00
Ugashik	$7.20	$44.44	$36.00
Egegik	$6.37	$38.30	$36.00
Levelock	$7.60	$47.41	$24.00
Igiugig	$8.20	$51.85	$24.00
Kokhanok	$8.20	$51.85	$18.00
Pedro Bay	$7.50	$47.41	$18.00
Iliamna	$7.00	$42.96	$18.00
Newhalen	$7.00	$42.96	$18.00
Nondalton	$7.00	$42.96	$18.00
Port Alsworth	$6.95	$42.59	$18.00

Analysis of Non-residential Heating Options

Wood has historically been used for heating where supplies are readily available, e.g., the Lakes Region. Communities with limited local wood resources throughout Alaska have begun to import wood by ocean and river barge where it is less expensive than local fuel oil supplies. Communities on the Kuskowkim River have begun to barge in a wood supply from Homer.

The development of the Pile Bay road would further facilitate the availability of wood resources in the Lake and Peninsula Borough. In addition to hauling wood from Homer, drift is available in west Cook Inlet bays as well as Lake Illiamna beaches. Other benefits of wood resources are that its delivery and preparation uses local residents - providing jobs and income, wood is also a non-toxic substance reducing the risk of hazardous fuel spills.

Heating with wood is not a new idea but the ways in which we are able to heat with wood has changed considerably. High-Efficiency-Low-Emissions (HELE) wood burning boilers can provide space and water heating for both small and large buildings but the real economic savings come when utilized to provide heat for larger buildings. HELE units require some maintenance; the

most successful utilization of these systems can be seen in places where staff is employed to maintain wood supply and stoke the boiler two to three times per day.

We reviewed the basic economic feasibility of adding a high efficiency, low emissions wood boiler to supplement the existing fuel oil heating systems for the schools in the area around Lake Iliamna and Lake Clark where there appears to be a relatively robust local wood supply available.[32]

Wood Boiler Heating Requirement Coverage

We estimate that a wood boiler in the Lakes region would be operational from October through April and be available on the order of 90 percent of the time during that period. This timeframe represents 80 percent of the heating load for the year offering potential net heating load coverage of 72 percent. We assume that the wood boiler will be used to supplement existing fuel oil systems and that it will be sized to meet the existing peak heating requirement, relying on the existing fuel oil system for backup and complementing any existing heating provided by secondary heat recovery from the diesel engine generator sets at the local electric utility. For Kokhanok, where the school and teacher housing use roughly 6,200 gallons of fuel oil per year, 72 percent heating coverage amounts to roughly 600 MMBtu/year of heating fuel required.

Wood Boiler Peak Heating Requirement Sizing

We use Kokhanok school and teacher housing data for a baseline case study. Kokhanok school reports that they are burning roughly 6,200 gallons of fuel oil per year. This amounts to an average of 837 MMBTU over the course of the year with roughly 11,372 heating degree-days. The average heating degree-days per day 11,372/365 = 31.1. The coldest day driving the peak heating requirements is assumed to be –22ºF, or 87 heating degree days (65ºF - -22ºF). Applying the peak/average heating degree-day ratio (87/31.1) to the average annual BTU per hour (95,550) yields a first order estimate of the peak heating requirement of 268,000 BTU per hour. Thus, we assume a 350,000 BTU per hour wood boiler is adequate to meet the estimated peak boiler capacity requirement.

[32] We wish to acknowledge our indebtedness to Harold Andrew, Bristol Bay Native Association, and Daniel Parrent, Wood Utilization Specialist, Juneau Economic Development Council for their report, "Preliminary Feasibility Assessment for High Efficiency, Low Emission Wood Heating in Kohkanok, AK," June 1, 2007. The analysis presented here updates and extends the analysis in that report.

Table 9 Estimated project cost components: Wood boiler, connections and support systems

		Equipment	Freight	Installation	Total Cost
Fuel storage fabric bldg	1500 sf (75 cords)				$37,500
Remote boiler building	400 sf				$40,000
HELE wood boiler	350,000 btu/hr	$12,599	$2,840		$15,340
Plumbing and interconnections				$30,000	$30,000
Control and monitoring systems				$2,500	$2,500
				Subtotal	$125,340
Owner's development costs	25% of construction cost				$31,335
				TOTAL	**$156,675**

Source: Kokhanok Study (2007), updated to 2008

HELE wood burning boilers are currently used in Alaska including in the following communities:

- City of Craig – wood fired boiler supplements oil/propane systems that provide heat for the municipal pool water, pool building, and the elementary and middle school buildings. The system is maintained by the school district. The project was funded by the USDA Forest Service, USDA National Resource Conservation Service, Alaska Energy Authority, Denali Commission, and the City of Craig.

- Kasilof – An intentional community of around 10 families located in Kasilof installed wood fired boilers to supplement their masonry heaters used to heat the community center, heat water for kitchen and laundry water. The project was funded by the Alaska Department of Health and Human Services[33] and the USDA Forest Service Jump-Start Wood Energy Program.[34]

- Tanana – Tanana has two wood fired boilers that heat the washeteria and the city water system. The city turned ownership and maintenance of the system over to the local non-profit utility Too'gha Inc. The project was funded by the USDA Forest Service Jump Start Wood Energy Program, the Alaska Department of Commerce Community and Economic Development and Too'gha Inc.

The highest marginal savings from wood fired boilers are seen in larger buildings. For this reason all community buildings should be considered. The analysis below describes potential savings associated with installing the systems in school buildings. Where teacher housing is in

[33] Note that AKDHHS funding was possible because the group is a non-profit providing mental health services

[34] Note this program is through the Division of Forestry and managed by the Juneau Economic Development Council http://jedc.org/2wood.shtml

close physical proximity to the school building it is recommended that the system incorporate those buildings as well.

The cost of heating oil throughout the Lake and Peninsula Borough is very high even for by remote rural Alaska standards with heating oil costs running $6 to $9 per gallon. Where local wood is available, we estimate a market price of $250 per cord. Where wood will need to be imported, we estimate a market price ranging from $250 to $400 per cord depending upon delivery and local storage requirements. We estimate that the delivered cost of wood ranges from roughly $18/MMBtu to $36/MMBtu, the thermal equivalent of roughly $2.00 to $4.00 a gallon for diesel fuel.

The communities included in the analysis (see table below) are in heavily wooded areas and, with the exception of Port Alsworth, they have few or no land-use issue that would create barriers to sustainable fuel (wood) supply. The schools in these communities served 243 children in the 2007-08 school year.

An initial feasibility assessment indicates that these communities could displace tens of thousands of gallons of diesel currently used to heat the facilities. Actual fuel consumption for the 2007-08 school year was used in the analysis.

Table 10 shows the estimated net savings and simple payback associated with installation of HELE wood boilers and avoidance of more than 25,000 gallons of fuel. Three of the schools – Nondalton, Newhalen/Iliamna and Levelock – show payback periods of less than ten years. When evaluating the payback for a project it is important to consider the life of the facility in question. Schools and other institutions can typically justify projects with longer payback periods than private residences.

Table 10 School energy consumption - Fuel oil versus wood cost

Community	Current fuel consumption 2007-08 yr	Heating oil cost ($/MMBtu)	Wood heat ($/MMBtu)	Net fuel savings ($/year)	Simple payback (years)
Pedro Bay	2,000	$56.30	$20.00	$ 6,011	15
Port Alsworth	2,000	$51.48	$20.00	$ 5,213	17
Levelock	4,000	$56.30	$20.00	$ 12,021	10
Kokhanok	6,200	$60.74	$20.00	$ 20,915	7
Nondalton	12,000	$51.85	$20.00	$ 21,978	8
Newhalen	18,000	$51.85	$20.00	$ 32,967	6
Total	**50,466 gallons**			**$99,104**	

The change to HELE generated space heating in the school buildings and teacher housing should have no negative impacts on other energy users in the community. Positive impacts include decreased reliance on fossil fuels, development of local knowledge of an alternative system for space heating, and local job creation through contracting to collect wood and stoke the boiler.

Diesel Combined Heat and Power ("Waste Heat")

Combine Heat and Power (CHP), also known as "cogeneration" and "waste heat", describes the utilization of excess energy generated by large machinery. One of the biggest creators of "waste heat" are generator sets used to create electricity – excess heat can be used for space heating, electricity generation, ice making etc. Rural Alaska has long recognized the opportunity presented by waste heat and where electric generation is in relatively close proximity to community facilities the opportunity to provide space heat is often exploited.

Waste heat agreements are in place for the schools in the following communities: Chignik Bay, Chignik Lagoon, Chignik Lake, Kokhanok, Levelock, Pedro Bay, Pilot Point and Port Alsworth. The Borough could act as an intermediary to facilitate agreements between local utilities and potential users of waste heat where this resource is currently underutilized.

END-USE

End-Use Electrical Efficiency

Households, businesses, schools, government buildings, and fish processors all have opportunities to improve the efficiency of their use of electrical energy. The list of promising measures, such as reducing use where it's not really needed, lower the temperature on hot water heaters, replacing incandescent bulbs with compact fluorescents, replacing T-12 fixtures with T-8 fixtures with electronic ballasts, replacing old inefficient refrigerators, remains much as it did almost a decade ago.[35] The difference today is that more of these measures have already been adopted and the price and performance of new lighting systems and appliances have continued to improve.

Nonetheless, many of these low life-cycle cost efficiency/conservation measures remain an underutilized resource to improve the cost effectiveness of the electrical service to consumers.[36]

A continuing challenge to *further* adoption of end-use efficiency measures in rural *households* involves the way the PCE program covers 95 percent of rural household electrical costs above 12.9c/kWh up to 500kWh a month. In households with usage below 500kWh, the household only sees up to five percent of the benefit of an end-use efficiency measure while the PCE program sees a reduction in support to the utility serving that household of 95 percent of every kWh reduced under 500kWh a month.

As household usage goes above 500kWh per month, more typical of wealthier fishing households with many children and multiple computers and TVs, the household theoretically sees 100 percent of the benefit of end-use efficiency. These benefits can be masked by month-to-month variation in electrical usage and overall growth in the number of lights and electrical devices.

Non-PCE supported rural electric customers continue to see high prices and have been especially challenged by the recent diesel fuel price spike in the summer of 2008 that is now flowing through utility fuel inventories.

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[35] See Chapter 4, End-Use Conservation, Screening Report for Alaska Rural Energy Plan (AIDEA), by Northern Economics, April 2001.

[36] See Excel Workbook "AK_Simple_GHG_Background_1b" for detailed analysis of the *net* benefits of CFLs over incandescent light bulbs, taking into account lighting, heating and carbon dioxide emissions considerations. The net benefit/cost ratio of a CFL investment tends to range upwards from 10 – a very favorable investment that frequently pays back in less than a couple of years.

Among the many challenges faced by non-PCE rural electric customers is a lack of locally available efficient lighting and appliances and limited knowledge about what might work for their particular circumstance. Providing consumer education resources to address these needs is helpful, but frequently it is more effective, if more expensive, to have end-use energy experts engage in a conversation with the local community about needs and priorities and develop a community wide program.

The AEA Efficiency Program and its associate organizations (RuralCAP, ACDC) have had good success with this approach. To the extent that a local community has a local energy efficiency champion, that person should take the lead in contacting the AEA Efficiency Program to see where their community is on the list to be visited and to volunteer to assist with AEA with data gathering to ensure a timely and effective visit.

