Intertie Options for Selected AVEC Villages

Prepared by consultants and staff of
Alaska Village Electric Cooperative
August 2014

45 Years: 1968-2013
AVEC
ALASKA VILLAGE ELECTRIC COOPERATIVE

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Credits

This report was prepared through efforts of consultants and staff of Alaska Village Electric Cooperative (AVEC). Principal contributors are:

Brent Petrie, former Manager of Project Development and Key Accounts, AVEC
Alden Worachek, Senior Accountant, AVEC
Douglas Vaught, P.E., V3 Energy, LLC
Chet Frost, Former Key Accounts Project Manager, AVEC
Michael Hubbard, Financial Engineering Company
Sean Robbins, Hawk Consultants
Matt Metcalf, Hawk Consultants
Amy Murphy, Public Relations Officer, AVEC

Energy and fuel statistics, and information gathered from geotechnical investigations, aerial surveys, and wind resource studies relevant to the identified villages were used for these analyses.

Prologue

Feasibility, development, and conceptual design of Alaska's rural power systems and bulk fuel upgrades have mostly been done on a village-by-village basis. In many cases villages are so far apart distance-wise that economies of scale for consolidation are lacking. However, villages that are close together may now warrant a revised approach.

With rising costs for fuel and escalating material prices for fuel tanks, generators, and buildings, there is increasing merit to considering consolidation of power generation and interconnection of selected villages. In addition, some sites in one village may have access, geotechnical, space, or ownership challenges that deter a project and are not present in an adjacent village. AVEC has experienced increased efficiency, improved feasibility of renewable generation such as wind, improved availability of recovered heat, a reduction in the number of fuel deliveries and a reduction in the number of engine running hours and associated expenses for lubricants and engine overhauls when it has connected two villages previously served by separate power plants.

Several intertie prospects have evolved after conventional single village CDRs have been completed. The supplemental work required in selecting and permitting the route of the line and prime and standby generation and fuel storage sites required additional time and resources to develop. Amendments to the original CDRs were required in order to describe and estimate the revised project. Intertie projects currently constructed or under development based on this process are Toksook-Nightmute, Brevig Mission-Teller and Stebbins-St. Michael.

In 2007 AVEC was awarded funding by the Denali Commission to integrate consideration of intertie options into project planning through an enhanced CDR process that would cover several prospect villages. Through this process the potential routing of interties, land ownership, siting of consolidated generation and fuel facilities and siting of standby generation could be considered early on in the project development process. Geotechnical, environmental, permitting issues could be addressed early on and assessed for their impact on schedule and cost and overall feasibility. Prospective intertie and generation consolidation candidates to be addressed with this funding include: Emmonak-Alakanuk, Pilot Station-St. Mary's, St. Mary's-Mt. Village, Togiak-Twin Hills, and New Stuyahok-Ekwok. Additional analyses in this report include Red Dog Port to Kivalina, Ambler to Shungnak-Kobuk, and Selawik-Kiana-Noorvik.

This report is a summary of work efforts and information on several prospective interties. A Microsoft Excel spreadsheet was adapted to evaluate the costs and benefits of electrical interties and associated facilities over varied economic lives of project features. The process can be used as a screening tool to determine which interties might be worthy of more detailed design and feasibility investigation or which might warrant deferral until certain capital or operating costs change. This report contains data, narratives and spreadsheet analyses based on projections and conditions as of December 2012 unless otherwise noted.

This analysis proposes, based on benefit-to-cost ratio and other considerations, that the following projects are worthy of further consideration in the near term, with calculated benefit-to-cost ratios presented in the table following:

- Emmonak-Alakanuk (constructed in 2011)
- Saint Mary's-Mountain Village
- New Stuyahok-Ekwok
- Stebbins-Saint Michael
- Brevig Mission-Teller (constructed in 2011; presently not operational)
- Saint Mary's-Pilot Station-Mountain Village
- Noorvik -Selawik-Kiana
- Ambler-Shungnak/Kobuk

Projects that can be deferred are:

- Togiak-Twin Hills
- Port of Red Dog-Kivalina

Project Benefit-to-cost ratios

Project	Benefit-to-Cost Ratio
Emmonak-Alakanuk	1.07
Saint Mary's-Pilot Station	1.14
Saint Mary's-Mountain Village	1.04
Togiak-Twin Hills	0.99
New Stuyahok-Ekwok	0.95
Stebbins-Saint Michael	1.07
Brevig Mission-Teller	1.32
Saint Mary's-Mountain Village-Pilot Station	1.10
Port of Red Dog-Kivalina	0.88
Noorvik-Selawik-Kiana	1.09
Ambler-Shungnak/Kobuk	1.01

Introduction

The Alaska Village Electric Cooperative (AVEC) is a member-owned cooperative with 2011 sales of approximately 71.6 million kilowatt-hours/year (kWh/yr) to over 7,909 metered customers. In many ways AVEC is unique in that this customer base is spread over fifty-four villages that are, with the exception of nine communities, electrically isolated from each another. Operating and maintaining generation for electrically isolated villages is very expensive with high costs for capital equipment such as generators, structures, bulk fuel storage, wind turbines, distribution lines, etc. Other direct costs include powerplant operator and Anchorage-based personnel costs, maintenance activities performed by Anchorage-based crews and out-of-state technicians, and training and other activities.

AVEC's generation costs, including depreciation and allocated interest expenses, totaled almost $3,831/member during fiscal year 2011, or 80 percent of the total cost of electric service. Of this, fuel alone accounted for approximately 66 percent of the total. Clearly, operating and maintaining diesel generation for the AVEC system is expensive. Total cost of power ($7,990,183) and operations and maintenance ($2,199,924) expense in 2011 was $10,190,107. Averaged across 48 prime-power operating plants results in an average expense of $212,300 per prime plant. AVEC estimates that $140,000 per plant site per year could be saved on average if a prime power plant and tank farm could be retired and the remaining storage and standby facilities reduced in size.

Environmental conditions can also increase generation costs or cause environmental damage. AVEC villages, like most in Alaska, are typically located on coastline or rivers to facilitate traditional transportation. As such, a number of generating plants and fuel storage are susceptible to flooding and ice damage which can require repairs costing tens of thousands of dollars. Villages along the lower Yukon River in particular have been susceptible to recurring flood and ice damage for many years, and risks appear to be increasing as shorelines erode toward village facilities.

Yukon River Flooding

Ice jams on the Yukon River are a natural hazard.

Backed up water floods low-lying villages.

Moving ice damages facilities.

Flood waters restrict access to power facilities.

Recognizing AVEC's electrical generation cost structure and environmental risks, AVEC has worked to take advantage of new or enhanced generating technologies. Diesel generators have been replaced with new equipment that is not only more fuel efficient but have flatter efficiency curves to allow for more efficient operation throughout the power band. Automated switchgear has been installed in a number of locations to optimize fuel efficiency by running the most efficient diesel generator(s) for a given load.

These are, however, short-term solutions to a long-term problem. Long-term solutions, such as renewable energy systems and relocating generating and fuel storage facilities out of flood plains, are capital intensive. Because AVEC's villages are electrically isolated, relatively few customers share in the benefits of individual upgrades. For the entire customer base to enjoy the benefits, renewable energy and power facility relocation upgrades must be accomplished in each village, a task that is not financially feasible.

A primary way to achieve better economies of scale with renewable energy and other capital infrastructure is to interconnect two or more load centers into a combined system. Interconnections have been implemented on a small scale in the past with the focus being better economies with diesel generation and a reduction in power plant buildings that must be maintained. With recent technological advances in diesel/wind systems, wind turbines and, potentially, hydroelectric plants can play expanded roles in AVEC's generation mix if the installed costs can be kept at reasonable levels. Interconnections are the key in achieving the economies of scale required for renewable energy installations.

The AVEC Board has also recognized the need for long term solutions and since 2005 has adopted successive strategic plans which include goals of:

- Reducing diesel fuel use by 25% by 2020
- Eliminating 24 power plants (50% of the 2011 total) by 2020
- Reducing non-fuel costs per kwh by 10%

Long-term solutions must, therefore, include interconnections between the villages to reduce the number of prime power plants. . These interconnections can be performed on a limited basis at first and then levered into larger systems with time. Several new candidates for interconnections have recently been identified by AVEC staff, and this paper provides a description and preliminary projection of benefits for each of these.

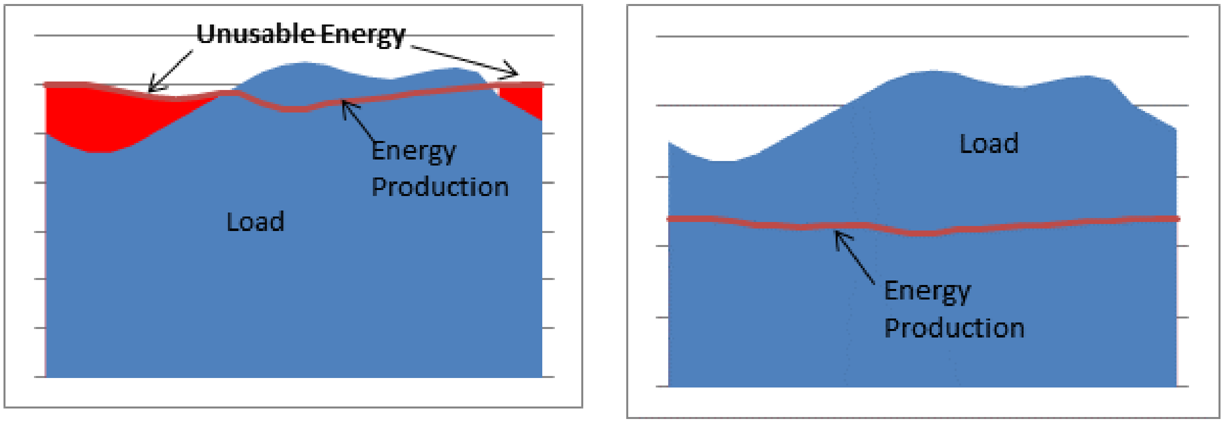
Economies of Scale

Interconnecting two or more villages will not eliminate the need for a powerhouse in each village, but only one – the primary – location will be managed for day-to-day operations. A stand-by/emergency generator module will be maintained at the other – the secondary – location(s). This stand-by generator would be used as an emergency back-up power supply if the intertie or prime power plant should fail. With this operational structure in place, interties offer the following economic benefits:

- Lower capital costs per installed kilowatt
- Lower operating costs with the reduction of the operating staff at the secondary location(s)
- Lower maintenance costs with the Anchorage-based crew traveling to fewer locations
- Increased fuel efficiency from larger loads during off-peak periods
- Increased economies of scale in bulk fuel storage costs
- Increased economies of scale for renewable energy through:
    - Larger installations at one location
    - Increased usability per installed kilowatt, especially during off-peak periods

The final benefit, increased usability of renewable energy, is important with resource economics. If generation is greater than load and cannot be stored for later use, economic benefits are quickly eroded. The graphs below provide a conceptual representation of how interties can increase usability of wind turbines. On the left, energy production is greater than load at certain periods and is lost or wasted without some means of storage. On the right, loads have been increased by interconnecting with another village, and the energy production is now fully usable.

Resource Usability of Wind Power



What do Rural Alaska Interties Look Like?

Villages can be electrically intertied by several methods. Most common, and shown in the photographs below, are conventional overhead power lines on wooden poles. The poles are direct set (or embedded) in the ground or attached to piles that are driven or twisted into the ground. Intertie voltages of 34.5 kV, 24.9 kV and 12.4 kV for three- phase systems are typical. The hardware and materials for such lines are readily available throughout North America.

Completed Interties

Completed intertie between Toksook Bay and Tununak.

With most interties, manual labor can be used to tension the lines.

Installation of pole, attached to an H-pile.

Emmonak-Alakanuk water crossing.

Methods and Assumptions

The spreadsheets ultimately developed for this project consist of two primary economic analyses: with and without construction of interties where benefit-to-cost ratio can be calculated. These are further divided by benefit-to-cost consideration of the intertied villages with and without inclusion of wind turbines. For each – with or without wind turbines – two discount rates are considered, zero percent and three percent. The result is benefit-to-cost ratios for each intertie defined by the following matrix.

Intertie 50-year economic benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost Ratio
Yes	0			
	3			
No	0			
	3			

Replacement

The interties are considered to be 50 year projects and the analysis spreadsheets are structured as such with respect to the net present value calculations. In general, capital costs for the intertie construction, powerplant and bulk fuel upgrades, and wind turbine installation are incurred in the initial years of the project. As time goes on, however, machinery and equipment wear out and items must be repaired or replaced. The analysis spreadsheets are designed to capture this by considering a replacement period and replacement percentage for each major capital cost category with the option of varying the period and/or percentage for the power systems intertied and not intertied. A typical consideration of replacement period and percentage is shown below.

Capital cost replacement period and percentages

	Without Intertie		With Intertie	
	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage
Diesel Generation	15	20%	15	20%

	Without Intertie		With Intertie	
	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage
Bulk Fuel Storage	30	25%	30	25%
Wind	20	50%	20	50%
Recovered Heat	20	100%	20	100%
Interties			30	10%

In general, diesel generators require a significant amount of maintenance and periodic overhaul throughout their service life with eventual replacement as they wear out and more efficient generators become available and/or more environmentally compliant generators are required. Newly constructed powerhouses, however, are designed as "platforms" for generators and associated switchgear and control systems and are expected to last many decades, perhaps even the full fifty year design life of the interties themselves. For these reasons, it is expected that 20 percent of the diesel generation power system, meaning principally the generators themselves and likely also associated switchgear, will be replaced every fifteen years, with or without the existence of an intertie.

The lifetime of new bulk fuel storage is longer, with an anticipated 30 year life before major replacement is required. Similarly to diesel generation powerplants, the bulk fuel facility will be considered as platforms, with replacement of tanks or associated pumping/piping systems required on long time cycles. The facility itself though is expected to remain intact throughout the 50 year life of the intertie project. If refurbishment of existing fuel tanks and diesel plants are substituted for new code-compliant construction, then the anticipated remaining economic life would be less.

Wind turbines are generally considered to have a 20 year operational life, beyond which they are replaced with new machines. Turbine foundations, however, assuming the new turbine is of similar height, weight, and thrust characteristics, is reusable, hence an assumption of 50 percent turbine replacement every 20 years.

Distribution lines require periodic maintenance as does any other infrastructure, but in general require little refurbishment or overhaul. For this project, it is assumed that the intertie will require an upgrade of 10 percent of construction value every 30 years.

Inflation

The intertie analysis assume an annual inflation rate of two percent applied to capital costs incurred in the future, which typically is treated as a less than 100 percent replacement cost. For instance, if wind turbines are constructed in year 1 with 50 percent replacement in year 20, the capital cost in year 20 is the original capital cost multiplied by 50 percent multiplied by the two percent inflation occurred annually for 20 years (or 1.02^{20}).

Cost escalation of fuel through the 50 year project timeline follows a modification of the two percent inflation rate. Initial, or start point, fuel prices are based on the University of Alaska Anchorage's Institute for Social and Economic Research (ISER) 2013 medium projection fuel price for each village plus the social cost of carbon as found in their *Alaska Fuel Price Projections 2012-2035,* July 2012, and accompanying spreadsheet. ISER's projected 2013 fuel prices is the start point and are escalated two percent per year for five years; 1.5 percent per year for the following five years, and one percent per year for the remaining 40 years of the projects.

Discount rate values of zero percent and three percent are applied to net present value calculations that summarize total energy generation costs, including initial and subsequent replacement capital costs, throughout the 50 year project life of the interties.

Inflation and discount rates for intertie analyses

Cost Escalation (inflation)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	0% and 3%

N-1 Criteria

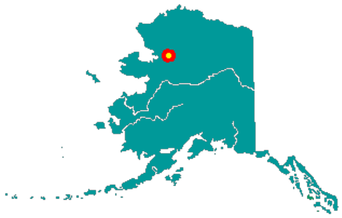
An isolated power generating grid should have sufficient capacity to meet the peak load with the largest unit out-of-service, known as N-1 criteria. In some situations it may be advisable to meet N-2 criteria where peak load can be met the two largest generating units out-of-service. Each intertie project is evaluated considering capability of the base or primary village diesel generators to meet N-1 criteria in meeting the combined peak load of both villages. This analysis is quite conservative in that annual peak loads of the two villages are added to yield a combined peak load, but in reality it is unlikely that both villages would experience their peak loads at exactly the same time. Still, the N-1 criteria analysis indicates readiness of the powerplant in the primary village to accept the electrical load of the secondary village.

AVEC Village Interties – Existing

AVEC has recognized for many years the advantages of connecting nearby village with electrical interties and completed the first project between Shungnak and Kobuk over thirty years ago. AVEC has five existing intertied systems that connect eleven villages:

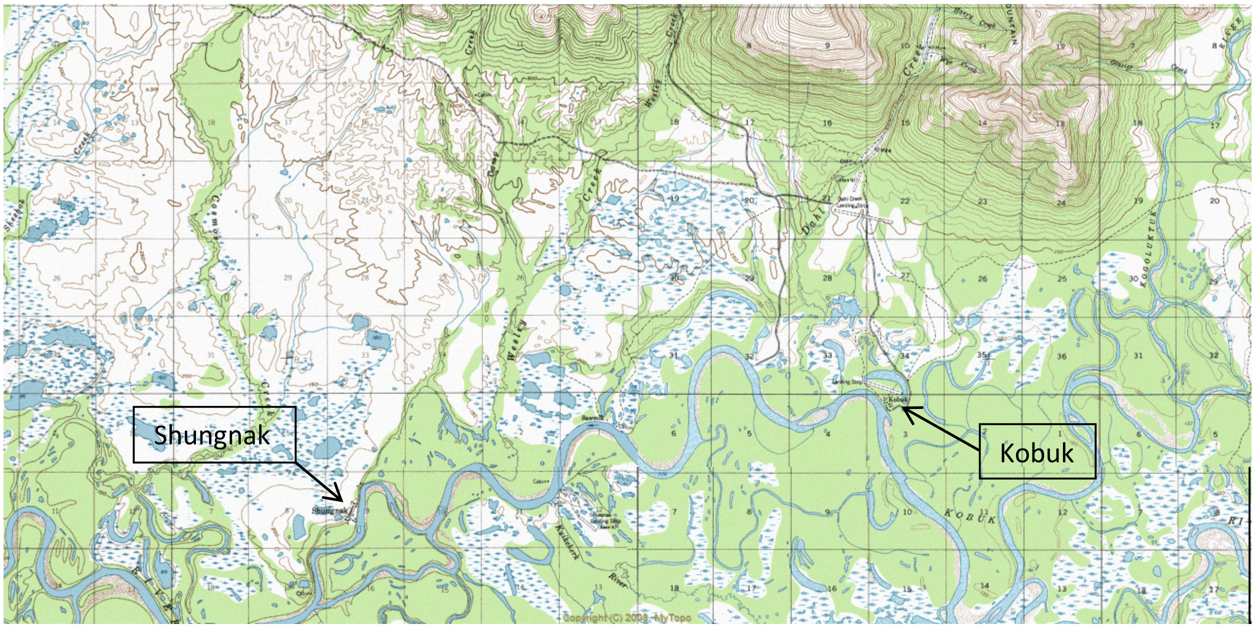
- Shungnak-Kobuk
- Kasigluk-Nunapitchuk
- Toksook Bay-Tununak-Nightmute
- Emmonak-Alakanuk
- Brevig Mission-Teller

Shungnak-Kobuk



Shungnak (pop. 261) is located on the west bank of the Kobuk River, about 150 miles east of Kotzebue in the Northwest Arctic Borough. The original settlement was ten miles further upstream near Kobuk. Kobuk (pop. 148) is located seven miles northeast of Shungnak and is the smallest village in the borough.

Topographic Map of Shungnak and Kobuk



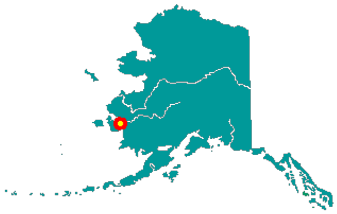
Intertie Route

An electrical intertie between the Shungnak and Kobuk was built by the State of Alaska Division of Energy and Power Development around 1980 as a demonstration project to prove the viability of single wire, earth return (SWER) to intertie isolated village power systems. The power distribution wire was suspended beneath an A-frame support made from locally-sourced timber poles. During winter 1991-

92, this SWER intertie was rebuilt by the Alaska Energy Authority as a conventional three-phase 12.4 kV system with treated wood poles supported by H-piles.

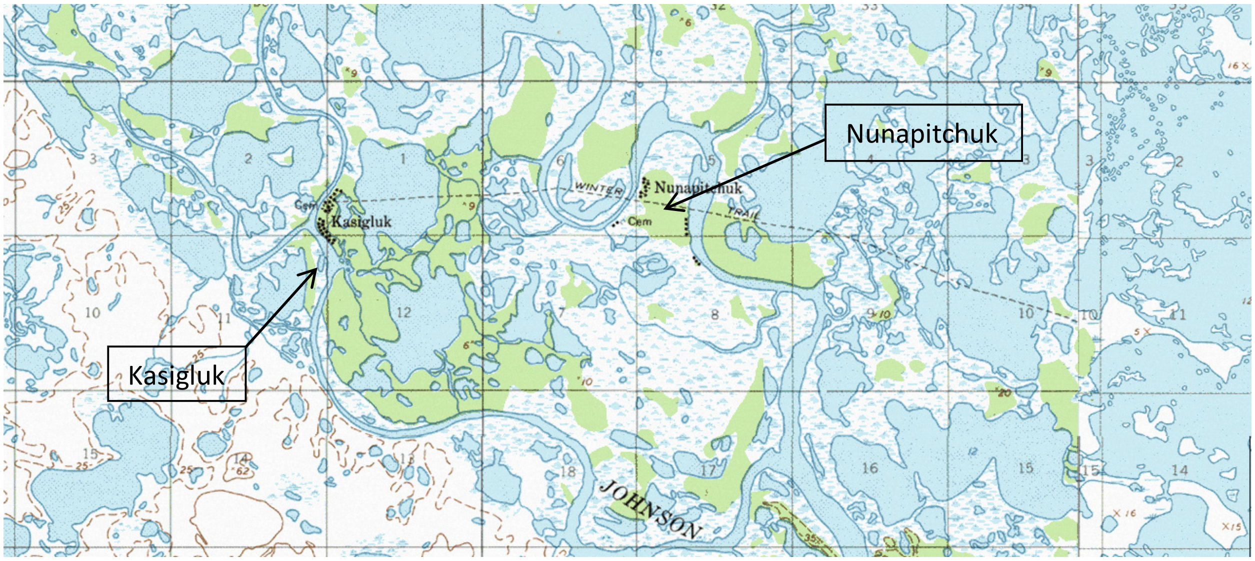
Shungnak-Kobuk Intertie Route

Kasigluk-Nunapitchuk (and Old Kasigluk)



Kasigluk (pop. 576) is located on the Johnson River in the Kuskokwim River Delta, about 26 miles northwest of Bethel in the Bethel Census Area. The community is comprised of New and Old Kasigluk, surrounded by the Johnson River and a network of lakes. Nunapitchuk (pop. 518) is located on both banks of the Johnson River two miles east of Kasigluk.

Topographic map of Kasigluk and Nunapitchuk



Intertie Route

Project scope of the new Kasiguk-Nunapitchuk intertie included construction of a new 4.2 mile long, three-phase primary power distribution from the new generation facility at Akula Heights in Kasigluk to the adjacent communities of Old Kasigluk and Nunapitchuk. The first intertie was a cable laid on the tundra between the communities in about 1968-69. That was replaced by an overhead line in 1980 using an experimental passively refrigerated pile similar to piles used for the Trans-Alaska Pipeline. These piles began failing due to corrosion at the ground line and wind and icing toppled many of the poles in a significant storm after twenty years of service with minimal maintenance.

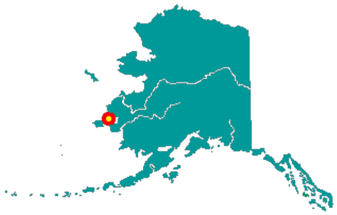
The new project consisted of replacement of the damaged older primary distribution line that had been in service for approximately 25 years and included new poles set on driven H-pile foundations, as well as new line hardware and conductors to provide greater stability and increase overall reliability. Initial planning for the intertie project started in 2002, concurrent with the upgraded generation and bulk fuel storage facilities serving these communities. Submittal of the final concept design report (CDR) was submitted in May 2004, with the project receiving initial funding for design in early 2005. The detailed design and accompanying base maps were submitted by NANA Engineering in October 2005, and construction was started at that time.

Suspended line sections of the project were completed in early 2005 and the final river crossings and trunk section of the line from the Nunapitchuk switch station to Old Kasigluk were completed in second quarter, 2006. With primary construction of the line complete, demobilization of most of the specialty construction equipment was finished in October 2006. AVEC line crews continued to complete the final detail construction of the line along spans connecting Old Kasigluk, including the installation of guy wires and tensioning of the conductors through the 2006-2007 winter construction season. Although portions of the project were energized in 2006, final construction was not 100% complete until May 2007.

This intertie replacement provided capability to supply all three village loads simultaneously with the generating capacity of a new power plant in Akula Heights (Kasigluk). The Akula Heights location offered an opportunity to upgrade power generation and bulk fuel storage at a location which offered sufficient space for code-compliant, pile-supported facilities, had good access to the nearby airport, and offered the possibility of supplying recovered heat to a community building and a planned new water plant.

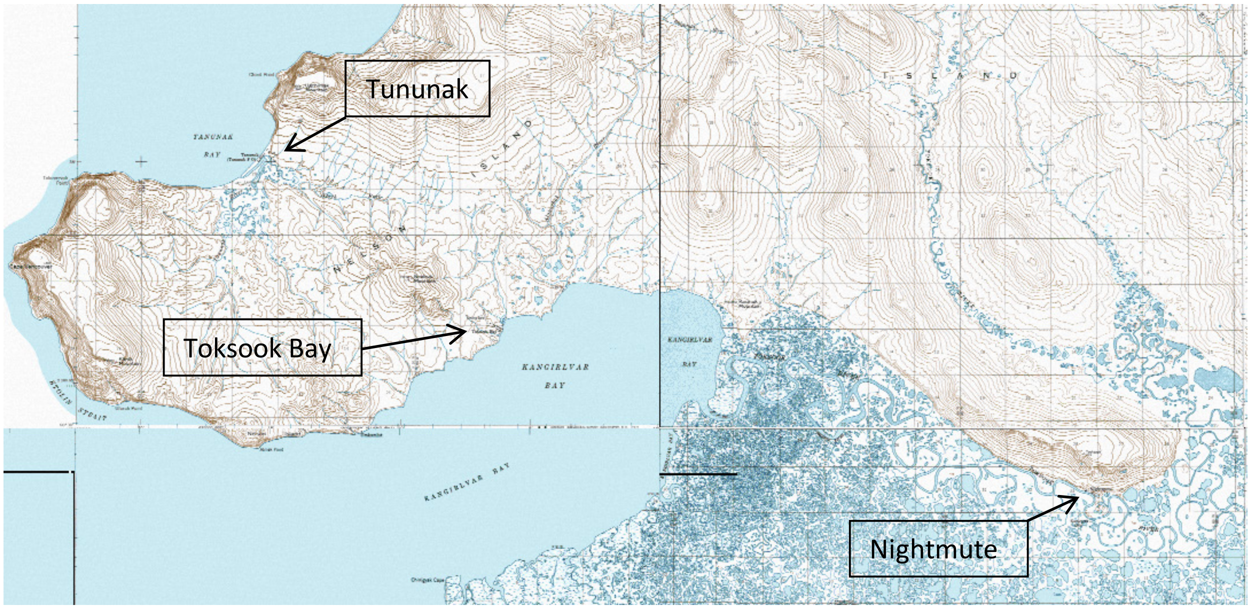
Note that the original plant in Nunapitchuk had a partially lined, on-grade tank farm that was on a foundation of deteriorating permafrost and could not be expanded because of nearby buildings. The original wood-framed power plant building was over 30 years old and in need of replacement. With a new code-compliant plant at Akula Heights, the former power plant site at Nunapitchuk was cleared and reconfigured to house a much smaller standby powerplant.

Toksook Bay-Tununak-Nightmute



Toksook Bay (pop. 598) is located on Nelson Island, about 115 miles northwest of Bethel in the Bethel Census Area. It is on Kangirlvar Bay, across from Nunivak Island. Tununak (pop. 342) and Nightmute (pop. 289) are the two other villages on Nelson Island. Tununak is located six miles northwest of Toksook Bay and Nightmute is located 14 straight-line miles east-southeast of Toksook Bay.