The Village End Use Efficiency Measures (VEUEM) program - run through the Alaska Building Science Network (ABSN) and funded through the Alaska Energy Authority and the Denali Commission - provides village community buildings with a range of energy efficiency measures including: relamping, weather stripping, set back thermostats, efficient boilers, etc.

Relamping commercial facilities with efficient lighting can reduce consumption by 44 percent.[37] Lighting in the average American household accounts for 10 percent of total energy consumption. Electricity in all Lake and Peninsula Borough households is subsidized through the PCE program so any potential savings from switching out standard incandescent bulbs with more efficient compact florescent bulbs (CFL) would be realized by the State of Alaska rather than the household. For this reason we recommend focusing relighting efforts in commercial and government facilities not covered under the PCE program.

In winter of 2005, Port Heiden received energy improvements to their teacher housing and six community buildings through the program – reducing electric energy consumption in these facilities by an estimated 34 percent. Chignik Lake is on the list of communities to have received services over the summer, the last status report sent to the Alaska Energy Authority indicated that the assessment was complete and that relighting materials were being ordered.

There is an opportunity in the future for the Borough to assist in coordinating commercial and government facilities in riding the coat tails of this program's activity. When the VEUEM assesses a village's need before making an order for energy efficient products, local commercial and government entities could pay for their own assessments and enjoy the cost savings associated with ordering products in bulk and through a preferred vendor (the State). The Borough could provide coordination of this effort, one that would not only save energy but would also save money for commercial properties not covered by the PCE program. We note that it is worthwhile to encourage policy makers to expand funding for this program.

[37] The 44 percent energy savings on lighting energy conservation measures are based on pre and post measurements taken at eight state-owned facilities by Siemens as part of their performance contract with the state. Findings are in line with industry average savings going from T-12 to T-8 lighting.

End-Use Heat

The last legislative session saw unprecedented spending on home energy efficiency programs with $200 million allocated to the low-to-moderate income home weatherization program and $160 million to the new home energy rebate program. Both of these programs offer opportunities to increase the energy efficiency of residential housing units.

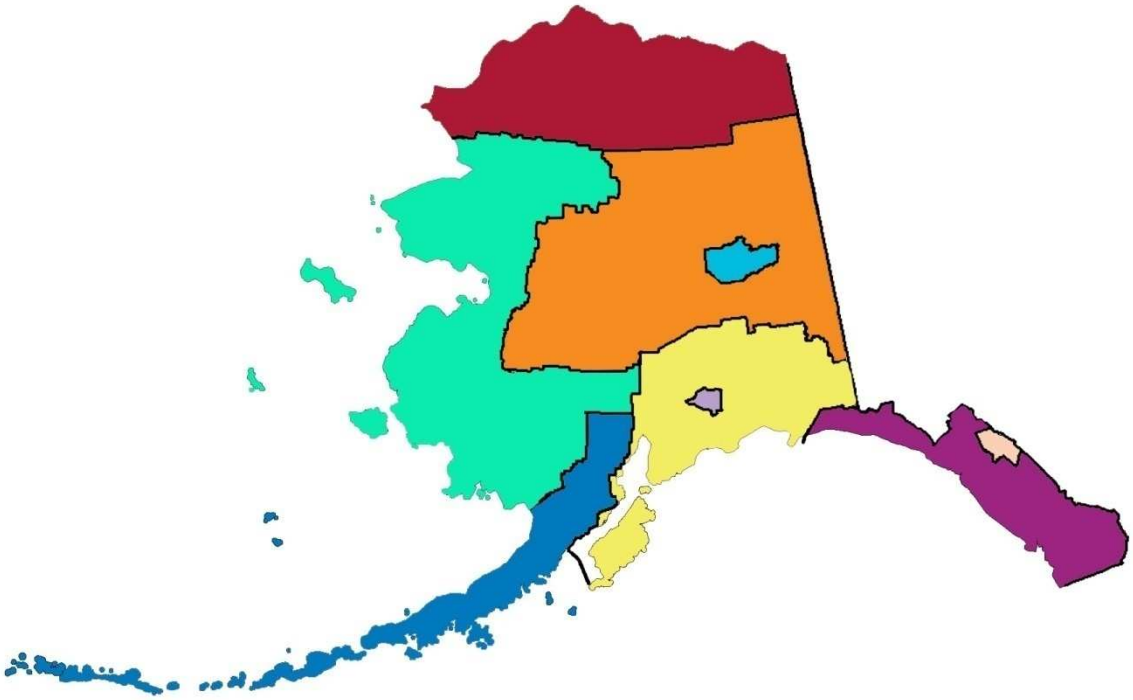

Figure 5 AHFC Weatherization Regions – Lake and Peninsula served by ACDC (DEFINE) and Bristol Bay Housing Authority

Low-to-Moderate Income Weatherization

- Weatherization program for households up to 100 percent of median income with priority given to the poor, elderly and disabled. The program requires no money outlay from the participant and is available to renters as well as home owners.
- $200 million in state funding over the next five years with $1.3 million allocated to the Lake and Peninsula Borough
- Between 1999 and 2007 nearly 200 homes, with 640 residents, participated in the home weatherization program offered by the Alaska Housing Finance Corporation. The US Census 2000 reported 562 occupied housing units in the Lake and Peninsula Borough communities. According to the 2005 Statewide Housing Assessment just under 45 percent of households report that their homes are drafty and 28 percent reported that they could not maintain a comfortable room temperature in the coldest parts of winter.

- The weatherization program has an average B/C ratio[38] of 2.0 for rural Alaska – excluding the Interior and the Four-Dam Pool areas.

Home Energy Rebate Program

- Offers rebate of up to $10,000 for home energy improvements recommended by a certified home energy rater. Participants must own and occupy the home on which they wish to make improvements
- $160 million in state funding over the next five years with $205,484 allocated to the Lake and Peninsula Borough. If each household that applied for, and received, the maximum reimbursement of $10,000 per household, 20 homes could participate in the program. The actual reimbursements are likely closer to $5,000 to $6,000 per home, increasing the numbers of potential participants.
- There are currently only a handful of households signed up to receive an energy rating to participate in the program. The Alaska Housing Finance Corporation facilitates a Roving Rater program to get raters out to remote locations but the wait is sometimes lengthy. The roving raters are sent to communities with multiple participants faster than those with few.
- One barrier to participating in the program is the initial outlay of funds. The Borough might consider public education about the program and encouraging the Bristol Bay Housing Authority to offer low (or no) interest loans for energy improvements, etc. The North Slope Borough is offering residents who are participating in the rebate program additional funds to supplement the rebate cap of $10,000 per household, increasing the energy improvements done at each household and further improving the performance of the house.

Both of these programs offer funding to make improvements that will increase the energy performance of residential building stock and decrease space heating costs for residents.

According to a 2006 study conducted by the Oak Ridge National Laboratory (ORNL) the average house that participates in the low income weatherization program sees a 32.3 percent decrease in energy consumption for space heating.

[38] The benefit cost ratio is the present value of all benefits from a project divided by cost of implementing the program. In benefit cost analysis values should be estimated for all impacts (costs and benefits) future and present.

Table 11 Potential community savings - Weatherization

	Occupied Housing Units	Total consumption @ median consumption of 718 gallons per household	Potential savings from weatherization efforts at average 30 percent savings	Dollar savings at $7 per gallon
		Gallons	**Gallons**	**$$**
Chignik	29	20,822	6,247	$43,726
Chignik Lagoon	33	23,694	7,108	$49,757
Chignik Lake	40	28,720	8,616	$60,312
Egegik	44	31,592	9,478	$66,343
Igiugig	16	11,488	3,446	$24,125
Iliamna	35	25,130	7,539	$52,773
Kokhanok	52	37,336	11,201	$78,406
Levelock	45	32,310	9,693	$67,851
Newhalen	39	28,002	8,401	$58,804
Nondalton	68	48,824	14,647	$102,530
Pedro Bay	17	12,206	3,662	$25,633
Perryville	33	23,694	7,108	$49,757
Pilot Point	29	20,822	6,247	$43,726
Port Alsworth	34	24,412	7,324	$51,265
Port Heiden	41	29,438	8,831	$61,820
TOTAL	**555**	**398,490**	**119,547**	**$836,829**

Savings are significant even at the household level. Table 12 shows the potential savings on space heat per household for a variety of fuel prices and consumption patterns. The high energy use of 818 gallons per year represents above average consumption for households with income similar to the averages in the Lake and Pen region. Typically, households that consume the most energy are those with above average incomes and are of less concern to local governments.

Average fuel consumption per household is based on tables 3 and 13 of ISER "Effects of Rising Utility Costs on Household Budgets, 2000 - 2006" and conversations with Ben Saylor. Savings to individual households will vary by housing unit but should offer a median savings of just over $1,500 with heating fuel at $7 per gallon and weatherization offering 32 percent reductions in space hating energy consumption.

Table 12 Potential household savings - Weatherization

	Low – Fuel @ 5/gal	Med – Fuel @ 6/gal	High – Fuel @ 7/gal
Potential savings per household – Low 618 gallons/yr	**$927**	**$1,112**	**$1,298**
Potential savings per household – Median 718 gallons/yr	**$1,077**	**$1,292**	**$1,508**
Potential savings per household – High 818 gallons/yr	**$1,227**	**$1,472**	**$1,718**

Building Codes

The Borough should adopt energy building codes for residential and commercial construction.

Commercial energy building codes should meet Leadership in Energy and Environmental Design (LEED) standards for new construction core and shell. LEED is a building rating system for sustainable energy practices in building. The core and shell certification sets standards for structure, envelope and the HVAC system. Actually obtaining LEED certification is not necessary, many policy makers and builders use language indicating they "meet LEED standards". The benefit of tying a commercial energy code to the LEED standard is that it is continually updated, known and widely accepted in the commercial building industry. (appendices)

Residential energy code should match the Alaska Building Energy Efficiency Standard (BEES). While there is no statewide residential energy code there is an energy code for all homes whose financing is underwritten by the Alaska Housing Finance Corporation (AHFC). AHFC underwrites roughly 40 percent of home mortgages in Alaska and all of these homes that began construction on or after January 1, 1992 must be built to BEES. As with LEED, BEES is continually reviewed and updated. (see appendices for a copy of the Alaska specific amendments to The International Energy Conservation Code (IECC) 2006, Second Printing)

It is difficult to quantify the impact of creating a residential energy efficiency building code because there is so little information about homes that are built below that standard. The AKWarm database maintained at AHFC holds more than 25,000 records; the majority of them are energy audits conducted on homes for the purpose of financing the sale through AHFC, which will only finance homes that meet BEES.

Even if impacts are not immediately evident, raising the bar on residential construction is an important piece of consumer protection policy. The table below shows the marginal change in energy consumption when moving from one energy rating level to the next. All homes sampled were built between 2000 and 2007. Unfortunately there were only 14 Four Star homes in AKWarm, making analysis of the change between Four Star (not shown in the table due to the small sample size) and Four Star Plus impossible.