Topographic Map of Toksook Bay, Tununak, and Nightmute



Intertie Route

Project scope included construction of a new, 18.0 mile long, three-phase primary intertie from the new generation facility at Toksook Bay to the adjacent community of Nightmute. The project provides the capability to carry both community loads simultaneously with the generating capacity of the new power plant in Toksook Bay.

Project scope also included construction of a new, 6.6 mile long, three-phase primary intertie from the new generation facility at Toksook Bay to the adjacent community of Tununak. The project provides the capability to carry both community loads simultaneously with the generating capacity of the new power plant in Toksook Bay.

Wind Generation

Wind generation was examined for both Toksook and Nightmute. The wind site at Nightmute had an excellent wind resource but had suspected permafrost degradation. Additionally, the integration of wind ower with a small isolated diesel plant at Nightmute would have been challenging. With the intertie, a four turbine wind site just west of Toksook provides wind power to all three of the interconnected villages with just one set of integrating controls at the prime power plant. The Toksook site could also be expanded or repowered in the future and with the intertie will continue to serve all three villages.

Toksook Bay-Tununak-Nightmute Intertie Route

Emmonak-Alakanuk

Although the Emmonak-Alakanuk intertie has already been constructed in 2011, because it is one of the listed projects in the Denali Commission planning document, it is addressed in the following section, *AVEC Village Interties – Proposed*.

Brevig Mission-Teller

Although the Brevig Mission-Teller intertie has already been constructed in 2011, because it is a listed project in the Denali Commission planning document, it is addressed in the following section, *AVEC Village Interties – Proposed*.

AVEC Village Interties – Proposed

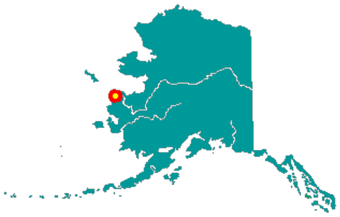
As originally proposed in the Denali Commission planning document, this project specified five possible village-to-village interties for enhanced conceptual design report analysis. They are:

- Emmonak-Alakanuk
- Saint Mary's-Pilot Station
- Saint Mary's-Mountain Village
- Togiak-Twin Hills
- New Stuyahok-Ekwok

Since project award, however, AVEC has determined that other potential village-to-village interties are possible or in the case of Brevig Mission and Teller, have been initiated. For Saint Mary's, combining the two original interties is possible to create a three-village intertie and is addressed separately in this report. The additional (or new combination) intertie possibilities addressed in this report are:

- Stebbins-Saint Michael
- Brevig Mission-Teller
- Saint Mary's-Pilot Station-Mountain Village
- Port of Red Dog-Kivalina
- Noorvik -Selawik-Kiana
- Ambler-Shungnak/Kobuk

Emmonak-Alakanuk

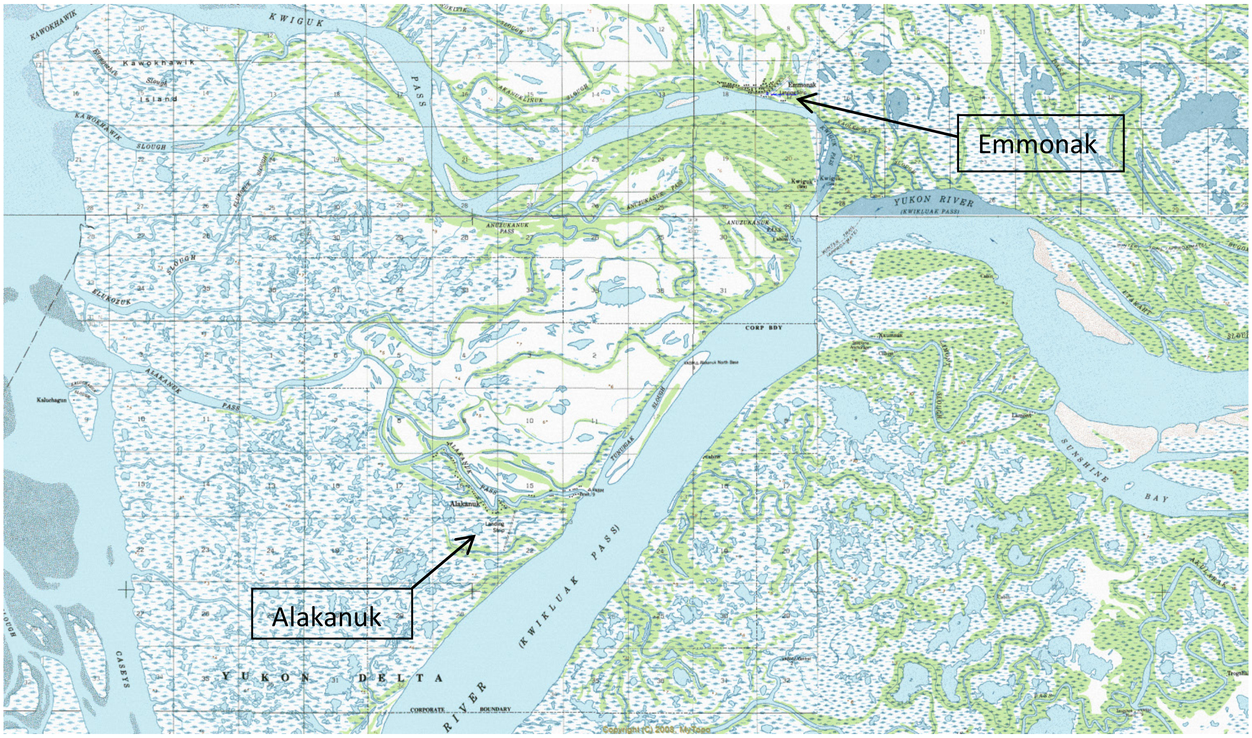


Emmonak (pop. 796) is located at the mouth of the Yukon River, 10 miles from the Bering Sea, on the north bank of Kwiguk Pass in the West Hampton Census Area. It lies 120 air miles northwest of Bethel and 490 air miles from Anchorage, in the Yukon Delta National Wildlife Refuge. Alakanuk (pop. 683) is located at the east entrance of Alakanuk Pass, the major southern channel of the Yukon River. Alakanuk is eight miles southwest of Emmonak, 15 miles from the Bering Sea, and within the Yukon Delta National Wildlife Refuge.

Emmonak and Alakanuk are about 9.5 miles apart on distributary channels (passes) of the Yukon River. Both villages have been subject to flooding and power plant and tank farm infrastructure at both locations have been affected by floods. Recent flood events in 2006 tipped over fuel tanks in Alakanuk. In 2009 flood waters in Emmonak were high enough that water entered the power plant. Flood waters receded just before the plant would have been forced to shut down.

Neither village has substantial gravel resources for construction. Gravel for major projects such as pads and roads is usually imported from other locations. Flood proofing and local geotechnical conditions warrant pile supported power plant and tank farm facilities. The costs of separate pile supported facilities in each village can be compared to a consolidated power plant and tank farm and intertie with a standby power plant at one location. AVEC has intertied Emmonak and Alakanuk and proposes to upgrade the Emmonak powerplant to serve as the primary operations center. The present Alakanuk powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Emmonak and Alakanuk



Electric Loads and Generation

The diesel generators in the Emmonak powerplant have sufficient capacity at present to power both Emmonak and Alakanuk if intertied, including with consideration of N-1 criteria where the largest generation unit is out-of-service. For Emmonak, loss of the largest generation unit, a 908 kW capacity Caterpillar 3512 diesel generator, would result in three remaining diesel generators to meet load demand: a 337 kW Caterpillar 3456, a 505 kW Caterpillar 3456 and a 557 kW Cummins K38G2. Combined capacity of these three diesel generators is 1,399 kW, which is sufficient to meet a possible combined village peak load demand of approximately 1,030 kW. This N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

Due to flooding risk and location problems, it is not fully certain, however, that Emmonak is the optimal location for the primary power operations center. Should AVEC decide to locate the primary operations center in Alakanuk, powerplant upgrade will be necessary to ensure sufficient generation capacity to meet a combined Emmonak and Alakanuk electrical load.

Emmonak and Alakanuk Generator and Load Data

	Emmonak		Alakanuk		Intertied (Emmonak as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	337		350		337	
2	505		499		505	
3	557		350		557	
4	908				908	
Total	2,307		1,199		2,307	
Avg Load (kW)	367		225		592	
Peak Load (kW)	607		424		1,031	
Firm Capacity (N-1)	1,399		700		1,399	

Renewable Energy Options

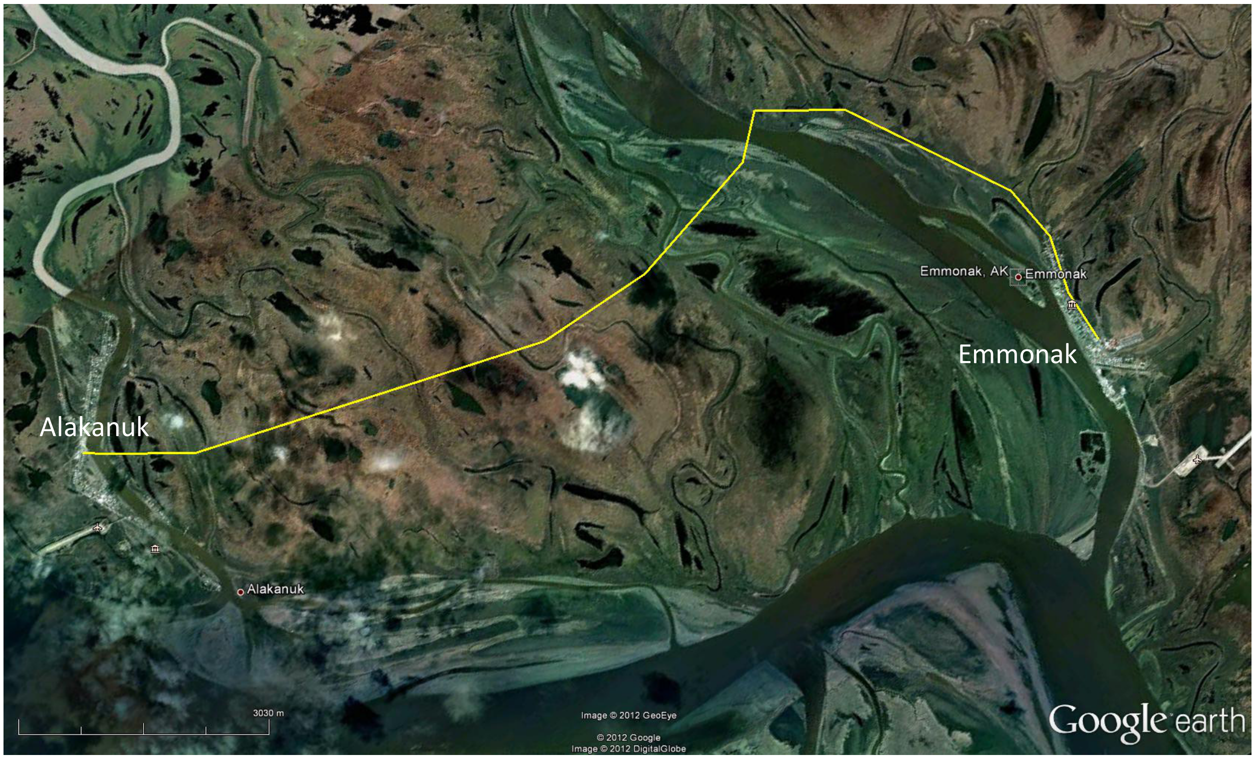
Practical renewable energy options for electricity generation in Emmonak and Alakanuk are limited to wind power, although potential exists for the development of hydrokinetic power in the Yukon River to serve village power needs. The wind resource in Emmonak was measured with a met tower from 2007 to 2009 at a site on the west side of the village as Class 2 to 3, which was somewhat less than expected for a near-coastal location. The wind resource in Alakanuk has not been measured, but proximity to Emmonak with similarly flat terrain indicates likely similar winds as measured in Emmonak.

With Alaska Energy Authority Renewable Energy Fund Round 2 funding, four Northwind 100 B model wind turbines were installed in 2011 on the west side of Emmonak. AVEC's preferred site was at a more central location in Emmonak near the power plant, but Federal Aviation Administration objections regarding instrument landing system missed approach routing at the Emmonak airport required moving the site to the west side of the village near the met tower site. The wind turbines are presently operational but in a limited mode due to incomplete development at present of the secondary load controller and electric boiler which, when operational, will enable excess electrical energy to serve village thermal loads. Upon resolution of the integration issues, AVEC proposed plans to expand Emmonak's installed wind capacity to 600 kW by adding two more Northwind 100 wind turbines.

Intertie Route

A 9.5 mile, three-phase, 12,470 volt electrical intertie between Emmonak and Alakanuk was constructed in 2011 by AVEC with grant funding from the Alaska Energy Authority Renewable Energy Fund. The intertie route was chosen to avoid Native land allotments, traverse drier terrain to the extent possible, and to cross Kwiguk Pass of the Yukon River at a relatively narrow point west of Emmonak, as shown in the Google Earth image below. The intertie project was constructed concurrently with the wind turbine project. The intertie was completed and available for operation in 2011.

Emmonak-Alakanuk Intertie Route



Assumptions and Special Issues

Although both Emmonak and Alakanuk are prone to severe flooding from the nearby Yukon River, given the larger size of Emmonak population, the larger power plant, the existing wind turbine farm, and the superior airport, AVEC intends that Emmonak would host the primary power plant and Alakanuk would be equipped with a standby generator and fuel storage for emergency mode operation in event of loss of the intertie or a similar emergency event.

Emmonak and Alakanuk Spring Floods, 2006 and 2009

AVEC powerplant and tank farm surrounded by flood water, Emmonak.

Water in the switchgear room, Emmonak.

Flooded gear and equipment, Alakanuk.

Fuel tanks floated off their foundations and toppled, Alakanuk.

Emmonak-Alakanuk Cost Summary Table

	Without Intertie		With Intertie	
	Emmonak	Alakanuk	Emmonak	Alakanuk
Energy (MWh/yr)	3,220	1,972	5,232	
Fuel Price ($/gal)	3.68	4.11	3.68	
Efficiency (kWh/gal)	13.53	12.44	13.80	
Non-fuel Expense ($/yr)	$767,671	$457,954	$1,085,625	
Powerplant Cap. Cost	$5,200,000	$4,800,000	$5,200,000	$1,000,000
Bulk Fuel Cap. Cost	$5,100,000	$3,600,000	$8,000,000	
Wind Farm Cap. Cost	$4,600,000	$2,040,000	$6,900,000	
Intertie Cap. Cost			$4,600,000	

The following table documents the assumptions of the Emmonak-Alakanuk intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix A.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Emmonak	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 300,000 gal of required storage capacity at $17.00/gallon for pile construction.
	Wind Farm	2012	Actual project cost of the four turbine Northwind 100 wind farm completed in 2011.
Alakanuk	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 200,000 gal of required storage capacity at $18.00/gallon for pile construction.
	Wind Farm	2014	Two Northwind 100 wind turbines at in Alakanuk (assumed equivalent wind regime as Emmonak) based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
With Intertie			
Emmonak	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission; scaled to accommodate increased load of both villages.
	Bulk Fuel Facility	2014	Based on 500,000 gal of required storage capacity at $16.00/gallon for pile construction.
	Wind Farm	2014	Actual project cost of the four turbine Northwind 100 wind farm completed in 2011 scaled to include two additional Northwind 100 turbines.
Alakanuk	Powerplant	2013	Based on standard cost for a standby power module constructed on piles, presently under construction.
Intertie		2013	Actual project cost for construction of the intertie connecting Alakanuk to Emmonak.

Economic Analysis

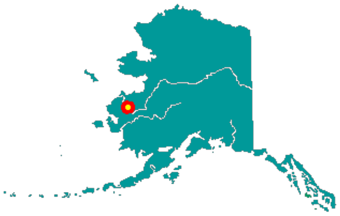
The economic benefit of a distribution intertie connecting Alakanuk to Emmonak is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbine configurations as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As presented in the Emmonak-Alakanuk 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Alakanuk and Emmonak. As expected, the economic benefit decreases with a non-zero discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

Emmonak-Alakanuk 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	240.3	221.2	1.09
	3	121.9	113.5	1.07
No	0	246.8	224.9	1.10
	3	123.1	113.4	1.09

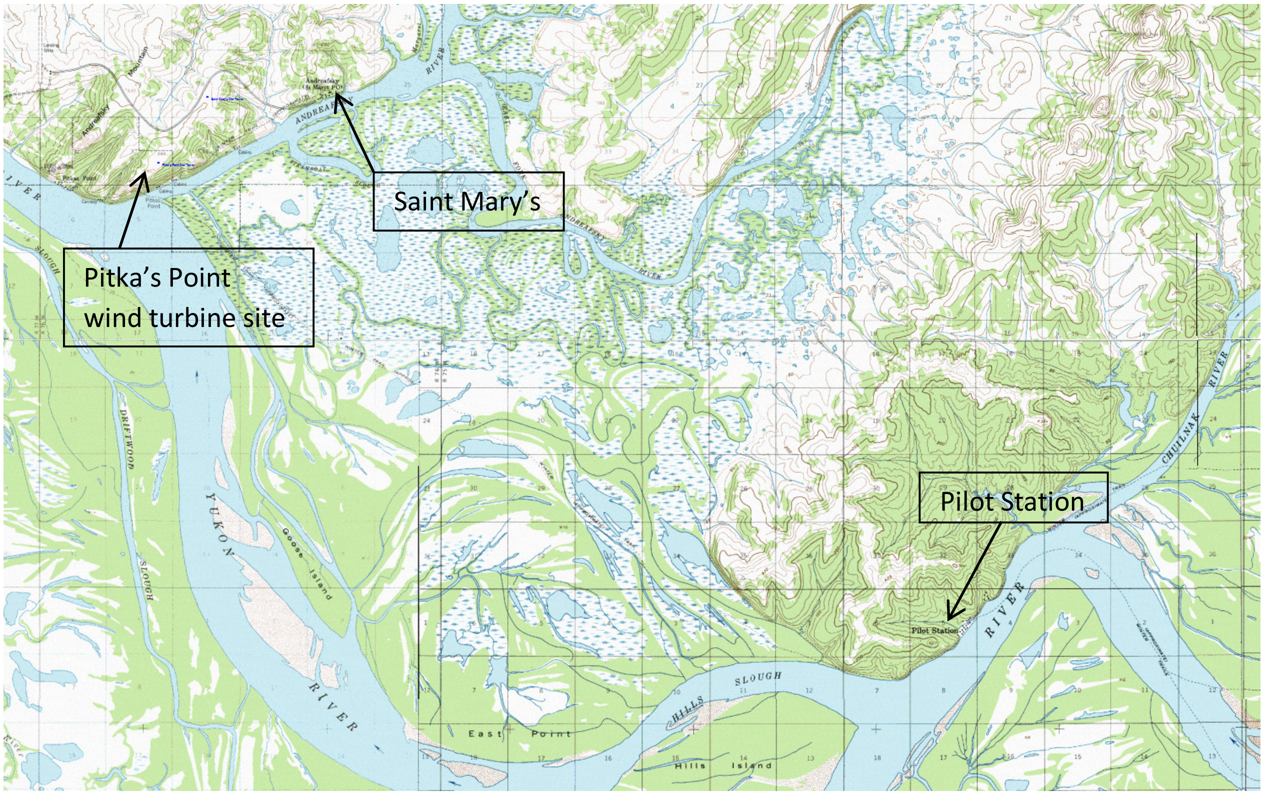
Saint Mary's-Pilot Station



St. Mary's (pop. 554) is located on the Andreafsky River, just north of its confluence with the Yukon River, 130 miles northwest of Bethel in the West Hampton Census Area. Pilot Station (pop. 583) is located on the Yukon River twelve direct-line and twenty river miles upriver or southeast of Saint Mary's. Saint Mary's and Pilot Station are not connected by a road or any other infrastructure improvement, but it is notable that the Saint Mary's airport has direct, non-stop flight service to and from Anchorage via Grant Airways.

This case proposes to intertie Saint Mary's and Pilot Station and upgrade the Saint Mary's powerplant to serve as the primary operations center. The present Pilot Station powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Saint Mary's and Pilot Station



Electric Loads and Generation

The diesel generators in the Saint Mary's powerplant have sufficient capacity at present to power both Saint Mary's (plus Pitka's Point) and Pilot Station if intertied, including with consideration of N-1 criteria where the largest generation unit is out-of-service. For Saint Mary's, loss of the largest generation unit, a 908 kW capacity Caterpillar 3512 diesel generator, would result in two remaining diesel generators to meet load demand: a 499 kW Cummins QXS15 and a 611 kW Caterpillar 3508. Combined capacity of these two diesel generators is 1,110 kW, which is sufficient to meet a possible combined village peak load demand of approximately 1,000 kW. The N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

St. Mary's and Pilot Station Generator and Load Data

	Saint Mary's		Pilot Station		Intertied (Saint Mary's as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	499	2006	397	1988	499	2006
2	611	1987	499	2005	611	1987
3	908	1995	314	2006	908	1995
Total	2,018		1,210		2,018	
Avg Load (kW)	368		202		574	
Peak Load (kW)	616		381		997	
Firm Capacity (N-1)	1,110		711		1,110	

Renewable Energy Options

Practical renewable energy options for electricity generation in Saint Mary's and Pilot Station are limited to wind power, although potential exists for the development of hydrokinetic power in the Yukon River to serve village power needs. AVEC began the process of wind power development in Saint Mary's and surrounding villages in 2007 with a reconnaissance effort to select suitable wind sites. Several potential wind power sites at or near Saint Mary's were identified but two were selected that were thought to have the most potential: a bluff site overlooking the Yukon River on Pitka's Point Native Corporation land immediately northeast of the village of Pitka's Point, and a site on Saint Mary's Corporation Land at lower elevation approximately one mile to the northeast of the Pitka's Point site. For Pilot Station, a good prospective wind site was identified on the ridge just north of the village, but it was never measured due to Native Allotment land ownership restrictions and future FAA airspace restrictions with planned new airport on higher ground to the northwest of Pilot Station.

Met towers were installed on the Pitka's Point site in 2007 and on the Saint Mary's site in 2008. Despite some problems with damage due to icing conditions, both wind measurement projects were successfully concluded. The Pitka's Point site is outstanding with a Class 6 wind resource while the Saint Mary's site, measured at Class 4, is also very good, but not the equivalent of the nearby Pitka's Point site. Modeling of the Pitka's Point wind data confirmed the significant variability of the wind resource surrounding the two met tower sites.

It is assumed that without an intertie, wind power development for Saint Mary's (plus Pitka's Point) alone would consist of four Northwind 100 (100 kW) wind turbines located at the Pitka's Point site and connected to the distribution line that connects Saint Mary's to Pitka's Point and the Saint Mary's airport. Also assumed is that wind turbines would not be installed in Pilot Station due to the constraints listed above.

If intertied, the large combined electric and (potential) thermal loads would enable increased wind power capacity and/or installation of more powerful wind turbines than the Northwind 100. AVEC proposed via the Alaska Energy Authority Renewable Energy Fund Round process installation of one

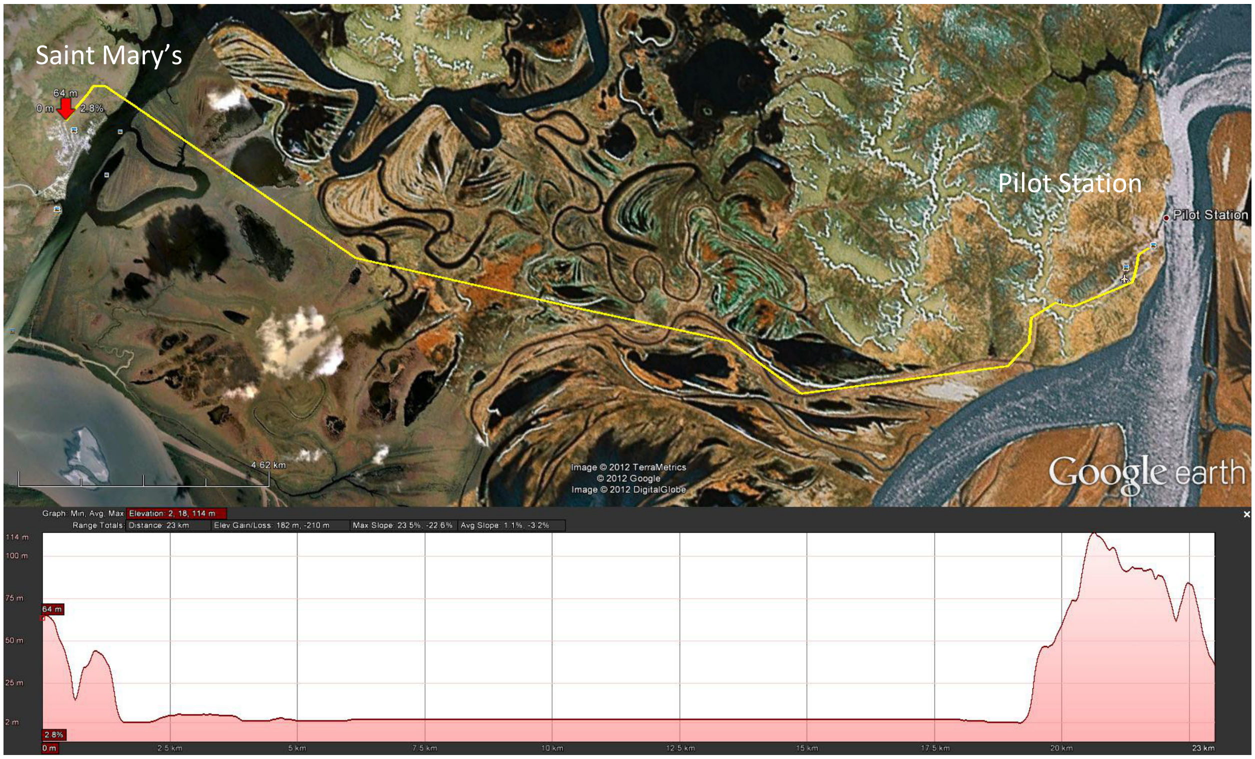
EWT 52-900 (900 kW) wind turbine to be located at the Pitka's Point site to serve a combined Saint Mary's and Pilot Station load. The EWT turbine has a lower per kilowatt capacity installed cost than the Northwind 100 turbine and has additional advantages such as variable pitch control rotors and scalable power output, via pitch control, to tune the turbine to a lower maximum power output should less capacity be necessary to manage the electric and thermal loads.

Intertie Route

Route designs for a Saint Mary's to Pilot Station intertie were recently developed for AVEC by CRW Engineering Group, LLC. Two options were considered: a shorter lowlands route and a longer uplands route. Details of the decision process are documented in CRW's design documentation with advantages and construction challenges specific to each route. At first, the longer and mostly uplands route was favored and forwarded as a construction funding proposal to Alaska Energy Authority in the 2012 Renewable Energy Fund Round 6 process.

The proposed uplands intertie route would consist of 13.5 miles of new construction and 3.2 miles of single phase to three phase upgrade for a total route length of 16.7 miles. Detailed design information of the uplands route design is presented in Appendix A. Later route analyses have focused on a lowlands route of about 15 miles length.

Saint Mary's-Pilot Station Intertie Route and Elevation Profile, Lowlands Route



Saint Mary's-Pilot Station Intertie Route and Elevation Profile, Uplands Route

Assumptions and Special Issues

Given the larger size of Saint Mary's population, the larger power plant, high value and accessible wind sites and the superior airport, Saint Mary's would host the primary power plant and Pilot Station would be equipped with a standby generator and fuel storage for emergency mode operation in event of loss of the intertie or a similar emergency event. To accomplish this, the St. Mary's tank farm must be enlarged.

Also, the power plant and tank farm in Pilot Station are subject to flooding from the Yukon River and there is no room near the existing plant sites for expansion. Relocation or upgrades would be necessary at Pilot Station to reduce the flood threat as an alternative to an intertie and standby generator. A flood in 1989 severely damaged the power plant and tank farm and since that year, the tank farm has been expanded at the original site, which consequential risk of even more costly flood damage in the future.

Pilot Station Flood, 1989

1989

Circled is the AVEC back in 1989
Now to this date AVEC has MORE Tanks for the Plant.