Table 13 Energy use per year – by BEES energy ratings

Stars	# houses	Avg. floor area	Avg. energy cost (2007$)	Avg. energy cost per sq ft	Avg. CO2 (tons/yr)
5 Star Plus	92	2,203	$ 1,369	$ 0.62	11.4
5 Star	1,428	1,873	$ 1,495	$ 0.73	12.0
4 Star Plus	5,435	1,842	$ 1,495	$ 0.81	13.7

Borough Procurement

The Borough should engage in simple energy conscious practices by:

- evaluating all building bids and project costs using a life cycle cost analysis. Evaluation using life cycle cost analysis is the easiest way to ensure that future government buildings will built with energy efficiency in mind.
- participating in Energy Star procurement practices for office supplies. Energy Star is a project of the US Department of Energy and the US Environmental Protection Agency which continually updates a list of approved efficient appliances. Establishing a policy to use Energy Star procurement removes the information barrier to efficient procurement by providing the research necessary to make an informed decision. (see appendices)

Transportation

Transportation in rural Alaska is expensive and fuel intensive. There is little that a community can do to reduce the fuel consumed in air travel beyond choosing not to fly. There are however, attractive options available for individuals and businesses that are replacing boats, cars, and ATVs. Fuel efficient engines are often price competitive with their less efficient counterparts and offer considerable savings over the life of the vehicle.

Public Information

Creating public awareness about energy efficiency and conservation is paramount to creating a sustainable energy future. Borough residents should be made aware of the programs available to assist them reducing energy consumption at the household, business and community levels as well as made aware of behavior change that can lead to reduced consumption.

TRANSPORTATION

Fuel delivery via air can run upwards of $2 per gallon per one hundred one way air miles from the fuel source where runways are less than 4,000 feet. Runways over roughly 4,000 feet in length are able to accommodate a DC6 fuel delivery plane with costs on the order of $1 per gallon per one hundred air miles from the source. Table 14 estimates savings associated with runway extensions to communities without the option of barge delivery. Savings range from $3.00 in Pedro Bay to $4.40 in Igiugig, with annual savings reaching $403,200 in Kokhanok.

Table 14 Runway extensions - Estimates of fuel cost savings

Summary of estimated fuel cost savings from larger deliveries with runway extensions						
	POP	Runway length	Runway extension	Fuel delivery benefits (existing new)	Annual Air Delivery	Runway extension fuel delivery benefits
Igiugig	32	3,000	1,000	$4.40	48,000	$211,200
Kokhanok	175	2,920	1,080	$3.60	112,000	$403,200
Nondalton	197	2,800	1,200	$3.40	100,000	$340,000
Pedro Bay	38	3,000	1,000	$3.00	50,000	$150,000

Source: MAFA Analysis, 2008

In many of the communities in the Iliamna Lake region, airplanes are the only consistent way to deliver fuel. Earlier this year Crowley Maritime informed communities in the Lake region that it would not be able to delivery fuel up the Kvichak River. Fuel delivery via barge from the Kenai Peninsula to Williamsport, truck across an improved road to Pile Bay, and around the lake by barge could reduce the cost of fuel delivery on the order of $1.00 per gallon.

In the long run, improvements in the transportation infrastructure in the region can make a significant reduction in the cost of importing energy and other goods.

Table 15 and Table 16 show the potential effect of the Pile Bay Road on delivered fuel costs in seven Lake and Peninsula Borough communities. Completion of Table 15 shows savings per gallon on the assumption that the same small scale barge deliveries would occur. Saving per gallon with a smaller scale barge delivery range from $1.23 in Nondalton to $1.82 per gallon in Igiugig If a larger scale barge deliver system were put in place along with the construction of the road, saving range from $1.37 in Nondalton to $2.19 per gallon in Igiugig. Annual estimated savings for the villages are substantial, totaling $1.3 million using a small barge system, growing to $1.5 million annually for a larger barge delivery system.

Table 15 Small scale fuel delivery system – Cost of fuel transportation legs from Kenai

Summary of estimated cost of fuel transportation legs from Kenai via Pile Bay Road by community – Existing small scale annual deliveries						
	POP	Fuel delivery via road + local system	Air delivery fuel cost	Fuel cost benefit from new road	Estimated annual fuel delivery	Estimated annual value of improved transportation system
		($/gallon)	($/gallon)	($/gallon)	Gallons	$
Igiugig	32	$0.71	$2.53	**$1.82**	69,000	$125,580
Iliamna	93	$0.48	$1.96	**$1.48**	200,000	$295,000
Kokhanok	175	$0.51	$2.07	**$1.56**	66,000	$102,960
Levelock	71	$0.76	$2.15	**$1.39**	180,000	$250,200
Newhalen	167	$0.48	$1.96	**$1.48**	270,000	$398,250
Nondalton	197	$0.73	$1.96	**$1.23**	60,000	$73,500
Pedro Bay	38	$0.46	$1.73	**$1.27**	50,000	$63,250

Source: MAFA Analysis, Pile Bay Road Fuel Delivery System, 2008

Table 16 Large scale fuel delivery system – Cost of fuel transportation legs from Kenai

Summary of estimated cost of fuel transportation legs from Kenai via Pile Bay Road by community: Large scale fuel delivery system						
	POP	Fuel delivery via road + local system	Air delivery fuel cost	Fuel cost benefit from new road	Estimated annual fuel delivery	Estimated annual value of improved transportation system
		($/gallon)	($/gallon)	($/gallon)	Gallons	$
Igiugig	32	$0.34	$2.53	**$2.19**	69,000	$151,110
Iliamna	93	$0.31	$1.96	**$1.65**	200,000	$329,000
Kokhanok	175	$0.19	$2.07	**$1.88**	66,000	$124,080
Levelock	71	$0.39	$2.15	**$1.76**	180,000	$316,800
Newhalen	167	$0.31	$1.96	**$1.65**	270,000	$444,150
Nondalton	197	$0.59	$1.96	**$1.37**	60,000	$81,900
Pedro Bay	38	$0.29	$1.73	**$1.44**	50,000	$71,750

Source: MAFA Analysis, Pile Bay Road Fuel Delivery System, 2008

PEBBLE MINE CONSIDERATIONS

At this stage in the exploration and permitting of the Pebble Creek Mine, whether the mine will be permitted or operated is still uncertain. However, to the extent that the mine remains a possibility, we consider the potential impact on the local energy picture during its exploration, construction and operation phases.

Given the high costs of energy in the Lake and Peninsula Borough and its immediate impact on the sustainability of villages and businesses, the uncertainty of the mine, the long time horizon for its development even if permitted today, and the infrastructure (interties) required to link villages to energy from the mine, we encourage the Borough to vigorously pursue the building code, energy efficiency, weatherization, and wood space heating initiatives – they typically pay back in less than ten years. These initiatives also protect Borough residents from energy price fluctuations while improving comfort and quality of life. They also give residents more independence and control over their energy use.

Over the longer term, the development of the mine may present some opportunities to reduce the unit cost of energy in the Borough. Some of these opportunities, like the construction of an electrical intertie from the Railbelt to serve a load of approximately 200MW at the mine with substations along the way that would allow local communities to tap into the Railbelt power grid, could be less expensive than *small scale* long lived local generation projects – like hydro or wind.

Conversely, the cost of electricity from a *larger scale* local hydro resource may be comparable to an expensive reliable submarine transmission cable across the Cook Inlet with the added advantage that local residents could benefit from local jobs, local power project development and lower electrical rates. For now, the Borough should continue to monitor efforts to develop the power supply for Pebble and consider the possibility that scaling up a local energy resource, such as a hydro resource, could provide residents with lower cost power over the long term.[39]

In the interim exploration and preconstruction phases, there may be opportunities for the cooperative purchasing of diesel for electric generators, space heating and transportation fuels that may lower prices for Borough residents. In addition, a larger fuel market may lower regional prices as costs are spread across more gallons. However, the ability to realize savings on a larger quantity purchases into a region will frequently depend upon whether all of the parties gather together under the same procurement. In this regard, it is important to note that a large outside firm may follow its' own schedule - limiting synergies. The possibilities of sharing

[39] Juneau and Southeast Alaska present an interesting set of case studies in this regard. Hydro projects built to support mining activities in the pre WWI era, circa 1910, continue to supply cost effective power to Juneau and other communities in Southeast.

common costs and entering into bulk fuel procurement arrangement, ala Sand Point, present throughout the exploration, construction and operations phases of the mine. So, while every effort should be made to start out b y vigorously exploring potential for cooperative procurement, it should remain an issue to pursue even when it does not come together on the first try.

To the extent that a local work force is hired, higher household incomes are likely to lead to higher energy consumption. Local hire from the villages may also lead to households making or being able to make different choices as to where to live year round or seasonally. Anecdotally, some believe that income and employment at the Red Dog Mine has lead to more households living in urban Alaska communities as well as "Outside."[40] If village residents choose to continue living in their home villages, higher incomes help stabilize utility payments; higher energy use allows fixed costs to be spread across more kilowatt hours, which tends to improve utility viability. These employment and income effects are similar throughout the exploration, construction and operation phases of the potential mine.

One potential impact of the mine on local energy prices could be larger, better maintained roads that lead to more efficient delivery of fuels, which could lower prices $1 to $2 per gallon compared to flying in fuel. However, the Pile Bay Road construction could occur with or without the mine. Though it seems likely that the presence of the mine would improve the prospects for higher quality and more frequent maintenance of the road. More extensive road construction could also reduce the cost to develop electrical interties along the transportation corridor, opening up the possibility of lower cost energy from regional resources being shared over a wider area. Our initial reconnaissance estimates suggest that the mine presents two interesting local electrical power opportunities:

1) Interconnection with the Railbelt power grid via undersea power cable across the Cook Inlet, potentially lowering electric costs to approximately $0.25 to $0.30 per kWh.
2) Development of larger scale local hydro resources and a regional electric grid, which could provide local residents with lower costs after the mine is played out due to lower long term operations and maintenance costs compared to the undersea cable option

It should be noted that State of Alaska permits were recently issued for meteorological stations in the vicinity of the mine. While the permit request stated that the intended use is for wind data to assess the potential for wind generation, the met stations described in the application appear shorter than those typically used to assess commercial scale wind resources (30 or 50 meters). We note that these lower height met stations are frequently used to develop data for air shed modeling in order to assess the ability of the local wind to disperse local concentrations of material that might become airborne as a result of mining development and operations.

[40] This phenomenon will analyzed in more depth later in 2008 with a cooperative study between the University of Alaska Anchorage, Institute of Social and Economic Research that will match employment and permanent fund dividend recipient files over time to identify employment and migration patterns. This may be of interest to the Borough for anticipating potential social and economic impacts of the Pebble Mine.

Table 17 on the following two pages outlines the potential impacts on the Lake and Peninsula Borough of activities associated with the Pebble Mine project.