St. Mary's-Pilot Station Cost Summary Table

	Without Intertie		With Intertie	
	Saint Mary's	Pilot Station	Saint Mary's	Pilot Station
Energy (MWh/yr)	3,220	1,770	5,026	
Fuel Price ($/gal)	4.27	3.71	4.27	
Efficiency (kWh/gal)	13.83	13.06	14.00	
Non-fuel Expense ($/yr)	$683,198	$421,302	$964,500	
Powerplant Cap. Cost	$5,000,000	$7,045,000	$5,400,000	$1,006,000
Bulk Fuel Cap. Cost	$4,500,000	$4,930,000	$6,500,000	
Wind Farm Cap. Cost	$4,080,000	$0	$6,153,991	
Intertie Cap. Cost			$6,500,000	

The following table documents the assumptions of the St. Mary's-Pilot Station intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix B.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Saint Mary's	Powerplant	2018	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2018	Based on 300,000 gal of required storage capacity at $15.00/gallon for pile construction.

	Wind Farm	2014	Four NW100 wind turbines at the Pitka's Point wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Pilot Station	Powerplant	2014	Based on May 2014 estimate by CRW for new relocated powerplant.
	Bulk Fuel Facility	2014	Based on May 2014 estimate by CRW for new relocated bulk fuel facility (AVEC portion).
With Intertie			
Saint Mary's	Powerplant	2018	Based on cost of construction of new powerplants in Chevak and Brevig Mission; scaled to accommodate increased load of both villages.
	Bulk Fuel Facility	2018	Based on 450,000 gal of required storage capacity at $14.50/gallon for pile construction.
	Wind Farm	2014	Larger EWT 52-900 turbine possible with the combined load of Saint Mary's and Pilot Station if intertied. Cost estimate by CRW Engineering Group for AVEC's Renewable Energy Fund Round 6 construction proposal. Turbine would be located at the Pitka's Point wind power site.
Pilot Station	Powerplant	2014	Based on May 2014 estimate by CRW for a standby power module constructed on grade.
	Bulk Fuel Facility	2014	Based on May 2014 estimate by CRW for new relocated bulk fuel facility to serve standby powerplant (AVEC portion).
Intertie		2014	Intertie construction cost estimate, updated to present, by CRW Engineering for AEA Renewable Energy Fund Round 6 construction proposal for upload route design. This is consistent with cost of the 2011 Emmonak-Alakanuk intertie.

Economic Analysis

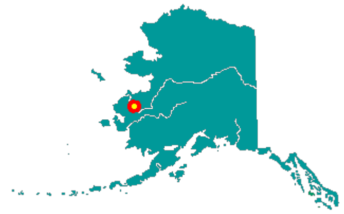
The economic benefit of a distribution intertie connecting Pilot Station to Saint Mary's is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbine configurations as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As presented in the St. Mary's-Pilot Station 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Pilot Station and Saint Mary's. As expected, the economic benefit decreases with a non-zero discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

St. Mary's-Pilot Station 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	233.5	202.1	1.16
	3	118.6	103.8	1.14
No	0	240.9	227.1	1.06
	3	121.0	114.1	1.06

Saint Mary's-Mountain Village



St. Mary's (pop. 554) is located on the Andreafsky River, just north of its confluence with the Yukon River, 130 miles northwest of Bethel in the West Hampton Census Area. Mountain Village (pop. 835) lies on the Yukon River eighteen miles west of Saint Mary's. Pitka's Point (pop. 93), which is already intertied (via single phase) with St. Mary's, is located four miles south of St. Mary's on the Yukon River. A gravel road connects St. Mary's to Pitka's Point with a branch road to the Saint Mary's airport. The road to the airport continues a further sixteen (road) miles to Mountain Village.

This case proposes to intertie Saint Mary's and Mountain Village and upgrade the Saint Mary's powerplant to serve as the primary operations center. The present Mountain Village powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Saint Mary's and Mountain Village

Electric Loads and Generation

The diesel generators in the Saint Mary's powerplant have sufficient capacity at present to power both Saint Mary's (plus Pitka's Point) and Mountain Village if intertied, although it potentially does not quite meet N-1 criteria where the largest generation unit is out-of-service. For Saint Mary's, loss of the largest generation unit, a 908 kW capacity Caterpillar 3512 diesel generator, would result in two remaining diesel generators to meet load demand: a 499 kW Cummins QXS15 and a 611 kW Caterpillar 3508. Combined capacity of these two diesel generators is 1,110 kW, which may not be sufficient to meet a possible combined village peak load demand of approximately 1,160 kW. This N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

St. Mary's and Mountain Village Generator and Load Data

	Saint Mary's		Mountain Village		Intertied (Saint Mary's as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	499	2006	350	1984	499	2006
2	611	1987	505	2005	611	1987
3	908	1995	601	1982	908	1995
Total	2,018		1,456		2,018	
Avg Load (kW)	368		324		692	
Peak Load (kW)	616		542		1,158	
Firm Capacity (N-1)	1,110		1,055		1,110	

Renewable Energy Options

Practical renewable energy options for electricity generation in Saint Mary's and Mountain Village are limited to wind power, although potential exists for the development of hydrokinetic power in the Yukon River to serve village power needs. AVEC began the process of wind power development in Saint Mary's and surrounding villages in 2007 with a reconnaissance effort to select suitable wind sites. Several potential wind power sites at or near Saint Mary's were identified but two were selected that were thought to have the most potential: a bluff site overlooking the Yukon River on Pitka's Point Native Corporation land immediately northeast of the village of Pitka's Point, and a site on Saint Mary's Corporation Land at lower elevation approximately one mile to the northeast of the Pitka's Point site. In Mountain Village, a prospective wind site was identified on a plateau about two miles east of the airport, between the Yukon River and the road to Saint Mary's

Met towers were installed on the Pitka's Point site in 2007, the Saint Mary's site in 2008, and the Mountain Village site in 2009. Despite some problems with damage due to icing conditions in Saint Mary's, all three wind measurement projects were successfully concluded. The Pitka's Point site is outstanding with a Class 6 wind resource while the Saint Mary's site, measured at Class 4, is also very good, but not the equivalent of the nearby Pitka's Point site. Modeling of the Pitka's Point wind data confirmed the significant variability of the wind resource surrounding the two met Saint Mary's area met tower sites. The Mountain Village site measured an excellent Class 5 wind resource, the near equivalent of the Pitka's Point site with respect to wind power, but with fewer icing events.

It is assumed that without an intertie, wind power development for Saint Mary's (plus Pitka's Point) alone would consist of four Northwind 100 (100 kW) wind turbines located at the Pitka's Point site and connected to the distribution line that connects Saint Mary's to Pitka's Point and the Saint Mary's airport. It is also that without an intertie, wind power development for Mountain Village would consist of four Northwind 100 (100 kW) wind turbines located at the Mountain Village site east of the airport and connected to Mountain Village with approximately three miles of new distribution line.

If intertied, the large combined electric and (potential) thermal loads would enable increased wind power capacity and/or installation of more powerful wind turbines than the Northwind 100. AVEC proposed via the Alaska Energy Authority Renewable Energy Fund Round process installation of one EWT 52-900 (900 kW) wind turbine to be located at the Pitka's Point site to serve a combined Saint Mary's and Pilot Station load. The EWT turbine has a lower per kilowatt capacity installed cost than the Northwind 100 turbine and has additional advantages such as variable pitch control rotors and scalable power output, via pitch control, to tune the turbine to a lower maximum power output should less capacity be necessary to manage the electric and thermal loads.

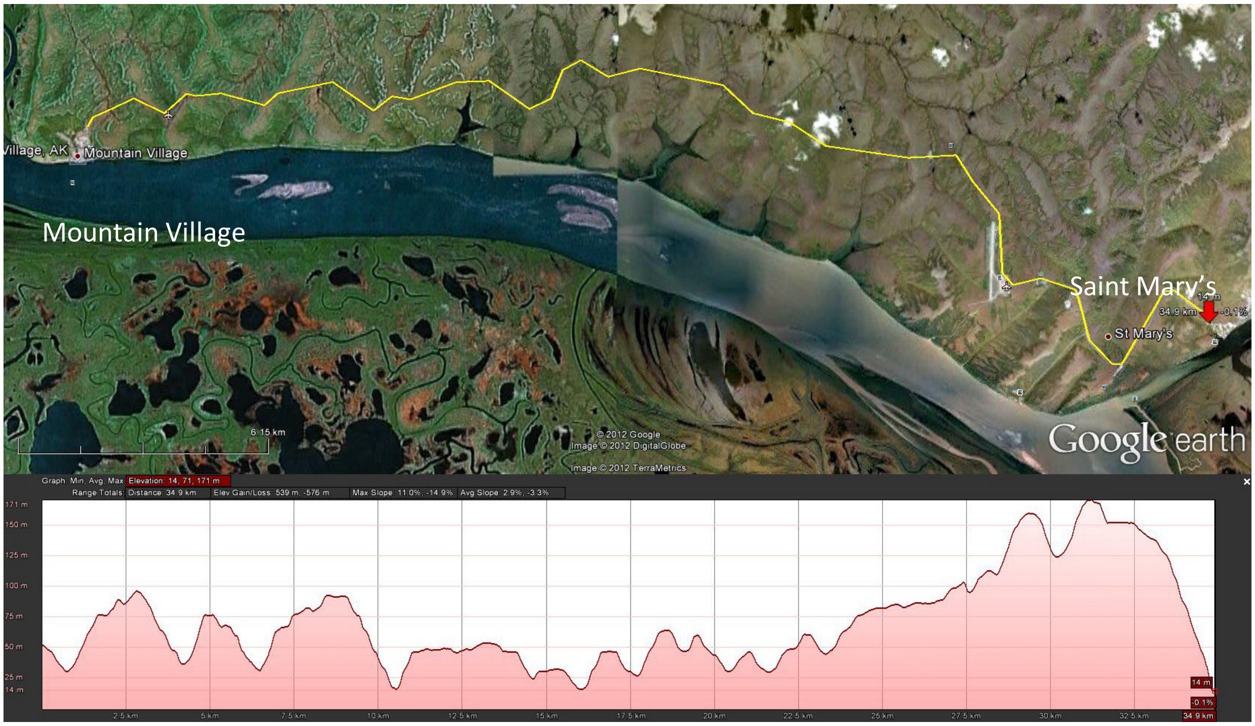
Intertie Route

At present, a single phase overhead intertie connects Saint Mary's to Pitka's Point, with a separate single phase branch line serving the Saint Mary's airport. These interties (combined from Saint Mary's to the Pitka's Point access road) are located in an easement alongside the roads.

The 20 mile (approx. 16 miles new; 4 miles upgrade) proposed Saint Mary's to Mountain Village intertie route for the most part follows the existing gravel roadway between the Saint Mary's airport and the Mountain Village airport. This roadway, with additional tundra protection in some areas, may allow for summer season construction. The road generally follows higher and better drained topography but crosses surface drainages, ponded wet areas, or other low lying areas. The intertie alignment may in some sections cross undisturbed areas to reduce overall length and to result in a straighter alignment.

In a 2009 reconnaissance study, Duane Miller and Associates noted that soils along the Saint Mary's to Mountain Village intertie alignment should be suitable for conventional pile supported construction. They noted, however, that the general geology of the area indicates variable thickness of icy silt and frozen organic soil over bedrock, with shallow bedrock in many locations that would limit pile embedment depths. Precise soil conditions and bedrock depth would be determined by a field geotechnical investigation as part of the intertie design.

Saint Mary's-Mountain Village Intertie Route and Elevation Profile



Assumptions and Special Issues

Although Saint Mary's and Mountain Village have roughly equivalent populations and electrical load demands, AVEC intends that Saint Mary's host the primary power plant and Mountain Village be equipped with a standby generator and fuel storage for emergency mode operation. Saint Mary's is the more centrally located of the two villages with respect to AVEC's options to extend the intertie to Pilot Station. With the Pitka's Point wind site identified as the primary location for wind turbines, the relative ease of travel to Saint Mary's with direct flight service from Anchorage, and the superior present condition of the Saint Mary's powerplant, centralizing power generation in Saint Mary's is the optimal solution.

In the late 1960's and early 1970's Mt. Village was connected to St. Mary's with a single phase insulated cable placed on the tundra and was protected by a utilidor at selected locations. Due to maintenance and safety issues this system was replaced with a separate power plant at Mt. Village. With the passage of time the upland area above the power plant has been developed with housing, school facilities, roads and utilidors. The Mt. Village power plant is now in the path of runoff water that slowly accumulates and freezes in the winter and creates thick ice throughout the AVEC plant site which encases plant features and supplies throughout the winter. In addition, fuel supply lines between the river and AVEC tank farm need to be rerouted.

St. Mary's-Mountain Village Cost Assumptions Table

	Without Intertie		With Intertie	
	Saint Mary's	Mountain Village	Saint Mary's	Mountain Village
Energy (MWh/yr)	3,220	2,839	6,116	
Fuel Price ($/gal)	4.27	3.96	4.27	
Efficiency (kWh/gal)	13.83	14.57	14.00	
Non-fuel Expense ($/yr)	$683,198	$690,979	$1,234,177	
Powerplant Cap. Cost	$5,000,000	$5,000,000	$5,400,000	$900,000
Bulk Fuel Cap. Cost	$4,500,000	$3,500,000	$7,800,000	
Wind Farm Cap. Cost	$4,080,000	$4,680,000	$6,153,991	
Intertie Cap. Cost			$7,449,000	

The following table documents the assumptions of the St. Mary's-Mountain Village intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix C.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Saint Mary's	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 300,000 gal of required storage capacity at $15.00/gallon for pile construction.
	Wind Farm	2014	Four NW100 wind turbines at the Pitka's Point wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Mtn. Village	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 250,000 gal of required storage capacity at $14.00/gallon for on-grade construction.
	Wind Farm	2014	Four NW100 wind turbines at the Mountain Village wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW, plus three miles new distribution at $200,000 per mile.
With Intertie			
Saint Mary's	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission; scaled to accommodate increased load of both villages.

Village	Capital Cost Item	Cost Year	Basis
	Bulk Fuel Facility	2014	Based on 550,000 gal of required storage capacity at $14.15/gallon for pile construction.
	Wind Farm	2014	Larger EWT 52-900 turbine possible with the combined load of Saint Mary's and Mountain Village if intertied. Cost estimate by CRW Engineering Group for AVEC's Renewable Energy Fund Round 6 design proposal. Turbine would be located at the Pitka's Point wind power site.
Mtn. Village	Powerplant	2014	Based on standard cost for a standby power module constructed on grade.
Intertie		2014	Intertie construction cost estimate by STG, Inc. for AEA Renewable Energy Fund Round 6 design proposal.