Table 17 Pebble project potential impacts

		Electric	Heating	Transportation Fuels
Development Phase	Preconstruction exploration	Planning for electrical requirements can create local options	Planning for heating fuel requirements can create local options	Planning for transportation fuel requirements can create local options
		Small scale diesel gen sets may be moved in to support local activities	Preconstruction equipment may require diesel fuel. However, fuel inventory practices of outside firms tend to be less flexible than local inventory practices	Preconstruction equipment may require diesel fuel. However, fuel inventory practices of outside firms tend to be less flexible than local inventory practices
		Local workforce hired	Local workforce hired	Local workforce hired
		Increase in household incomes leads to increase in energy consumption	Larger local/regional fuel market may enable more cost effective delivery. However, outside firm fuel procurement will tend to follow a separate timeline limiting synergies	Larger local/regional fuel market may enable more cost effective delivery. However, outside firm fuel procurement will tend to follow a separate timeline limiting synergies
		Some households may become snowbirds; work in region in summer, fly out for the winter	Increase in household incomes leads to increase in energy consumption	Increase in household incomes leads to increase in energy consumption
		Net impact = more annual kWhs over which to spread fixed costs (INN hydro fixed + G&A)	Some households may become snowbirds; work in region in summer, fly out for the winter	Some households may become snowbirds; work in region in summer, fly out for the winter
			Net impact = large summer, smaller winter population, clever local administrators capture summer scraps for winter	Net impact = large summer, smaller winter population, clever local administrators capture summer scraps for winter
	Construction	Diesel gen sets moved in to support local activities	Larger local/regional fuel market may enable more cost effective delivery. However, outside firm fuel procurement will tend to follow a separate timeline limiting synergies	Larger local/regional fuel market may enable more cost effective delivery. However, outside firm fuel procurement will tend to follow a separate timeline limiting synergies
		Construction on roads and electrical transmission infrastructure; potential for coordination with local systems	Larger, better maintained roads allow more efficient delivery of fuel oil; could lower fuel costs on the order of $1 to $2 per gallon	Larger, better maintained roads allow more efficient delivery of transportation fuels; could lower fuel costs on the order of $1 to $2 per gallon

Development Stage		Electric	Heating	Transportation Fuels
	Construction	Interconnection with Railbelt Grid could lower electrical costs toward 25c/kWh range = Railbelt COP + Subsea cables + Local substations	*IF* prices for electricity were significantly subsidized, heating systems could convert to electric heat (ala subsidized hydro systems)	Electric four wheelers remain niche market due to high cost of electricity vs. fuel oil
		Local workforce expands rapidly	Local workforce expands rapidly	Local workforce expands rapidly
		Increase in household incomes leads to significant increase in local energy consumption	Increase in household incomes leads to significant increase in local energy consumption	Increase in household incomes leads to significant increase in local energy consumption
		More households have the option to become snowbirds; work in region in summer, fly out for the winter	More households have the option to become snowbirds; work in region in summer, fly out for the winter	More households have the option to become snowbirds; work in region in summer, fly out for the winter
		Net impact = more annual kWhs over which to spread fixed costs (INN hydro fixed + G&A)	Net impact = large summer with some carryover to winter population, clever local administrators capture summer scraps for winter	Net impact = large summer with some carryover to winter population, clever local administrators capture summer scraps for winter
	Operations	Local Power Generation Employment vs. Offshore Power Generation Employment associated with interties		
		Substations could provide local security guards with employment	Net impact = large summer, declining winter population, clever local administrators capture summer scraps for winter	Net impact = large summer, declining winter population, clever local administrators capture summer scraps for winter

APPENDICES

Appendices

Appendix A: Community Summary

Electric Appendices

Appendix B: Newhalen River Project + Regional Grid Total Project Cost

Appendix C: Newhalen River Project + Regional Grid – Local Load Scenario

Appendix D: Newhalen River Project + Regional Grid Break-Even Scenario

Appendix E: Newhalen River Project + Regional Grid Industrial Load Scenario

Appendix F: Pebble Mine Intertie to HEA Power Supply Scenario

Appendix G: Update 1982 Stone & Webster Hydroelectric Reconnaissance Estimates to 2008

Appendix H: Chigniks Hydro + Wind Combinations; Chignik + Chignik Lagoon Load Combinations

Appendix I: Economic Value of Indian Creek Hydro

Appendix J: Rate Impact Analysis of Indian Creek Hydro

Heating Appendices

Appendix K: Wood Boilers for Electricity and Heat

Appendix L: Igiugig In-Stream Hydro

Appendix M: Heating Fuel Comparisons, Alaska, Fall 2008

Appendix N: Long Run Incremental Cost Analysis – Includes Capital Replacement Costs

Appendix O: Long Run Levalized Cost Comparison – Fuel Oil Versus Wood Heat (Household Scale)

Appendix P: Wood Boiler Specifications

Appendix Q: Industry Case Study

References

Appendix A: Community Summary

	POP	Initiatives			Potential Funding Sources for L&P
		Heating	Electric	Transport	
Regionwide		Install wood stoves, wood boilers			AHFC, AEA
		Aid development of wood collection and delivery businesses			AIDEA, AEA, Denali
		Aid development of wood pellet businesses			AIDEA, AEA, Denali
		Home weatherization, energy grants			AHFC, AEA
			Village electric efficiency reviews		AEA EE Program
		Weatherization, energy efficiency workforce training			Denali, AEA
		Public education campaign - effective efficiency, conservation measures			AEA, AHFC
Chignik Lake	128	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans, extend runway	AEA, Denali
Chignik Lagoon	68	Bundle new AEA bulk fuel loans	Develop design-build wind-diesel + intertie project, Develop hydro + intertie project	Bundle new AEA bulk fuel loans	AEA, Denali
Chignik Bay	81	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans, extend runway	AEA, Denali
Perryville	119	Bundle new AEA bulk fuel loans	*Wind appears marginal from local met tower study, explore tidal for demonstration project*	Bundle new AEA bulk fuel loans	AEA, Denali
Port Heiden	87	Bundle new AEA bulk fuel loans	Develop met data for design-build wind project, explore tidal	Bundle new AEA bulk fuel loans	AEA, Denali
Pilot Point	61	Bundle new AEA bulk fuel loans	Develop met data for design-build wind project, explore tidal	Bundle new AEA bulk fuel loans	AEA, Denali
Ugashik	13	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans	AEA, Denali
Egegik	64	Bundle new AEA bulk fuel loans	Develop met data for design-build wind project, explore tidal	Bundle new AEA bulk fuel loans	AEA, Denali
Levelock	71	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans	AEA, Denali
Igiugig	32	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans; Williamsport road + lake barge	AEA, Denali
Kokhanok	175	Bundle new AEA bulk fuel loans	Develop design-build wind procurement	Bundle new AEA bulk fuel loans; Williamsport road + lake barge	Existing grant
Pedro Bay	38	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans; Williamsport road + lake barge	AEA, Denali
Iliamna	93	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans; Williamsport road + lake barge	AEA, Denali
Newhalen	167	Bundle new AEA bulk fuel loans	Develop met data for design-build wind project	Bundle new AEA bulk fuel loans; Williamsport road + lake barge	AEA, Denali
Nondalton	197	Bundle new AEA bulk fuel loans		Bundle new AEA bulk fuel loans; Newhalen River Bridge + fuel truck	AEA, Denali
Port Alsworth	118	Bundle new AEA bulk fuel loans	Develop hydro; hydro + intertie assessment project	Newhalen River Bridge + fuel truck + lake barge	AEA

Appendix B: Newhalen River Project + Regional Grid Total Project Cost

NEWHALEN REGIONAL HYDRO UPDATE PRELIMINARY ECONOMIC FEASIBILITY ANALYSIS

CAPITAL COST ESTIMATE

										16000	656
										kW	miles
FERC Account	Description	Estimated Cost (1982$)	2009/1982 Cost Multiplier	Update to 2009$	EPC Scope Reconfiguration + Value Engineering	Estimated Cost (2009$)	% of Total Project Cost	$ hydro	$ grid	$/kW	$/mile
330	Land and land rights	$0	2.05	$0	$2,068,000	$2,068,000	1%	$2,068,000			
331	Power plant, structures & improvements	$5,645,000	2.05	$11,572,250	$0	$11,572,250	4%	$11,572,250			
332	Waterway (diversion canal)	$35,212,000	2.05	$72,184,600	($1,443,692)	$70,740,908	24%	$70,740,908			
333	Turbines and generators	$8,570,000	2.05	$17,568,500	$0	$17,568,500	6%	$17,568,500			
334	Accessory Electrical Equipment	$1,150,000	2.05	$2,357,500	$0	$2,357,500	1%	$2,357,500			
335	Misc. Power Plant Equipment	$576,000	2.05	$1,180,800	$0	$1,180,800	0%	$1,180,800			
336	Roads	$387,000	2.05	$793,350	($90,000)	$703,350	0%	$703,350			
352	Substation & Switching Station - Structures and Improvements	$100,000	2.05	$205,000	$95,000	$300,000	0%	$300,000			
353	Substation & Switching Station - Equipment	$625,000	2.05	$1,281,250	$0	$1,281,250	0%	$1,281,250			
353-359	Transmission Interties	$51,375,000	2.05	$105,318,750	($5,265,938)	$100,052,813	34%		$100,052,813		
	Subtotal	$103,640,000		$212,462,000	($4,636,630)	$207,825,371	72%	$107,772,558	$100,052,813	$6,736	$152,520
								52%	48%		
	Construction Camp, Mob & Demob	$1,800,000	2.05	$3,690,000	($369,000)	$3,321,000	1%	$1,722,180	$1,598,820		
	Total Construction / Engineering, Procurement & Construction (EPC) Contract	$105,440,000	2.05	$216,152,000	($5,005,630)	$211,146,371	73%	$109,494,738	$101,651,633	$6,843	$154,957
71	Environmental assessment & permitting	$2,040,000	2.05	$4,182,000	$2,000,000	$6,182,000	2%	$3,205,816	$2,976,184		
	Prelim Engineering (pre-EPC)	$8,435,000	2.05	$17,291,750	($6,916,700)	$10,375,050	4%	$5,380,217	$4,994,833		
	Construction Management	$6,854,000	2.05	$14,050,700	($2,810,140)	$11,240,560	4%	$5,829,047	$5,411,513		
	Allowance for Indeterminates	$18,415,000	2.05	$37,750,750	($7,750,750)	$30,000,000	10%	$15,557,180	$14,442,820		
	Interest During Construction	$8,683,000	2.05	$17,800,150	$3,314,487	$21,114,637	7%	$10,949,474	$10,165,163		
	Subtotal	$44,427,000		$91,075,350	($12,163,103)	$78,912,247	27%	$40,921,735	$37,990,512	$2,558	$57,912
	Total Project Cost	$149,867,000		$307,227,350	($17,168,732)	$290,058,618	100%	$150,416,473	$139,642,145	**$9,401**	**$212,869**

Appendix C: Newhalen River Project + Regional Grid – Local Load Scenario

NEWHALEN REGIONAL HYDRO UPDATE PRELIMINARY ECONOMIC FEASIBILITY ANALYSIS

All values are in 2009$

		Hydro Power			Transmission Infrastructure			Avoided Diesel Costs		
		16,000	Capacity (kW)		$212,900	$/mile		$4.50	/gallon long run diesel price	
		0.5	Annual Capacity Factor		620	miles		0.0769	Diesel Efficiency (gallons/kWh	
		0.94	Annual Availability		$131,998,000	Capital ($)		$0.35	$/kWh avoided fuel	
		66,096,000	Estimated annual production (kWh)		$220,000	Annual O&M		$0.02	$/kWh avoided diesel O&M	
1.66E+07	1.66E+07	$1,035	/kW Development Costs							
		$9,450	/kW EPC Contract Cost					5.0%	Real Discount Rate	
		$50	/kW Annual O&M							
		$100,000	5 year maintenance cycle							
							1.01			
		COSTS						BENEFITS - AVOIDED COSTS		
Date	Year	Development	EPC Contract	O&M Cost	Total Cost	NPV COSTS	Avoided kWhs	Annual Avoided Cost	NPV Benefits	Benefiit / Cost Ratio
2009	0	$2,000,000			$2,000,000	$239,334,014			$198,129,435	**0.83**
2010	1	$3,000,000			$3,000,000					
2011	2	$3,600,000			$3,600,000					
2012	3	$4,000,000			$4,000,000					
2013	4	$4,000,000			$4,000,000					
2014	5		$94,399,333		$94,399,333		26,000,000	$9,520,000		
2015	6		$94,399,333		$94,399,333		26,260,000	$9,615,200		
2016	7		$94,399,333		$94,399,333		26,522,600	$9,711,352		
2017	8			$1,020,000	$1,020,000		26,787,826	$9,808,466		
2018	9			$1,020,000	$1,020,000		27,055,704	$9,906,550		
2019	10		$100,000	$1,020,000	$1,120,000		27,326,261	$10,005,616		
2020	11			$1,020,000	$1,020,000		27,599,524	$10,105,672		
2021	12			$1,020,000	$1,020,000		27,875,519	$10,206,729		
2022	13			$1,020,000	$1,020,000		28,154,274	$10,308,796		
2023	14			$1,020,000	$1,020,000		28,435,817	$10,411,884		
2024	15		$100,000	$1,020,000	$1,120,000		28,720,175	$10,516,003		
2025	16			$1,020,000	$1,020,000		29,007,377	$10,621,163		
2026	17			$1,020,000	$1,020,000		29,297,451	$10,727,374		
2027	18			$1,020,000	$1,020,000		29,590,425	$10,834,648		
2028	19			$1,020,000	$1,020,000		29,886,330	$10,942,995		
2029	20		$100,000	$1,020,000	$1,120,000		30,185,193	$11,052,424		
2030	21			$1,020,000	$1,020,000		30,487,045	$11,162,949		
2031	22			$1,020,000	$1,020,000		30,791,915	$11,274,578		
2032	23			$1,020,000	$1,020,000		31,099,834	$11,387,324		
2033	24			$1,020,000	$1,020,000		31,410,833	$11,501,197		
2034	25		$100,000	$1,020,000	$1,120,000		31,724,941	$11,616,209		
2035	26			$1,020,000	$1,020,000		32,042,190	$11,732,371		
2036	27			$1,020,000	$1,020,000		32,362,612	$11,849,695		
2037	28			$1,020,000	$1,020,000		32,686,238	$11,968,192		
2038	29			$1,020,000	$1,020,000		33,013,101	$12,087,874		
2039	30		$100,000	$1,020,000	$1,120,000		33,343,232	$12,208,753		
2040	31			$1,020,000	$1,020,000		33,676,664	$12,330,840		
2041	32			$1,020,000	$1,020,000		34,013,431	$12,454,149		
2042	33			$1,020,000	$1,020,000		34,353,565	$12,578,690		
2043	34			$1,020,000	$1,020,000		34,697,101	$12,704,477		
2044	35		$100,000	$1,020,000	$1,120,000		35,044,072	$12,831,522		
2045	36			$1,020,000	$1,020,000		35,394,513	$12,959,837		
2046	37			$1,020,000	$1,020,000		35,748,458	$13,089,435		
2047	38			$1,020,000	$1,020,000		36,105,942	$13,220,330		
2048	39			$1,020,000	$1,020,000		36,467,002	$13,352,533		
2049	40		$100,000	$1,020,000	$1,120,000		36,831,672	$13,486,058		
2050	41			$1,020,000	$1,020,000		37,199,988	$13,620,919		
2051	42			$1,020,000	$1,020,000		37,571,988	$13,757,128		
2052	43			$1,020,000	$1,020,000		37,947,708	$13,894,699		
2053	44			$1,020,000	$1,020,000		38,327,185	$14,033,646		
2054	45		$100,000	$1,020,000	$1,120,000		38,710,457	$14,173,983		
2055	46			$1,020,000	$1,020,000		39,097,562	$14,315,723		
2056	47			$1,020,000	$1,020,000		39,488,537	$14,458,880		
2057	48			$1,020,000	$1,020,000		39,883,423	$14,603,469		
2058	49			$1,020,000	$1,020,000		40,282,257	$14,749,503		
2059	50		$100,000	$1,020,000	$1,120,000		40,685,079	$14,896,998		

Appendix D: Newhalen River Project + Regional Grid Break-Even Scenario

NEWHALEN REGIONAL HYDRO UPDATE PRELIMINARY ECONOMIC FEASIBILITY ANALYSIS

All values are in 2009$

		Hydro Power			Transmission Infrastructure			Avoided Diesel Costs		
		8,000	Capacity (kW)		$212,900	$/mile		$4.50	/gallon long run diesel price	
		0.5	Annual Capacity Factor		620	miles		0.0769	Diesel Efficiency (gallons/kWh	
		0.94	Annual Availability		$131,998,000	Capital ($)		$0.35	$/kWh avoided fuel	
		33,048,000	Estimated annual production (kWh)		$220,000	Annual O&M		$0.02	$/kWh avoided diesel O&M	
1.28E+07	1.28E+07	$1,600	/kW Development Costs							
		$12,500	/kW EPC Contract Cost					5.0%	Real Discount Rate	
		$50	/kW Annual O&M							
		$100,000	5 year maintenance cycle							
							1.01			
		COSTS						BENEFITS - AVOIDED COSTS		
Date	Year	Development	EPC Contract	O&M Cost	Total Cost	NPV COSTS	Avoided kWhs	Annual Avoided Cost	NPV Benefits	Benefiit / Cost Ratio
2009	0	$2,000,000			$2,000,000	$192,745,097			$193,682,583	**1.00**
2010	1	$2,000,000			$2,000,000					
2011	2	$2,800,000			$2,800,000					
2012	3	$3,000,000			$3,000,000					
2013	4	$3,000,000			$3,000,000					
2014	5		$77,332,667		$77,332,667		26,000,000	$9,520,000		
2015	6		$77,332,667		$77,332,667		26,260,000	$9,615,200		
2016	7		$77,332,667		$77,332,667		26,522,600	$9,711,352		
2017	8			$620,000	$620,000		26,787,826	$9,808,466		
2018	9			$620,000	$620,000		27,055,704	$9,906,550		
2019	10		$100,000	$620,000	$720,000		27,326,261	$10,005,616		
2020	11			$620,000	$620,000		27,599,524	$10,105,672		
2021	12			$620,000	$620,000		27,875,519	$10,206,729		
2022	13			$620,000	$620,000		28,154,274	$10,308,796		
2023	14			$620,000	$620,000		28,435,817	$10,411,884		
2024	15		$100,000	$620,000	$720,000		28,720,175	$10,516,003		
2025	16			$620,000	$620,000		29,007,377	$10,621,163		
2026	17			$620,000	$620,000		29,297,451	$10,727,374		
2027	18			$620,000	$620,000		29,590,425	$10,834,648		
2028	19			$620,000	$620,000		29,886,330	$10,942,995		
2029	20		$100,000	$620,000	$720,000		30,185,193	$11,052,424		
2030	21			$620,000	$620,000		30,487,045	$11,162,949		
2031	22			$620,000	$620,000		30,791,915	$11,274,578		
2032	23			$620,000	$620,000		31,099,834	$11,387,324		
2033	24			$620,000	$620,000		31,410,833	$11,501,197		
2034	25		$100,000	$620,000	$720,000		31,724,941	$11,616,209		
2035	26			$620,000	$620,000		32,042,190	$11,732,371		
2036	27			$620,000	$620,000		32,362,612	$11,849,695		
2037	28			$620,000	$620,000		32,686,238	$11,968,192		
2038	29			$620,000	$620,000		33,013,101	$12,087,874		
2039	30		$100,000	$620,000	$720,000		33,048,000	$12,100,652		
2040	31			$620,000	$620,000		33,048,000	$12,100,652		
2041	32			$620,000	$620,000		33,048,000	$12,100,652		
2042	33			$620,000	$620,000		33,048,000	$12,100,652		
2043	34			$620,000	$620,000		33,048,000	$12,100,652		
2044	35		$100,000	$620,000	$720,000		33,048,000	$12,100,652		
2045	36			$620,000	$620,000		33,048,000	$12,100,652		
2046	37			$620,000	$620,000		33,048,000	$12,100,652		
2047	38			$620,000	$620,000		33,048,000	$12,100,652		
2048	39			$620,000	$620,000		33,048,000	$12,100,652		
2049	40		$100,000	$620,000	$720,000		33,048,000	$12,100,652		
2050	41			$620,000	$620,000		33,048,000	$12,100,652		
2051	42			$620,000	$620,000		33,048,000	$12,100,652		
2052	43			$620,000	$620,000		33,048,000	$12,100,652		
2053	44			$620,000	$620,000		33,048,000	$12,100,652		
2054	45		$100,000	$620,000	$720,000		33,048,000	$12,100,652		
2055	46			$620,000	$620,000		33,048,000	$12,100,652		
2056	47			$620,000	$620,000		33,048,000	$12,100,652		
2057	48			$620,000	$620,000		33,048,000	$12,100,652		
2058	49			$620,000	$620,000		33,048,000	$12,100,652		
2059	50		$100,000	$620,000	$720,000		33,048,000	$12,100,652		

Appendix E: Newhalen River Project + Regional Grid Industrial Load Scenario

NEWHALEN REGIONAL HYDRO UPDATE PRELIMINARY ECONOMIC FEASIBILITY ANALYSIS

All values are in 2009$

		Hydro Power			Transmission Infrastructure				Avoided Costs	
		16,000	Capacity (kW)		$212,900	$/mile		Local	Industrial	
		0.5	Annual Capacity Factor		656	miles		$4.50	$8.00	/gallon long run diesel / $/MMBtu
		0.94	Annual Availability		$139,662,400	Capital ($)		0.0833	7,120	Efficiency (gallons/kWh; btu/kwh)
		66,096,000	Estimated annual production (kWh)		$220,000	Annual O&M		$0.38	$0.06	$/kWh avoided fuel
1.66E+07	1.66E+07	$1,035	/kW Development Costs					$0.02	$0.04	$/kWh avoided O&M
		$9,450	/kW EPC Contract Cost							
		$50	/kW Annual O&M						5.0%	Real Discount Rate
		$100,000	5 year maintenance cycle							
							1.01	24 years		
		COSTS							BENEFITS - AVOIDED COSTS	