Economic Analysis

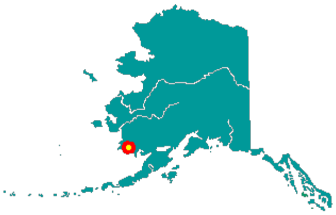
The economic benefit of a distribution intertie connecting Mountain Village to Saint Mary's is presented in the table below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in St. Mary's-Mountain Village 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Mountain Village and Saint Mary's. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

St. Mary's-Mountain Village 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	271.7	254.5	1.07
	3	136.5	130.9	1.04
No	0	282.7	281.9	1.00
	3	139.2	142.5	0.98

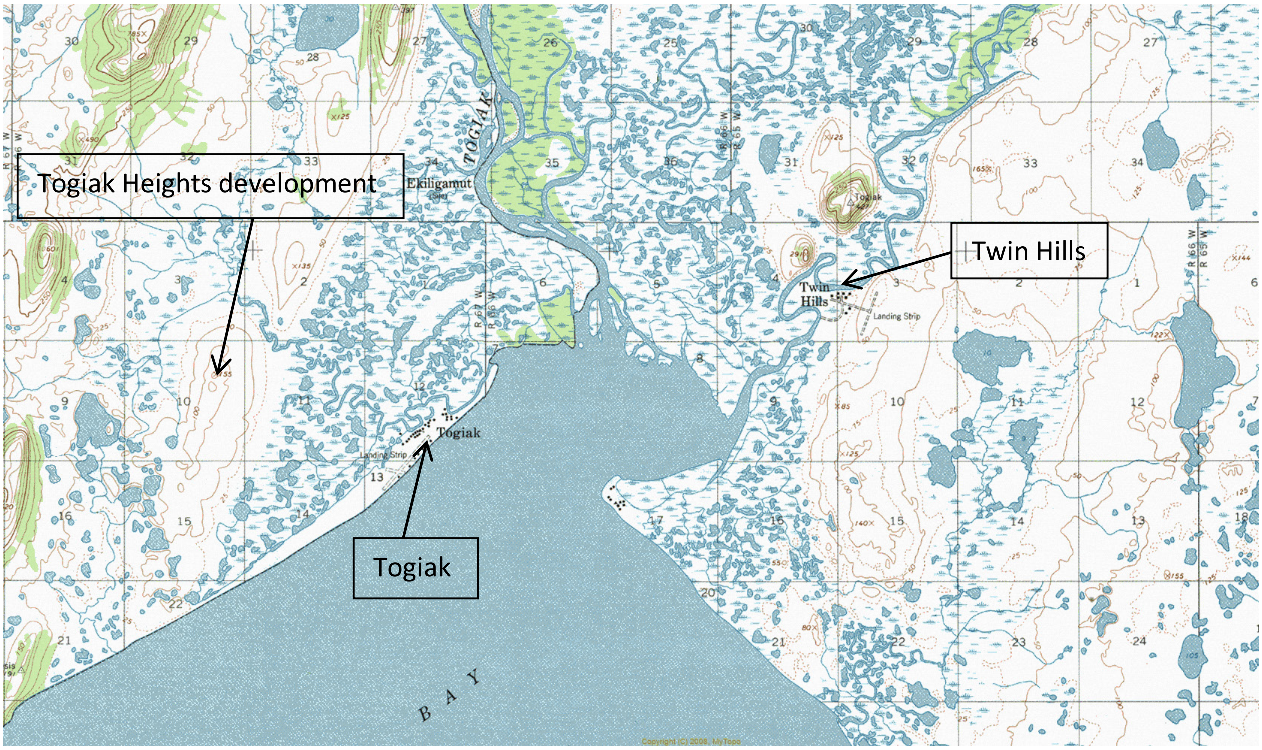
Togiak-Twin Hills



Togiak (pop. 842) is located at the head of Togiak Bay, just north of Bristol Bay and 67 miles west of Dillingham in the Dillingham Census Area. It lies in the Togiak National Wildlife Refuge and is the gateway to the Walrus Island Game Sanctuary. Twin Hills (pop. 79) is 3.5 miles east-northeast of Togiak near the mouth of the Twin Hills River, a tributary of the Togiak River. Twin Hills is not at present an AVEC village but has expressed interest in doing so.

This case proposes to intertie Togiak and Twin Hills and upgrade the Togiak powerplant to serve as the primary operations center. The present Twin Hills powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Togiak and Twin Hills



Electric Loads and Generation

The diesel generators in the Togiak powerplant have sufficient capacity at present to power both Togiak and Twin Hills if intertied with sufficient excess capacity to meet N-1 criteria where the largest generation unit is out-of-service. For Togiak, loss of the largest generation unit, an 824 kW capacity Cummins K38G2 diesel generator, would result in two remaining diesel generators to meet load demand: a 499 kW Cummins QXS15 and a 350 kW Caterpillar 3412. Combined capacity of these two diesel generators is 849 kW, which would be sufficient to meet a combined village peak load demand of approximately 650 kW. This N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

Togiak and Twin Hills Generator and Load Data

	Togiak		Twin Hills		Intertied (Togiak as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	499				499	
2	350				350	
3	824				824	
Total	1,673		-		1,673	
Avg Load (kW)	351		34		385	
Peak Load (kW)	588		60		648	
Firm Capacity (N-1)	849				849	
Note: Twin Hills peak load is estimated						

Renewable Energy Options

Practical renewable energy options for electricity generation in Togiak and Twin Hills are limited to wind power. A wind resource study for Togiak was completed in 2007 using 32 months of data collected from a 30 meter met tower that had been erected in 2004. The site, located on the northern part of the hill identified as “Togiak Heights development” in the preceding map, classified as Class 3 with good turbulence behavior and low extreme wind potential. Neither a wind reconnaissance effort nor wind monitoring has been conducted in Twin Hills, but the wind power potential is likely lower than in Togiak due to topography constraints: the village itself is at lower elevation than the Togiak met tower site and is shadowed from northerly prevailing winds by the “twin hill” features that give the village its name. The tops of the hills themselves may have good wind potential, but would be difficult to develop due to the steep slopes of the hills and constrained summit areas.

For this analysis, it is assumed that if separate (not intertied), wind power development in Togiak would consist of three Northwind 100/21 B model turbines and no wind power development would occur in Twin Hills. It is further assumed that should the villages be intertied, four Northwind 100/21 B model turbines would be installed in Togiak, which would supply power to the combined Togiak-Twin Hills load.

Intertie Route

The Twin Hills Village Council has expressed interest over the past several years in an intertie that would connect Twin Hills to Togiak, an AVEC village, and which would absorb Twin Hills into the AVEC community of villages. Two intertie routes are possible: an overland route that would require crossing the Togiak River and an underwater route across Togiak Bay. At 4.1 miles, the overland route is the shortest, most straight-forward to design, and likely the least expensive to construct, but it would require an overhead crossing of the Togiak River which may present a permitting issue with respect to bird migration through this area. The alternate route across Togiak Bay, at 6.1 miles, would negate the avian concerns with respect to crossing the Togiak River, but it would likely prove expensive to design and construct. This tentative route would connect to the area of a fish processing plant immediately across the bay from Togiak and then follow an access road along the beach and then inland to Twin Hills.

Togiak-Twin Hills Intertie Route, Overland Option

Togiak-Twin Hills Intertie Route, Togiak Bay Crossing Option

Assumptions and Special Issues

Crossing of the braided and potentially changeable channel of the Togiak River may require extra care in the design and placement of towers to carry an overhead line. A cable option may be difficult to access and repair should it be necessary.

Togiak-Twin Hills Cost Assumptions Table

	Without Intertie		With Intertie	
	Togiak	Twin Hills	Togiak	Twin Hills
Energy (MWh/yr)	3,079	300	3,385	
Fuel Price ($/gal)	4.18	4.97	4.18	
Efficiency (kWh/gal)	13.82	12.39	13.82	
Non-fuel Expense ($/yr)	$737,788	$20,000	$757,788	
Powerplant Cap. Cost	$4,950,000	$1,200,000	$4,950,000	$489,000
Bulk Fuel Cap. Cost	$4,200,000	$500,000	$4,200,000	
Wind Farm Cap. Cost	$3,060,000	$0	$4,080,000	
Intertie Cap. Cost			$1,954,000	

The following table documents the assumptions of the Togiak-Twin Hills intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix D.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Togiak	Powerplant	2013	2012 CAPSIS request for construction of a new powerplant to serve Togiak and possibly Twin Hills in the future
	Bulk Fuel Facility	2013	Based on 300,000 gal of required storage capacity at $14.00/gallon for pile construction.
	Wind Farm	2013	Three NW100 wind turbines at the Togiak Heights met tower site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Twin Hills	Powerplant	2013	Estimated cost to upgrade Twin Hills powerplant
	Bulk Fuel Facility	2013	Cost estimate for one new 27,000 gallon fuel storage tank.
With Intertie			
Togiak	Powerplant	2013	2012 CAPSIS request for construction of a new powerplant to serve Togiak and possibly Twin Hills in the future
	Bulk Fuel Facility	2013	Based on 550,000 gal of required storage capacity at $14.15/gallon for pile construction.
	Wind Farm	2013	Four NW100 wind turbines at the Togiak Heights met tower site based on AEA's 2012 Renewable

Village	Capital Cost Item	Cost Year	Basis
			Energy Fund default wind turbine cost of $10,200/kW.
Twin Hills	Powerplant	2013	Gray Stassell Engineering cost estimate, 12/18/2013; standby power module constructed on grade.
Intertie		2013	Gray Stassell Engineering cost estimate, 12/18/2013; based on $441,000 per mile.

Economic Analysis

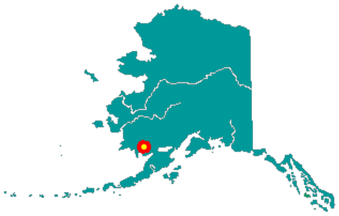
The economic benefit of a distribution intertie connecting Twin Hills to Togiak is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the Togiak-Twin Hills 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Togiak and Twin Hills. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

Togiak-Twin Hills 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	161.4	162.5	0.99
	3	80.0	81.1	0.99
No	0	161.8	163.1	0.99
	3	79.5	80.4	0.99

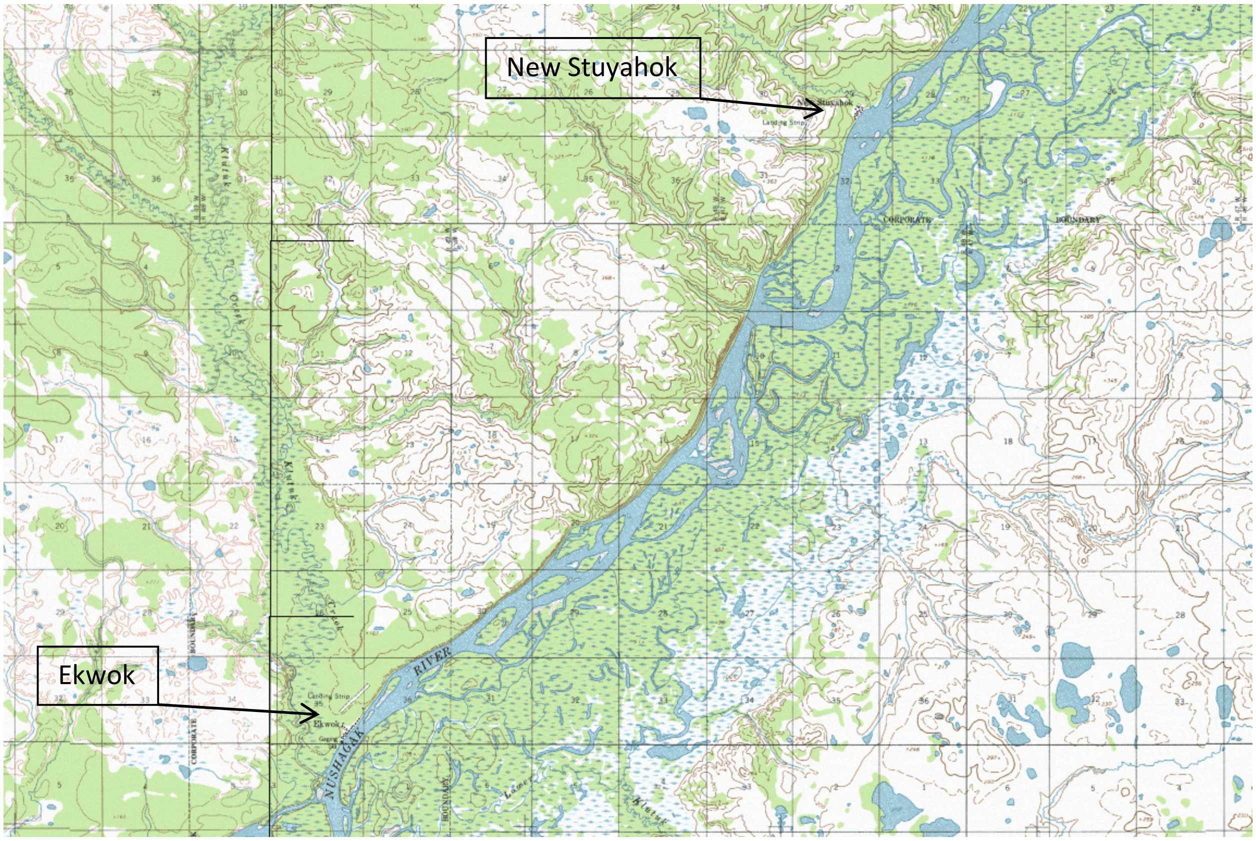
New Stuyahok-Ekwok



New Stuyahok (pop. 501) is located on the Nushagak River in the Bristol Bay drainage area, about 52 miles northeast of Dillingham in the Dillingham Census Area. The village has been constructed at two elevations, one 25 feet above river level and the other higher, at about 140 feet above river level. Ekwok (pop. 115) is also located on the Nushagak River, about 12 miles downstream from New Stuyahok. Ekwok is the newest addition to the AVEC family of villages.