Date	Year	Development	EPC Contract	O&M Cost	Total Cost	NPV COSTS	Avoided kWhs - Local	Avoided kWhs Industrial	Annual Avoided Cost	NPV Benefits	Benefit / Cost Ratio
2009	0	$2,000,000			$2,000,000	$245,057,846				$277,460,176	**1.13**
2010	1	$3,000,000			$3,000,000						
2011	2	$3,600,000			$3,600,000						
2012	3	$4,000,000			$4,000,000						
2013	4	$4,000,000			$4,000,000						
2014	5		$96,954,133		$96,954,133		28,000,000	38,096,000	$14,753,788		
2015	6		$96,954,133		$96,954,133		28,280,000	37,816,000	$14,837,239		
2016	7		$96,954,133		$96,954,133		28,562,800	37,533,200	$14,921,525		
2017	8			$1,020,000	$1,020,000		28,848,428	37,247,572	$15,006,654		
2018	9			$1,020,000	$1,020,000		29,136,912	36,959,088	$15,092,633		
2019	10		$100,000	$1,020,000	$1,120,000		29,428,281	36,667,719	$15,179,473		
2020	11			$1,020,000	$1,020,000		29,722,564	36,373,436	$15,267,181		
2021	12			$1,020,000	$1,020,000		30,019,790	36,076,210	$15,355,766		
2022	13			$1,020,000	$1,020,000		30,319,988	35,776,012	$15,445,237		
2023	14			$1,020,000	$1,020,000		30,623,188	35,472,812	$15,535,603		
2024	15		$100,000	$1,020,000	$1,120,000		30,929,420	35,166,580	$15,626,872		
2025	16			$1,020,000	$1,020,000		31,230,714	34,057,206	$15,719,054		
2026	17			$1,020,000	$1,020,000		31,551,101	34,544,899	$15,812,158		
2027	18			$1,020,000	$1,020,000		31,866,612	34,229,388	$15,906,193		
2028	19			$1,020,000	$1,020,000		32,185,278	33,910,722	$16,001,168		
2029	20		$100,000	$1,020,000	$1,120,000		32,507,131	33,588,869	$16,097,093		
2030	21			$1,020,000	$1,020,000		32,832,202	33,263,798	$16,193,978		
2031	22			$1,020,000	$1,020,000		33,160,524	32,935,476	$16,291,831		
2032	23			$1,020,000	$1,020,000		33,492,129	32,603,871	$16,390,662		
2033	24			$1,020,000	$1,020,000		33,827,051	32,268,949	$16,490,482		
2034	25		$100,000	$1,020,000	$1,120,000		34,165,321	31,930,679	$16,591,300		
2035	26			$1,020,000	$1,020,000		34,506,974	31,589,026	$16,693,127		
2036	27			$1,020,000	$1,020,000		34,852,044	31,243,956	$16,795,971		
2037	28			$1,020,000	$1,020,000		35,200,565	30,895,435	$16,899,844		
2038	29			$1,020,000	$1,020,000		35,552,570		$14,043,265		
2039	30		$100,000	$1,020,000	$1,120,000		35,908,096		$14,183,698		
2040	31			$1,020,000	$1,020,000		36,267,177		$14,325,535		
2041	32			$1,020,000	$1,020,000		36,629,849		$14,468,790		
2042	33			$1,020,000	$1,020,000		36,996,147		$14,613,478		
2043	34			$1,020,000	$1,020,000		37,366,109		$14,759,613		
2044	35		$100,000	$1,020,000	$1,120,000		37,739,770		$14,907,209		
2045	36			$1,020,000	$1,020,000		38,117,167		$15,056,281		
2046	37			$1,020,000	$1,020,000		38,498,339		$15,206,844		
2047	38			$1,020,000	$1,020,000		38,883,322		$15,358,912		
2048	39			$1,020,000	$1,020,000		39,272,156		$15,512,501		
2049	40		$100,000	$1,020,000	$1,120,000		39,664,877		$15,667,626		
2050	41			$1,020,000	$1,020,000		40,061,526		$15,824,303		
2051	42			$1,020,000	$1,020,000		40,462,141		$15,982,546		
2052	43			$1,020,000	$1,020,000		40,866,763		$16,142,371		
2053	44			$1,020,000	$1,020,000		41,275,430		$16,303,795		
2054	45		$100,000	$1,020,000	$1,120,000		41,688,185		$16,466,833		
2055	46			$1,020,000	$1,020,000		42,105,066		$16,631,501		
2056	47			$1,020,000	$1,020,000		42,526,117		$16,797,816		
2057	48			$1,020,000	$1,020,000		42,951,378		$16,965,794		
2058	49			$1,020,000	$1,020,000		43,380,892		$17,135,452		
2059	50		$100,000	$1,020,000	$1,120,000		43,814,701		$17,306,807		

Appendix F: Pebble Mine Intertie to HEA Power Supply Scenario

FIRST ORDER OF MAGNITUDE ESTIMATE - POWER SUPPLY FROM HEA TO PEBBLE					
ASSUME 230KV SUBMARINE + OVERLAND CABLE FROM HEA (Anchor Point) TO PEBBLE					
ASSUME HEA POWER = COOK INLET NATURAL GAS, 260MW CC SCALE					
TOTAL ESTIMATED PRICE OF POWER		**$0.240**			
		Cost of Power	$0.100	$/kWh	
	General & Administrative		$0.140	$/kWh	
Transmission Links					
From	To	Mileage	$/mile Baseline	Local Cost Multiplier	Capital Cost $
Anchor Point	Chinitna	38	$3,000,000	1.00	$114,000,000
Chinitna	Pebble	70	$850,000	1.00	$59,500,000
	Subtotal	108	$1,606,481		$173,500,000
Add local substations					$2,500,000
	Total				$176,000,000
	Assume 30 year capital recovery, 5% real interest			CRF=	0.06505
				Annual Capital	$11,449,053
				O&M =	$500,000
				Total Annual	$11,949,053
				Capacity Req'd (MW)	200
				Capacity Factor	0.8
				Availability	0.9
				MWh/year	1,262,304
				$/MWh	$9.47
COOK INLET NATURAL GAS FIRED TURBINES					
260MW CC Unit	Heat Rate	7120	MMBTU/MWh		
NYMEX (Jan 10)	Long Run Price of Fuel	$8.00	$/MMBtu		
	Cost of Fuel	$56.96	$/MWh		
	Fixed O&M	11	$/kW-year		
	Fixed O&M	$2,860,000	$/kW-year	$1.74	
	Variable O&M	$4.50	$/MWh		
	Capital Cost	1200	$/kW		
	Capital Cost	$312,000,000	2008$		
	Capital Recovery Factor	0.08024			
	Capital Cost	$25,035,687	$/year	$15.26	
	Capacity Factor	0.8			
	Availability	0.9			
	MWh/year	1,640,995			
	Fuel + O&M + Capital ($/MWh)	$78.46		$17.00	
	CO2 Emissions Cost ($/MWh)	$12.00			
	TOTAL GENERATION COST ($/MWh)	$90.46			
	ADD Transmission ($/MWh)	$9.47			
	TOTAL G&T ($/MWh)	**$99.93**			

Appendix G: Update 1982 Stone & Webster Hydroelectric Reconnaissance Estimates to 2008

Lake & Peninsula Regional Energy Screening Study

draft: 4-Oct-08
q's to: mafa@alaska.net

HYDRO OPPORTUNITY RECON & SCREENING

Discount Rate	5.0%
Life	40
CRF	0.05828
O&M	$0.03

File	ID	Project Name	Source	Land Issues	Environmental	Transmission (miles)	Firm Energy (kWh/yr)	EPC + OC Project Cost ($)	Estimate Year	Construction (2008$)	2008$ ($/kW)	LCOE $/kWh
Lakes Region												
SW 218	1961	Kontrashibuna Lake, Tanalian River + Regional Grid	Bristol Bay Regional Power Plan Interim Feasibility; by Stone & Webster Engr Corp; for APA; July 1982; BRI 013, ex sum, vol 1 & 2; DOE Library.	Lake Clark National Park & Preserve		450	70,128,000	$216,114,000	1982	$438,711,420	$27,419	**$0.39**
SW 128	575	Newhalen River	Bristol Bay Regional Power Plan Interim Feasibility; by Stone & Webster Engr Corp; for APA; July 1982; BRI 013, ex sum, vol 1 & 2; DOI Library.	Local	Diversion allows fish passage enhancement	420	69,001,956	$149,867,000	1982	$304,230,010	$19,014	**$0.29**
SW 151	651	Newhalen River	Bristol Bay Interregional Power Plan Preliminary Assessment; by Stone and Webster Engineering Corp.; for APA; April 1983; BRI 021; DOE Library.	Local	Diversion allows fish passage enhancement	420	94,497,480	$201,407,000	1983	$402,814,000	$18,310	**$0.28**
SW 175	1273	Tazimina Falls (Recon)	Bristol Bay Regional Power Plan Interim Feasibility; by Stone & Webster Engr Corp; for APA; July 1982; BRI 013, ex sum, vol 1 & 2; DOI Library.		Salmon spawn below falls	16	5,259,600	$15,773,000	1982	$32,019,190	$26,683	**$0.38**
		Tazimina Falls (Feasibility)	Feasibilty Report Tazimina River Hydroelectric Project; by Stone And Webster; for APA; March 1987; TAZI 003-2; DOE Library.		Salmon spawn below falls	16	3,068,100	$10,665,000	1986	$20,583,450	$29,405	**$0.42**
		Tazimina Falls (Construction)	I-N-N Site	Installed + Transmission ROW	Salmon spawn below falls	16	4,032,360	$11,600,000	1997	$17,400,000	$18,913	**$0.28**
Chigniks												
SW 190	1595	Chignik (Indian Creek)	Chignik AK Draft Small Hydropower Feasibility Report and EIS; by ACOE; for ACOE; July 1984; TK 1424 A4 C44d; BLM/AR Library and Reg. Inven. & Recon Study for Small Hydro Projects, Aleutians Oct 1980	Local	Rec'd Fed authorization for construction	0.25	5,118,000	$8,711,000	1983	$17,422,000	$15,838	**$0.23**

Appendix H: Chigniks Hydro + Wind Combinations; Chignik + Chignik Lagoon Load Combinations

Lake & Peninsula Regional Energy Screening Study

draft: 4-Oct-08
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HYDRO OPPORTUNITY RECON & SCREENING

Initial Review of Precipitation (Hydro) and Wind (Wind Power) Monthly Coorelation

CHIGNIK PRECIPITATION
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak1716

1961-1990	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average Total Precipitation (in.)	6.06	7.5	6.89	5.37	6.24	6.07	4.18	5.05	9.53	9.13	9.45	7.41
Monthly Mean vs. Avg. Annual	0.88	1.09	1.00	0.78	0.90	0.88	0.61	0.73	1.38	1.32	1.37	1.07

CHIGNIK WIND
see Chignik Bay at: http://www.akenergyauthority.org/programwindresourcedata.html

WIND (Mud Bay Hill)												
MPH	15	17.1	18	15.5	13.4	10.4	12.4	13.5	13.8	15.9	18.2	15.7
Monthly vs. Avg	1.01	1.15	1.21	1.04	0.90	0.70	0.83	0.91	0.93	1.07	1.22	1.05
WIND + PRECIP	1.88	2.23	2.20	1.82	1.80	1.58	1.44	1.64	2.31	2.39	2.59	2.13

Chignik Load

kWh_g/month	46,530	41,760	43,950	41,280	50,310	46,470	43,770	45,510	43,560	39,450	42,540	31,920
Monthly vs Avg.	1.08	0.97	1.02	0.96	1.17	1.08	1.02	1.06	1.01	0.92	0.99	0.74
517,050 kWh/year												

Chignik Lagoon Load

kWh/month	43240	39890	28430	35280	40520	41490	42460	40200	37920	36800	35560	36400
Monthly vs Avg.	**1.13**	1.04	0.74	0.92	1.06	1.09	**1.11**	1.05	0.99	0.96	0.93	0.95
458,190 kWh/year												

Chignik + Chignik Lagoon Loads

kWh/month	89,770	81,650	72,380	76,560	90,830	87,960	86,230	85,710	81,480	76,250	78,100	68,320
Monthly vs Avg.	1.10	1.00	0.89	0.94	1.12	1.08	1.06	1.05	1.00	0.94	0.96	0.84
975,240 kWh/year												

Appendix I: Economic Value of Indian Creek Hydro

All values are in 2008$

Hydro Power	
500	Capacity (kW)
0.5	Annual Capacity Factor
0.94	Annual Availability
2,065,500	Estimated annual production (kWh)
$1,500	/kW Development Costs
$15,000	/kW EPC Contract Cost
$120	/kW Annual O&M
$50,000	5 year maintenance cycle

Avoided Costs	
$4.36	/gallon long run diesel price
0.0833	Diesel Efficiency (gallons/kWh)
$0.36	$/kWh avoided fuel
$0.02	$/kWh avoided diesel O&M

5.0%	Real Discount Rate

		COSTS					1.05	BENEFITS - AVOIDED DIESEL		
Date	Year	Development	EPC Contract	O&M Cost	Total Cost	NPV COSTS	Avoided kWhs	Annual Avoided Cost	NPV Benefits	Benefiit / Cost Ratio
2008	0	$300,000			$300,000	$8,221,111			$11,423,098	**1.39**
2009	1	$450,000			$450,000					
2010	2		$2,500,000		$2,500,000					
2011	3		$2,500,000		$2,500,000					
2012	4		$2,500,000		$2,500,000					
2013	5			$60,000	$60,000		1,000,000	$383,611		
2014	6			$60,000	$60,000		1,050,000	$402,792		
2015	7			$60,000	$60,000		1,102,500	$422,931		
2016	8			$60,000	$60,000		1,157,625	$444,078		
2017	9			$60,000	$60,000		1,215,506	$466,282		
2018	10		$50,000	$60,000	$110,000		1,276,282	$489,596		
2019	11			$60,000	$60,000		1,340,096	$514,076		
2020	12			$60,000	$60,000		1,407,100	$539,779		
2021	13			$60,000	$60,000		1,477,455	$566,768		
2022	14			$60,000	$60,000		1,551,328	$595,107		
2023	15		$50,000	$60,000	$110,000		1,628,895	$624,862		
2024	16			$60,000	$60,000		1,710,339	$656,105		
2025	17			$60,000	$60,000		1,795,856	$688,910		
2026	18			$60,000	$60,000		1,885,649	$723,356		
2027	19			$60,000	$60,000		1,979,932	$759,524		
2028	20		$50,000	$60,000	$110,000		2,065,500	$792,349		
2029	21			$60,000	$60,000		2,065,500	$792,349		
2030	22			$60,000	$60,000		2,065,500	$792,349		
2031	23			$60,000	$60,000		2,065,500	$792,349		
2032	24			$60,000	$60,000		2,065,500	$792,349		
2033	25		$50,000	$60,000	$110,000		2,065,500	$792,349		
2034	26			$60,000	$60,000		2,065,500	$792,349		
2035	27			$60,000	$60,000		2,065,500	$792,349		
2036	28			$60,000	$60,000		2,065,500	$792,349		
2037	29			$60,000	$60,000		2,065,500	$792,349		
2038	30		$50,000	$60,000	$110,000		2,065,500	$792,349		
2039	31			$60,000	$60,000		2,065,500	$792,349		
2040	32			$60,000	$60,000		2,065,500	$792,349		
2041	33			$60,000	$60,000		2,065,500	$792,349		
2042	34			$60,000	$60,000		2,065,500	$792,349		
2043	35		$50,000	$60,000	$110,000		2,065,500	$792,349		
2044	36			$60,000	$60,000		2,065,500	$792,349		
2045	37			$60,000	$60,000		2,065,500	$792,349		
2046	38			$60,000	$60,000		2,065,500	$792,349		
2047	39			$60,000	$60,000		2,065,500	$792,349		
2048	40		$50,000	$60,000	$110,000		2,065,500	$792,349		
2049	41			$60,000	$60,000		2,065,500	$792,349		
2050	42			$60,000	$60,000		2,065,500	$792,349		
2051	43			$60,000	$60,000		2,065,500	$792,349		
2052	44			$60,000	$60,000		2,065,500	$792,349		
2053	45		$50,000	$60,000	$110,000		2,065,500	$792,349		
2054	46			$60,000	$60,000		2,065,500	$792,349		
2055	47			$60,000	$60,000		2,065,500	$792,349		
2056	48			$60,000	$60,000		2,065,500	$792,349		
2057	49			$60,000	$60,000		2,065,500	$792,349		
2058	50		$50,000	$60,000	$110,000		2,065,500	$792,349		

Appendix J: Rate Impact Analysis of Indian Creek Hydro

All values are in 2008$

Hydro Power		Rate Impact Assumptions		Avoided Costs	
500	Capacity (kW)	80%	Pct Grant Funded	$4.36	/gallon long run diesel price
0.5	Annual Capacity Factor	30	Amortization (yrs)	0.0833	Diesel Efficiency (gallons/kWh)
0.94	Annual Availability	7%	Real Interest	$0.36	$/kWh avoided fuel
2,065,500	Estimated annual production (kWh)	$0.18	Non-Fuel Costs	$0.02	$/kWh avoided diesel O&M
$1,500	/kW Development Costs				
$15,000	/kW EPC Contract Cost			5.0%	Real Discount Rate
$120	/kW Annual O&M				
$50,000	5 year maintenance cycle				

1.05

		COSTS						BENEFITS - AVOIDED DIESEL	Existing Diesel Rates	New Hydro Rates	Rate Savings
Date	Year	Development	EPC Contract	O&M Cost	Total Cost	Revenue Requirement	Avoided kWhs	Annual Avoided Cost	$/kWh	$/kWh	$/kWh
2008	0	$300,000			$300,000				$0.56		
2009	1	$450,000			$450,000				$0.56		
2010	2		$2,500,000		$2,500,000				$0.56		
2011	3		$2,500,000		$2,500,000				$0.56		
2012	4		$2,500,000		$2,500,000				$0.56		
2013	5			$60,000	$60,000	$204,301	1,000,000	$383,611	$0.56	$0.38	$0.18
2014	6			$60,000	$60,000	$204,301	1,050,000	$402,792	$0.56	$0.37	$0.19
2015	7			$60,000	$60,000	$204,301	1,102,500	$422,931	$0.56	$0.37	$0.20
2016	8			$60,000	$60,000	$204,301	1,157,625	$444,078	$0.56	$0.36	$0.21
2017	9			$60,000	$60,000	$204,301	1,215,506	$466,282	$0.56	$0.35	$0.22
2018	10		$50,000	$60,000	$110,000	$204,301	1,276,282	$489,596	$0.56	$0.34	$0.22
2019	11			$60,000	$60,000	$204,301	1,340,096	$514,076	$0.56	$0.33	$0.23
2020	12			$60,000	$60,000	$204,301	1,407,100	$539,779	$0.56	$0.33	$0.24
2021	13			$60,000	$60,000	$204,301	1,477,455	$566,768	$0.56	$0.32	$0.25
2022	14			$60,000	$60,000	$204,301	1,551,328	$595,107	$0.56	$0.31	$0.25
2023	15		$50,000	$60,000	$110,000	$204,301	1,628,895	$624,862	$0.56	$0.31	$0.26
2024	16			$60,000	$60,000	$204,301	1,710,339	$656,105	$0.56	$0.30	$0.26
2025	17			$60,000	$60,000	$204,301	1,795,856	$688,910	$0.56	$0.29	$0.27
2026	18			$60,000	$60,000	$204,301	1,885,649	$723,356	$0.56	$0.29	$0.28
2027	19			$60,000	$60,000	$204,301	1,979,932	$759,524	$0.56	$0.28	$0.28
2028	20		$50,000	$60,000	$110,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2029	21			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2030	22			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2031	23			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2032	24			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2033	25		$50,000	$60,000	$110,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2034	26			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2035	27			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2036	28			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2037	29			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2038	30		$50,000	$60,000	$110,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2039	31			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2040	32			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2041	33			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2042	34			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2043	35		$50,000	$60,000	$110,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2044	36			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2045	37			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2046	38			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2047	39			$60,000	$60,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2048	40		$50,000	$60,000	$110,000	$204,301	2,065,500	$792,349	$0.56	$0.28	$0.28
2049	41			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2050	42			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2051	43			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2052	44			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2053	45		$50,000	$60,000	$110,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2054	46			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2055	47			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2056	48			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2057	49			$60,000	$60,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38
2058	50		$50,000	$60,000	$110,000	$0	2,065,500	$792,349	$0.56	$0.18	$0.38

Appendix K: Wood Boilers for Electricity and Heat

WOOD-FIRED POWER PLANT

Crimp Biomass Cost Model; described in "Renewable Power in Rural Alaska" (Arctic Energy Summit, 2007)
Adopted for use in screening study to ascertain first order economic value of wood power options in L&P Lakes Region

										Fuel	
	Regional Cost X	20		20		$200				$250	per cord
	1.2	(A/P, 5%, years)	35%	(A/F, 5%, years)		$70,000				4,400	kWh/cord
Power Plant Size (kW)	Total Project Cost ($/kW)	Levelized Capital $Cost_{TPC}$ ($/kW-yr)	Major Rehabilitation Cost ($/kW)	Levelized Capital $Cost_{rehab}$ ($/kW-yr)	Total Capital Levelized Cost ($/kW-yr)	Fixed O&M ($/kW-yr)	Total Levelized Cost (Capital + O&M) ($/kW-yr)	Net Average Annual Capacity Factor	Net Annual Production (kWh-yr/kW)	Fuel Cost ($/kWh)	Levelized Cost of Electricity ($/kWh)
50	$28,004	$2,247	$9,801	$296	$2,544	$1,600	$4,144	80%	7,013	$0.057	$0.65
60	$24,002	$1,926	$8,401	$254	$2,180	$1,367	$3,547	80%	7,013	$0.057	$0.56
70	$21,143	$1,697	$7,400	$224	$1,920	$1,200	$3,120	80%	7,013	$0.057	$0.50
80	$18,998	$1,524	$6,649	$201	$1,726	$1,075	$2,801	80%	7,013	$0.057	$0.46
90	$17,329	$1,391	$6,065	$183	$1,574	$978	$2,552	80%	7,013	$0.057	$0.42
100	$15,994	$1,283	$5,598	$169	$1,453	$900	$2,353	80%	7,013	$0.057	**$0.39**

Appendix L: Igiugig In-Stream Hydro

In-Stream Vertical Axis Turbine Recon Analysis											
								$4.26	FY08		
						100%		$7.00	Projected		
Month	kWh_g req'd	Water Velocity (ft/s)	Water Velocity (m/s)	Encurrent 25kW kWh/mo	Diesel kWh req'd	gallons / kWh_g	Gallons of Fuel Req'd	Projected Price per Gallon	Fuel Cost	Baseline Fuel Cost	Fuel Savings ($)
July-07	16634	5.0	1.52	2,269	14,365	0.0956	1,373	$7.00	$9,612	$11,130	$1,518
August-07	16111	5.5	1.68	3,040	13,071	0.1004	1,312	$7.00	$9,183	$11,319	$2,136
September-07	17794	5.8	1.77	3,573	14,221	0.0926	1,316	$7.00	$9,214	$11,529	$2,315
October-07	17451	5.7	1.74	3,390	14,061	0.0944	1,327	$7.00	$9,290	$11,529	$2,239
November-07	18321	5.2	1.58	2,560	15,761	0.0900	1,418	$7.00	$9,924	$11,536	$1,612
December-07	20047	4.8	1.46	1,999	18,048	0.0906	1,635	$7.00	$11,444	$12,712	$1,268
January-08	23979	4.5	1.37	1,633	22,346	0.0841	1,880	$7.00	$13,157	$14,119	$962
February-08	24000	4.0	1.22	1,121	22,879	0.0770	1,761	$7.00	$12,325	$12,929	$604
March-08	21518	3.8	1.16	948	20,570	0.0883	1,817	$7.00	$12,721	$13,307	$586
April-08	19294	3.5	1.07	720	18,574	0.0898	1,667	$7.00	$11,672	$12,124	$452
May-08	17628	3.5	1.07	720	16,908	0.0964	1,631	$7.00	$11,414	$11,900	$486
June-08	15391	4.2	1.28	1,312	14,079	0.0960	1,352	$7.00	$9,464	$10,346	$882
TOTALS	228,168			23,284	204,884		18,489	$7.00	$129,420	$144,480	$15,060