This case proposes to intertie New Stuyahok and Ekwok and upgrade the New Stuyahok powerplant to serve as the primary operations center. The present Ekwok powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of New Stuyahok and Ekwok



Electric Loads and Generation

The diesel generators in the New Stuyahok powerplant have sufficient capacity at present to power both New Stuyahok and Ekwok if intertied with sufficient excess capacity to meet N-1 criteria where the largest generation unit is out-of-service. For New Stuyahok, loss of the largest generation unit, a 505 kW capacity Caterpillar 3456 diesel generator, would result in two remaining diesel generators to meet load demand: a 499 kW Cummins QXS15 and a 363 kW Detroit Diesel S60K4c. Combined capacity of these two diesel generators is 862 kW, which would be more than sufficient to meet a combined village peak load demand of approximately 430 kW. This N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

New Stuyahok and Ekwok Generator and Load Data

	New Stuyahok		Ekwok		Intertied (Alakanuk as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	499		123		499	
2	363		220		363	
3	505				505	
Total	1,367		343		1,367	
Avg Load (kW)	171		65		236	
Peak Load (kW)	312		120		432	
Firm Capacity (N-1)	862		123		862	

Renewable Energy Options

Practical renewable energy options for electricity generation in New Stuyahok and Ekwok are limited to wind power. A wind resource assessment at a site near the tarmac of the old airport in New Stuyahok was completed in 2005. This assessment was comprised of 21 months of data and indicated a Class 2 to Class 3 wind resource. It was thought that this wind study was compromised somewhat by the presence of trees near the met tower, and a second wind resource assessment, this time with a met tower located on the north end of the old runway, was initiated in January 2012 and is presently ongoing. Data to date indicates slightly higher wind speeds than previously measured, likely due to the higher elevation and better exposure of the new met tower. Wind classification though likely will remain the same as high Class 2 to low Class 3.

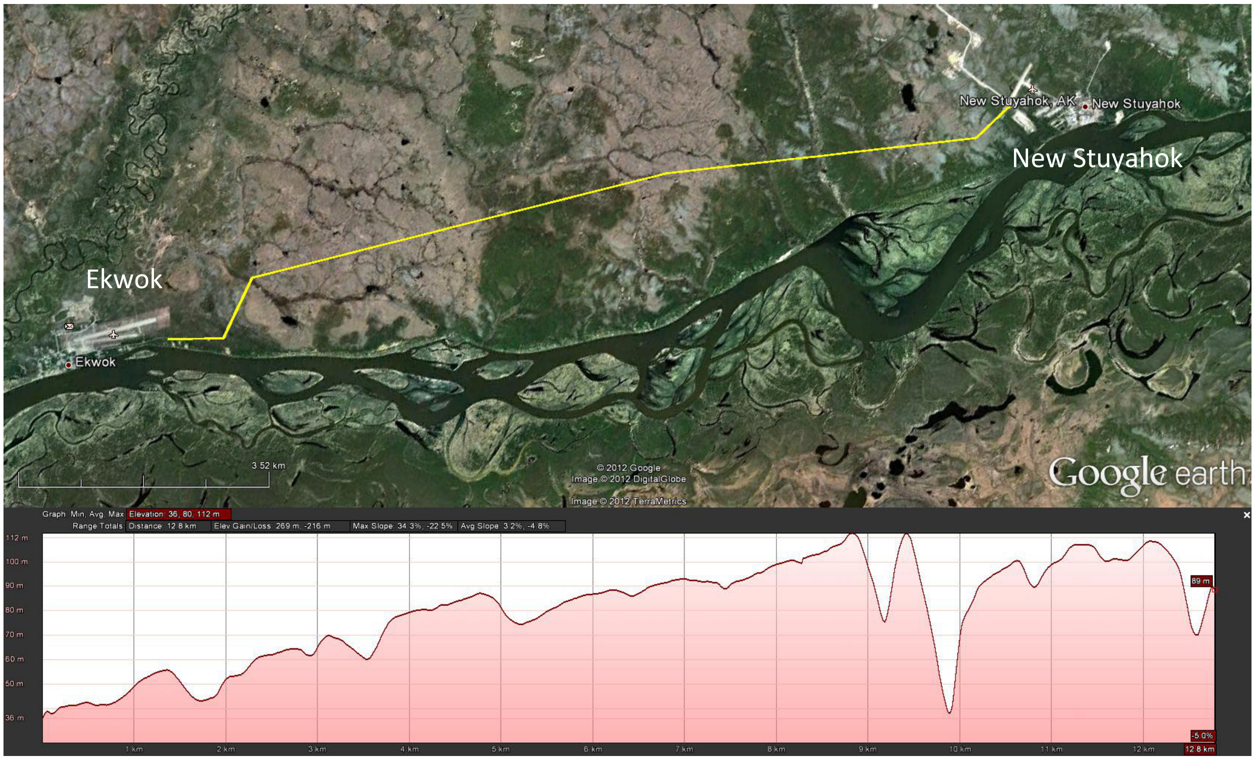
The wind resource in Ekwok has not been formally assessed, but wind models predict a Class 1 wind resource in the immediate vicinity of the village, although a Class 2 wind resource may exist along the proposed intertie route.

For this analysis, it is assumed that if separate or not intertied, wind power development in New Stuyahok would consist of four Northwind 100/21 B model turbines and no wind power development would occur in Ekwok. It is further assumed that should the villages be intertied, six Northwind 100/21 B model turbines would be installed in New Stuyahok, which would supply power to the combined New Stuyahok-Ekwok load.

Intertie Route

Investigations in 2013 considered a 9.39 mile intertie route to connect Ekwok to New Stuyahok originating at the new New Stuyahok powerplant near the old airport and traversing upland and wetland terrain to terminate at an appropriate connection point in Ekwok. A dogleg portion of the route near Ekwok is required to avoid Native Allotments near Ekwok and other deviations may be required after further field investigations in order to find suitable soils for construction.

New Stuyahok-Ekwok Intertie Route and Elevation Profile



Assumptions and Special Issues

The New Stuyahok village electric system was energized in 1972 and major energy upgrades including moving and expanding the power plant and tank farm were accomplished between 2004 and 2011. In 2011 the nearby village of Ekwok, located approximately ten miles downstream of New Stuyahok, became a member of the AVEC system. As part of the consolidation with AVEC, the Ekwok plant and tank farm was consolidated on a new gravel pad further away from flood prone areas, and plant upgrades were made such that with minimal changes the Ekwok plant could be operated as a standby plant in the future should an intertie to New Stuyahok be constructed.

Map studies completed in 2005 indicated an eight mile overland intertie could connect New Stuyahok and Ekwok depending upon the point of interconnection. In 2013 engineers traversed the area and made allowances for avoiding native allotments and wet soil conditions, resulting in a redesigned route length of about 9.4 miles. Portions of the intertie would be constructed on piles and most construction would be accomplished during winter.

Wind turbines near New Stuyahok could serve both New Stuyahok and Ekwok if the villages were interconnected. Separately though, only New Stuyahok has a potentially developable wind resource.

New Stuyahok-Ekwok Cost Assumptions Table

	Without Intertie		With Intertie	
	New Stuyahok	Ekwok	New Stuyahok	Ekwok
Energy (MWh/yr)	1,502	237	1,744	
Fuel Price ($/gal)	4.49	4.46	4.49	
Efficiency (kWh/gal)	12.44	13.53	13.50	
Non-fuel Expense ($/yr)	$355,221	$25,000	$380,221	
Powerplant Cap. Cost	$4,000,000	$1,000,000	$4,000,000	$100,000
Bulk Fuel Cap. Cost	$1,870,000	$500,000	$1,870,000	
Wind Farm Cap. Cost	$4,080,000	$0	$5,100,000	
Intertie Cap. Cost			$4,872,888	

The following table documents the assumptions of the New Stuyahok-Ekwok intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix E.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
New Stuyahok	Powerplant	2023	Cost estimate based on actual cost of Brevig Mission powerplant less one diesel generator.
	Bulk Fuel Facility	2011	Actual cost of 2011 bulk fuel project; AVEC portion 189,000 gal (of 546,000 gal total). Total project cost $5.4M.
	Wind Farm	2013	Four NW100 wind turbines at New Stuyahok old airport site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Ekwok	Powerplant	2012	Actual powerplant upgrade cost in 2012 after Ekwok joined AVEC
	Bulk Fuel Facility	2013	Cost estimate for one new 27,000 gallon fuel storage tank.
With Intertie			
New Stuyahok	Powerplant	2023	Cost estimate based on actual cost of Brevig Mission powerplant less one diesel generator.
	Bulk Fuel Facility	2011	Actual cost of 2011 bulk fuel project; AVEC portion 189,000 gal (of 546,000 gal total). Total project cost $5.4M.
	Wind Farm	2013	Six NW100 wind turbines at New Stuyahok old airport site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.

Ekwok	Powerplant	2013	Upgrade of existing powerplant to place into standby service; new standby plant not required.
Intertie		2013	Estimated cost of $4,872,888 for the overland route based on 2013 field investigations; approximate $519K per mile construction cost based on 35% design.

Economic Analysis

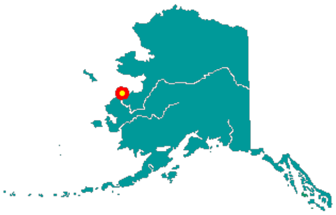
The economic benefit of a distribution intertie connecting Ekwok to New Stuyahok is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the New Stuyahok-Ekwok economic benefit table, with or without consideration of wind power development, it is economically beneficial to intertie New Stuyahok and Ekwok. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

New Stuyahok-Ekwok 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	90.5	91.6	0.99
	3	44.4	46.8	0.95
No	0	94.7	95.1	1.00
	3	45.4	47.2	0.96

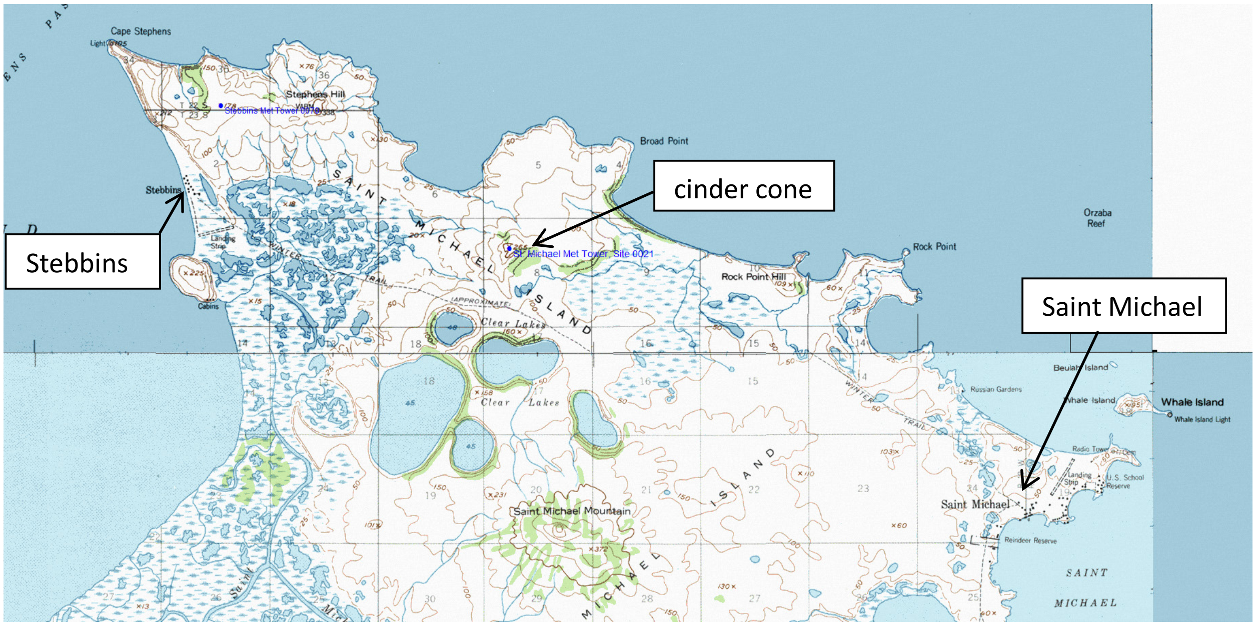
Stebbins-Saint Michael



Stebbins (pop. 585) is located on the northwest coast of Saint Michael Island, on Norton Sound approximately 120 miles southeast of Nome in the Nome Census Area. Saint Michael (pop. 411) is located on the east coast of Saint Michael Island about eight straight line miles from southeast of Stebbins. An approximately 10 mile long gravel road that traverses higher terrain on the north side of Saint Michael Island connects the two villages.

AVEC proposes to intertie Stebbins and Saint Michael and currently is upgrading the Stebbins powerplant to serve as the primary operations center. The present Saint Michael powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Stebbins and Saint Michael



Electric Loads and Generation

The diesel generators in the new Stebbins powerplant have sufficient capacity at present to power both Stebbins and Saint Michael if intertied with sufficient excess capacity to meet N-1 criteria where the largest generation unit is out-of-service. For Stebbins, loss of the four identical generation units, a 450 kW capacity Caterpillar 3456 diesel generator, would result in three remaining 450 kW Caterpillar 3456 diesel generators to meet a combined village peak load demand of approximately 660 kW. In fact, new diesel generation capacity in Stebbins is sufficient to meet N-2 criteria where peak load demand can be met with the two largest generation units out of service. This N-1 (and N-2) analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

Stebbins and Saint Michael Generator and Load Data

	Stebbins		Saint Michael		Intertied (Stebbins as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	450	2012	499	1984	499	1992
2	450	2012	314	2005	350	1992
3	450	2012	207	1982	250	1990
4	450	2012				
Total	1,800		1,020		1,099	
Avg Load (kW)	158		203		361	
Peak Load (kW)	289		370		659	
Firm Capacity (N-1)	1,350		521		1,350	

Renewable Energy Options

The plateau area just north of Stebbins was chosen as a potential wind turbine site because it is a particularly convenient location for construction and was believed to have good wind energy potential. The road connecting Stebbins to Saint Michael passes through this area and the electrical intertie will be located on an easement alongside the road, making connection to the turbines relatively inexpensive. Six months of data from a met tower located at this site, however, indicated a less than expected wind resource compared to met tower data collected further several miles to the east on a site not available for wind turbines due to landowner restrictions. Wind modeling accomplished for a recently completed Conceptual Design Report indicated that the bluffs of Cape Stephans located at the northwest tip of Saint Michael Island possesses a superior wind resource than either met tower location and at present is the primary wind turbine site for planning purposes.

Although the Conceptual Design Report considered several wind power options for Stebbins and Saint Michael, not all are relevant for this intertie study. Of interest are turbine options possible with and without the intertie. Without construction of an intertie, four Northwind 100 wind turbines located at the Cape Stephans bluff site and serving Stebbins is considered. Although construction of wind turbines nearer Saint Michael at the cinder cone site and serving only Saint Michael is possible, this would require construction of distribution connection half the distance or more of the Stebbins-Saint Michael intertie and hence extremely unlikely as a project by itself. East of the cinder cone site, the terrain drops away toward sea level elevation and the wind resource decreases significantly as well.