In Stream Vertical Axis Turbine Recon System Economics																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Benefit - Fuel Savings ($/year)		$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060	$15,060
In Stream Turbine	($110,000)															
Balance of Plant	($40,000)															
Investment	($150,000)															
O&M		($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)	($4,800)
Net Cash Flow	($150,000)	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260	$10,260
NPV (5%)	($43,507)															
Benefit/Cost	**0.78**															

Appendix M: Heating Fuel Comparisons, Alaska, Fall 2008

Fuel	price	per unit	gross heat (BTU)	heater efficiency	$/1,000,000 BTU's of useful heat	useful BTUs per $1.00
Natural gas (Southcentral)	$8.40	/ mcf	1,010,000	85%	**$9.78**	102,202
Coal (Fairbanks, North Pole)	$120.00	/ ton	15,200,000	75%	**$10.53**	95,000
Wood, birch (local)	$200.00	/ cord	18,200,000	75%	**$14.65**	68,250
Wood, spruce (local)	$200.00	/ cord	15,000,000	75%	**$17.78**	56,250
Fuel Oil (Equivalent to $200/cord wood)	$2.04	/ gal	135,000	85%	**$17.78**	56,250
Natural gas (Fairbanks)	$23.35	/ mcf	1,010,000	85%	**$27.20**	36,767
Electricity (MLP, Sitka, Ketchikan, Juneau)	$0.10	/ kWh	3,413	100%	**$29.30**	34,130
Wood, birch (imported)	$400.00	/ cord	18,200,000	75%	**$29.30**	34,125
Wood, spruce (imported)	$400.00	/ cord	15,000,000	75%	**$35.56**	28,125
Fuel Oil (Equivalent to $400/cord wood)	$4.08	/ gal	135,000	85%	**$35.56**	28,125
Fuel oil (winter grade - Interior)	$4.50	/ gal	135,000	85%	**$39.22**	25,500
Fuel Oil (winter grade - L&P/BB)	$5.00	/ gal	135,000	85%	**$43.57**	22,950
Propane (Fairbanks)	$4.00	/ gal	91,333	85%	**$51.52**	19,408
Propane (Anchorage)	$4.00	/ gal	91,333	85%	**$51.52**	19,408
Fuel Oil (L&P/Pt. Alsworth)	$7.00	/ gal	135,000	85%	**$61.00**	16,393
Electricity (GVEA)	$0.23	/ kWh	3,413	100%	**$67.39**	14,839

Appendix N: Long Run Incremental Cost Analysis – Includes Capital Replacement Costs

	Long Run Outlook: Utility Diesel Fuel	Long Run Outlook: Heating Oil	Heating Oil	Wood Delivered	Heating Oil - Central Furnace/Boiler	Direct Vent Heating Unit (Toyo, Monitor)	Existing Wood Stove	New Wood **Stove** ($/MMBtu)	New Wood **Boiler** ($/MMBtu)	Passive Solar Water/Space Heating	Building Envelope: Weatherization & Insulation	Difference
	($/gallon)	($/gallon)	($/MMBtu)	($/MMBtu)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	
Chignik	$4.52	$5.72	$42.37	$25.33	$43,316	$532	$0	$0	$48,940	$0	$0	
Chignik Lagoon	$4.72	$5.92	$43.85	$25.33	$44,797	$532	$0	$0	$48,940	$0	$0	
Chignik Bay	$4.57	$5.77	$42.74	$25.33	$43,686	$532	$0	$0	$48,940	$0	$0	
Ivanof Bay	$6.00	$7.20	$53.33	$26.67	$54,278	$532	$0	$0	$50,073	$0	$0	
Perryville	$5.00	$6.20	$45.93	$26.67	$46,871	$532	$0	$0	$50,073	$0	$0	
Port Heiden	$5.50	$6.70	$49.63	$26.67	$50,575	$532	$0	$0	$50,073	$0	$0	
Pilot Point	$6.00	$7.20	$53.33	$26.67	$54,278	$532	$0	$0	$50,073	$0	$0	
Ugashik	$6.00	$7.20	$53.33	$26.67	$54,278	$532	$0	$0	$50,073	$0	$0	
Egegik	$5.17	$6.37	$47.19	$26.67	$48,130	$532	$0	$0	$50,073	$0	$0	
Naknek/South Naknek	$4.50	$5.70	$42.22	$25.33	$43,167	$532	$0	$0	$48,940	$0	$0	
King Salmon	$4.50	$5.70	$42.22	$25.33	$43,167	$532	$0	$0	$48,940	$0	$0	
Dillingham	$4.41	$5.60	$41.48	$25.33	$42,427	$532	$0	$0	$48,940	$0	$0	
Aleknagik	$4.41	$5.85	$43.33	$25.33	$44,278	$532	$0	$0	$48,940	$0	$0	
Manokotak	$4.61	$5.95	$44.07	$25.33	$45,019	$532	$0	$0	$48,940	$0	$0	
Togiak	$4.70	$6.00	$44.44	$25.33	$45,390	$532	$0	$0	$48,940	$0	$0	
Ekwok	$5.70	$6.90	$51.11	$25.33	$52,056	$532	$0	$0	$48,940	$0	$0	
New Stuyahok	$5.45	$6.65	$49.26	$25.33	$50,204	$532	$0	$0	$48,940	$0	$0	
Koliganek	$5.80	$7.00	$51.85	$25.33	$52,797	$532	$0	$0	$48,940	$0	$0	
Levelock	$6.40	$7.60	$56.30	$23.33	$57,241	$532	$0	$0	$47,240	$0	$0	
Igiugig	$7.00	$8.20	$60.74	$23.33	$61,686	$532	$0	$0	$47,240	$0	$0	
Kokhanok	$7.00	$8.20	$60.74	$16.67	$61,686	$532	$0	$0	$41,573	$0	$0	$20,113
Pedro Bay	$6.40	$7.60	$56.30	$16.67	$57,241	$532	$0	$0	$41,573	$0	$0	$15,668
Iliamna	$5.80	$7.00	$51.85	$16.67	$52,797	$532	$0	$0	$41,573	$0	$0	$11,224
Newhalen	$5.80	$7.00	$51.85	$16.67	$52,797	$532	$0	$0	$41,573	$0	$0	$11,224
Nondalton	$5.80	$7.00	$51.85	$16.67	$52,797	$532	$0	$0	$41,573	$0	$0	$11,224
Port Alsworth	$5.75	$6.95	$51.48	$16.67	$52,427	$532	$0	$0	$41,573	$0	$0	

Appendix O: Long Run Levalized Cost Comparison – Fuel Oil Versus Wood Heat (Household Scale)

Description	Capital Cost ($)	Life (years)	Levelized Capital ($/year)	Rehab / Replace @ end of useful life	Levelized Capital ($/year)	Annual O&M ($/year)	TOTAL CAPITAL + O&M ($/year)	FUEL ($/gallon)	FUEL ($/cord)	FUEL ($/year)	Total Capital + O&M + Fuel ($/year)	Incremental - Benefit / Cost Ratio
Central Fuel Oil Furnace, Boiler	$0	15	$0	$5,000	$232	$200	$432	$5.00		$4,500	$4,932	
High Efficiency Direct Vent Fuel Oil Heater, e.g., Toyo, Monitor Stove	$2,000	15	$193	$0	$0	$50	$243	$5.00		$3,690	$3,933	**4.3**
High Efficiency Low Emissions Wood Stove	$6,000	15	$578	$0	$0	$250	$828		$250	$2,000	**$2,828**	**2.9**
High Efficiency Low Emissions Wood Boiler	$15,000	15	$1,445	$0	$0	$350	$1,795		$250	$2,000	$3,795	0.5
<u>Where a wood stove cannot be installed within the household</u>												
High Efficiency Direct Vent Fuel Oil Heater, e.g., Toyo, Monitor Stove	$2,000	15	$193	$0	$0	$50	$243	$5.00		$3,690	$3,933	
High Efficiency Low Emissions Wood Boiler	$15,000	15	$1,445	$0	$0	$350	$1,795		$250	$2,000	**$3,795**	**1.1**

Appendix P: Wood Boiler Specifications

Boiler Specifications – Summer 2008			
BTU/Hour	350,000	425,000	950,000
MSRP (Price)	$12,500	$15,000	$32,900
Wt (lbs)	3,550	3,980	7,500
Air Freight to Lakes	$2,840	$3,184	$6,000
Barge-Road-Barge Freight	$1,420	$1,592	$3,000
Landed Cost of Boiler			
Low	$13,920	$16,592	$35,900
High	$15,340	$18,184	$38,900

Appendix Q: Industry Case Study

The predominant Lake and Peninsula Borough private business opportunities are outfitter guiding/tourism and commercial fishing. Both of these sectors bring jobs and income to Borough residents and revenue to the Borough to help support schools and public services. Income from these activities also helps support the costs of subsistence activities critical to the lives of Borough residents.

The costs of visiting Southwest Alaska, including the Bristol Bay region and Lake and Peninsula Borough are high compared to visiting other more accessible regions of Alaska. As a result, less than 10 percent of visitors to Alaska travel to the region. However, a large number of Alaska owned small businesses are based and operate in the region making it important both to regional income and employment, and to the Alaska tourism sector.

To help understand the impact of higher fuel costs on businesses we conducted a case study of a handful of guiding businesses in the Lake and Peninsula Borough. We generally found that the largest increases in fuel prices occurred after most companies had posted their summer 2008 prices and advertising and had negotiated contracts with air carriers. As a result, most were forced to absorb approximately 30 percent increases in operating costs due to rising fuel costs. Most remote lodges and guides were not able to add fuel surcharges to their prices. Air carriers who did add fuel surcharges reported that the added charges generally were not sufficient to cover total cost increases.

In addition to the 2008 operating challenges, all operators also stressed that fuel price increases were undermining Alaska's ability to compete as a destination. If the cost of flying to Alaska erodes the state's ability to attract visitors, then Southwest Alaska and the Lake and Peninsula Borough area have little chance of competing since they host such a small portion of Alaska visitors. Most operators noted that 2008 will be a watershed year for Alaska tourism in general and small remote operators in particular, with a high likelihood of many going out of business.

There is relatively little the Borough can do to change these economic fundamentals. However, to the extent to which energy costs can be lowered, this will help all businesses in the Borough. The potential for cooperative purchases of aviation fuel, regional purchasing of aviation fuel transported across the Pile Bay Road, and support of tourism marketing efforts at the local, state and national levels are all actions that would support these businesses. For example, Kenai Fjords National Park provides web links to all the businesses permitted to operate in the park. If Lake Clark and Katmai National Parks and Preserves and the Alagnak Wild River hosted similar links it would provide considerable market exposure for these businesses.

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