With construction of an intertie, the combined Stebbins and Saint Michael electrical load is sufficient to consider installation of larger capacity wind turbines than the Northwind 100. In the Conceptual Design Report, a 900 kW EWT 52-900 wind turbine was modeled at the Cape Stephans bluff site. Although present electrical and thermal loads in Stebbins and Saint Michael likely require operation of the EWT turbine in reduced output mode, for this report the wind turbine was modeled at full output capacity less excess wind energy that would go to thermal loads or be excessed.

Intertie Route

The St. Michael – Stebbins intertie consists of approximately 11 miles of overhead three phase, 12,470 volt power line. The proposed route begins at the new Stebbins power plant, then generally follows the

Stebbins to St. Michael road to St. Michael. The line is contemplated as a combination of direct set and pile-supported poles.

Stebbins-Saint Michael Intertie Route and Elevation Profile

Assumptions and Special Issues

Both villages have facilities that are in need of relocation and upgrade. The St. Michael powerplant and its bulk fuel storage is on a constricted site adjacent to the sea that cannot be further expanded. Multiple fuel deliveries by barge and sometimes by truck from Stebbins were necessary to supply sufficient fuel for the year.

The Stebbins power plant and fuel storage site is at the Stebbins Airport on land leased from the State of Alaska, Division of Aviation. The Division of Aviation requested removal of the plant in order to upgrade Stebbins airfield. The old plant site was also subject to high water from ocean storm surges. At present a new power plant and bulk fuel facility is under construction in the central area of Stebbins. These facilities are construction above flood level and will be able to operate safely during flooding events, such as occurred during a November, 2013 storm. Note that the new Stebbins power plant and bulk fuel facility is sized to accommodate the combined electrical loads of both Stebbins and St. Michael on the assumption that the Stebbins-St. Michael intertie will soon be constructed.

New Stebbins Power Plant and Bulk Fuel Facility, Fall Flood, 2013

Stebbins-Saint Michael Cost Assumptions Table

	Without Intertie		With Intertie	
	Stebbins	Saint Michael	Stebbins	Saint Michael
Energy (MWh/yr)	1,388	1,781	3,204	
Fuel Price ($/gal)	4.00	4.04	4.00	
Efficiency (kWh/gal)	12.98	13.48	14.50	
Non-fuel Expense ($/yr)	$329,138	$421,623	$610,761	
Powerplant Cap. Cost	$4,000,000	$4,000,000	$5,400,000	$750,000
Bulk Fuel Cap. Cost	$2,520,000	$3,220,000	$5,200,000	$227,000
Wind Farm Cap. Cost	$4,324,000	$0	$5,000,725	
Intertie Cap. Cost			$3,763,000	

The following table documents the assumptions of the Stebbins-Saint Michael intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix F.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Stebbins	Powerplant	2013	Estimated cost of new powerplant if intertie were not constructed.
	Bulk Fuel Facility	2012	Cost estimate of 180,000 gal storage capacity at $14/gal.
	Wind Farm	2013	Four NW100 wind turbines at the Cape Stephans wind power site based on a construction cost estimate developed for the Stebbins wind power conceptual design report (2012).

Village	Capital Cost Item	Cost Year	Basis
Saint Michael	Powerplant	2013	Estimated cost of new powerplant if intertie were not constructed.
	Bulk Fuel Facility	2013	Cost estimate of 230,000 gal storage capacity at $14/gal.
	Wind Farm	2013	A Class 5 wind power site was measured on Saint Michael Corporation land, but availability for turbine construction was denied due to use of the site as a sellable gravel resource. Modeling suggests other site options in Saint Michael of low wind energy value and not developable.
With Intertie			
Stebbins	Powerplant	2013	Budget as funded for powerplant under construction in 2013. Powerplant was constructed with sufficient generation capacity to power both Stebbins and Saint Michael under presumption that intertie would be constructed.
	Bulk Fuel Facility	2012	AVEC portion of bulk fuel project: 410K gal of 788K gal; total project cost $10.0M
	Wind Farm	2013	One EWT-900 wind turbine at the Cape Stephans wind power site based on a construction cost estimate developed for the Stebbins wind power conceptual design report (2012).
Saint Michael	Powerplant	2013	Based on standard cost for a standby power module constructed on pilings.
	Bulk Fuel Facility	2013	Based on 27,000 gal storage capacity for standby generator (part of Denali project #38A)
Intertie		2013	Estimated cost of intertie; approximately $355,000 per mile cost based on previous projects in similar terrain.

Economic Analysis

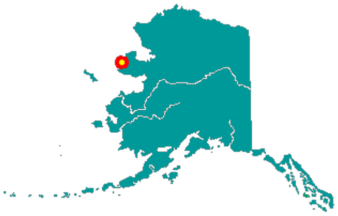
The economic benefit of a distribution intertie connecting Saint Michael to Stebbins is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the Stebbins-St. Michael economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Stebbins and Saint Michael. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

Stebbins-St. Michael 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	156.0	140.0	1.11
	3	78.7	73.7	1.07
No	0	161.6	147.8	1.09
	3	80.1	76.0	1.05

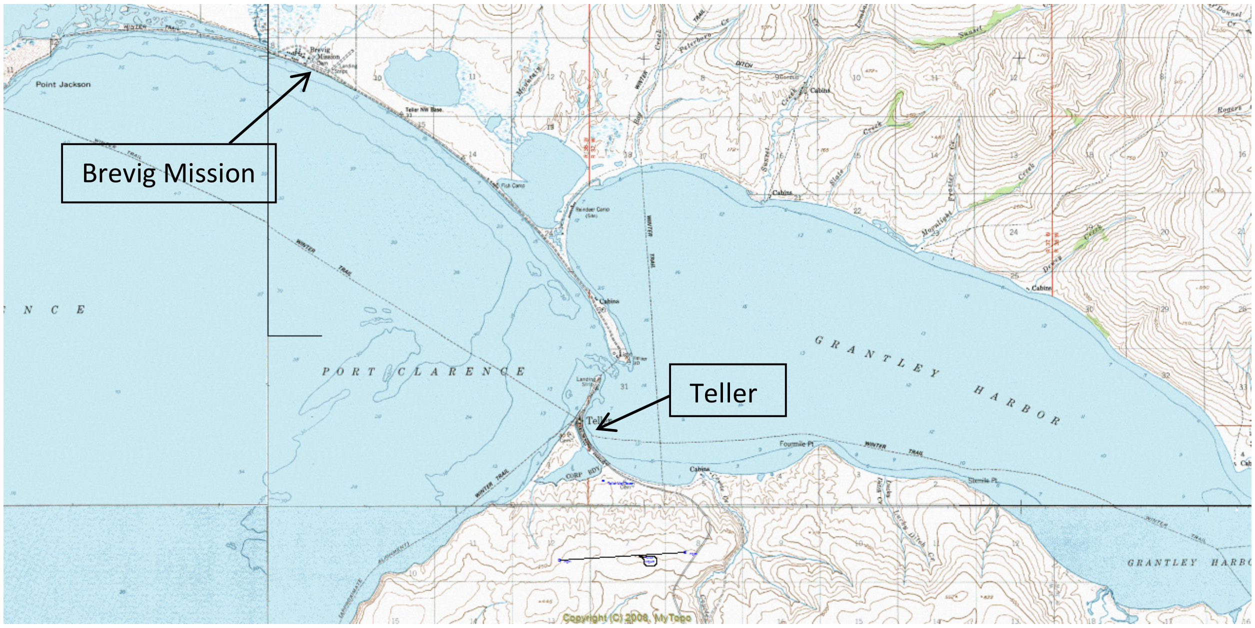
Brevig Mission-Teller



Brevig Mission (pop. 414) is located at the mouth of Shelman Creek on Port Clarence, five miles northwest of Teller and 65 miles northwest of Nome in the Nome Census Area. Teller (pop. 245) is located on a spit between Port Clarence and Grantley Harbor six miles southeast across Port Clarence from Brevig Mission. New development of Teller, including the airport, is on higher ground on the mainland. A gravel road connects Teller to Nome.

Completed in November 2011, AVEC intertied Brevig Mission to Teller and upgraded the Brevig Mission powerplant to serve as the primary operations center. The intertie was intended to be operational by late 2011 but the underwater connection spanning the channel between Port Clarence and Grantley Harbor was damaged in a severe wind storm in November 2011 and has not yet been fully repaired. Once the intertie is fully functional, which may require rerouting, the Teller powerplant can be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Brevig Mission and Teller



Electric Loads and Generation

The diesel generators in the Brevig Mission powerplant, built in 2010, have sufficient capacity at present to power both Brevig Mission and Teller if intertied with sufficient excess capacity to meet N-1 criteria where the largest generation unit is out-of-service. For Brevig Mission, loss of the largest generation unit, a 505 kW capacity Caterpillar 3456 diesel generator, would result in two remaining diesel generators to meet load demand: a 236 kW Detroit Diesel S60K4 and a 363 kW Detroit Diesel S60K4. Combined capacity of these two diesel generators is 599 kW, which would be sufficient to meet a combined village peak load demand of approximately 460 kW. This N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

Brevig Mission and Teller Generator and Load Data

	Brevig Mission		Teller		Intertied (Brevig Mission as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	236	2010	124		236	2010
2	363	2010	156		363	2010
3	505	2010	297		505	2010
			150			
			87			
			236			
Total	1,104		1,050		1,104	
Avg Load (kW)	140		100		240	
Peak Load (kW)	271		190		461	
Firm Capacity (N-1)	599		753		599	

Renewable Energy Options

Practical renewable energy options for electricity generation in Brevig Mission and Teller are limited to wind power.   Wind power sites options have been extensively investigated in the Brevig Mission and Teller area and although it would be desirable to locate wind turbines near Brevig Mission as Brevig Mission will be the base powerplant for the intertied communities, a suitable site could not be identified. The focus instead has been on Teller where several site options exist. With hopes that a suitable wind resource could be found very near Teller, a met tower was installed in November 2009 on the sloped terrain between the village center and the airport. Data analysis, however, indicates only a marginal wind resource.

Another effort to find and measure a better wind resource near Teller was initiated in 2011 and several sites south of the airport were identified. This area was always assumed to have a superior wind resource, but the cost of distribution connection was considered a drawback. But, with no other site options possible, a second met tower was installed on a site approximately 1.7 miles south of the airport and just west of the Teller Highway leading to Nome. This met tower was installed in May, 2012 and data collected to date indicates a substantially more robust wind resource than the first site near the village. Wind turbines in Teller would be installed at or near this site.

Intertie Route

Planning of the Brevig Mission-Teller intertie began in 2009 and construction was completed in 2011, although unfortunately portions of the intertie were damaged in a severe windstorm in November 2011. At time of writing this report, repairs are not fully completed and the intertie is not yet operational.

Two routes were considered during design: an overland route along the shoreline and across the channel separating Port Clarence and Grantley Harbor, and a shorter underwater route across Port Clarence. Both route designs contained approximately 1.4 miles of overhead distribution leading east from Brevig Mission to a point where the route designs split with underground but land-based distribution continuing along the shoreline or the underwater route across the Port. The overland route was administratively complex due to a large number of Native allotments that had to be crossed and slightly longer than the underwater route. After careful consideration of construction cost estimates and risk evaluation, AVEC choose to construct the intertie along the overland route.

Brevig Mission-Teller Intertie Route

Assumptions and Special Issues

The entire line was constructed by early November, 2011. However on November 9, 2011 one of the most powerful cyclonic storms to ever affect Alaska swept ashore along the Bering Sea coast. Thirty-seven villages experienced damaged and in Teller one person was swept off the Spit and lost. This area normally would have been protected by shorefast ice but the ice had not yet formed at the time of the storm. Segments of the spit eroded and the underwater cable and cabinets were damaged. The damage assessment continued through 2012 and by December the line remained out of service as repairs or relocation were considered. Note that lower cost of new powerplant in Brevig Mission is due to procurement of equipment from past years.

Brevig Mission-Teller Cost Assumptions Table

	Without Intertie		With Intertie	
	Brevig Mission	Teller	Brevig Mission	Teller
Energy (MWh/yr)	1,229	882	2,129	
Fuel Price ($/gal)	3.53	4.08	3.53	
Efficiency (kWh/gal)	13.97	11.37	14.00	
Non-fuel Expense ($/yr)	$279,831	$204,955	$400,000	
Powerplant Cap. Cost	$0	$4,000,000	$0	$650,000
Bulk Fuel Cap. Cost	$0	$1,500,000	$5,400,000	
Wind Farm Cap. Cost	$0	$2,040,000	$6,120,000	
Intertie Cap. Cost			$4,230,000	

The following table documents the assumptions of the Brevig Mission-Teller intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix G.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Brevig Mission	Powerplant	2010	Estimated construction cost if built to serve only Brevig Mission.
	Bulk Fuel Facility	2013	Based on 135,000 gal of required storage capacity at $12.00/gallon for on-grade construction.
Teller	Powerplant	2013	Estimated cost of new powerplant.
	Bulk Fuel Facility	2013	Based on 108,000 gal of required storage capacity at $13.00/gallon for on-grade construction.
	Wind Farm	2013	Two Northwind 100 wind turbines at the lower Teller met tower site based on AEA’s 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
With Intertie			
Brevig Mission	Powerplant	2013	Actual cost of construction; powerplant completed in 2010.
	Bulk Fuel Facility	2011	Actual cost of construction; bulk fuel facility completed in 2010.
Teller	Powerplant	2013	Based on standard cost for a standby power module constructed on grade.
	Wind Farm	2013	Six Northwind 100 wind turbines at the upper Teller met tower site based on AEA’s 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Intertie		2011	Actual cost of construction; intertie completed in 2011. Nov. 2011 storm damage not accounted for and repair costs not yet funded.

Economic Analysis

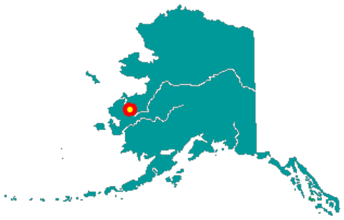
The economic benefit of a distribution intertie connecting Teller to Brevig Mission is presented in the below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the Brevig Mission-Teller 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Brevig Mission and Teller. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

Brevig Mission-Teller 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	99.7	76.5	1.30
	3	49.9	37.7	1.32
No	0	102.9	83.6	1.23
	3	50.8	39.2	1.30

Saint Mary's-Mountain Village-Pilot Station



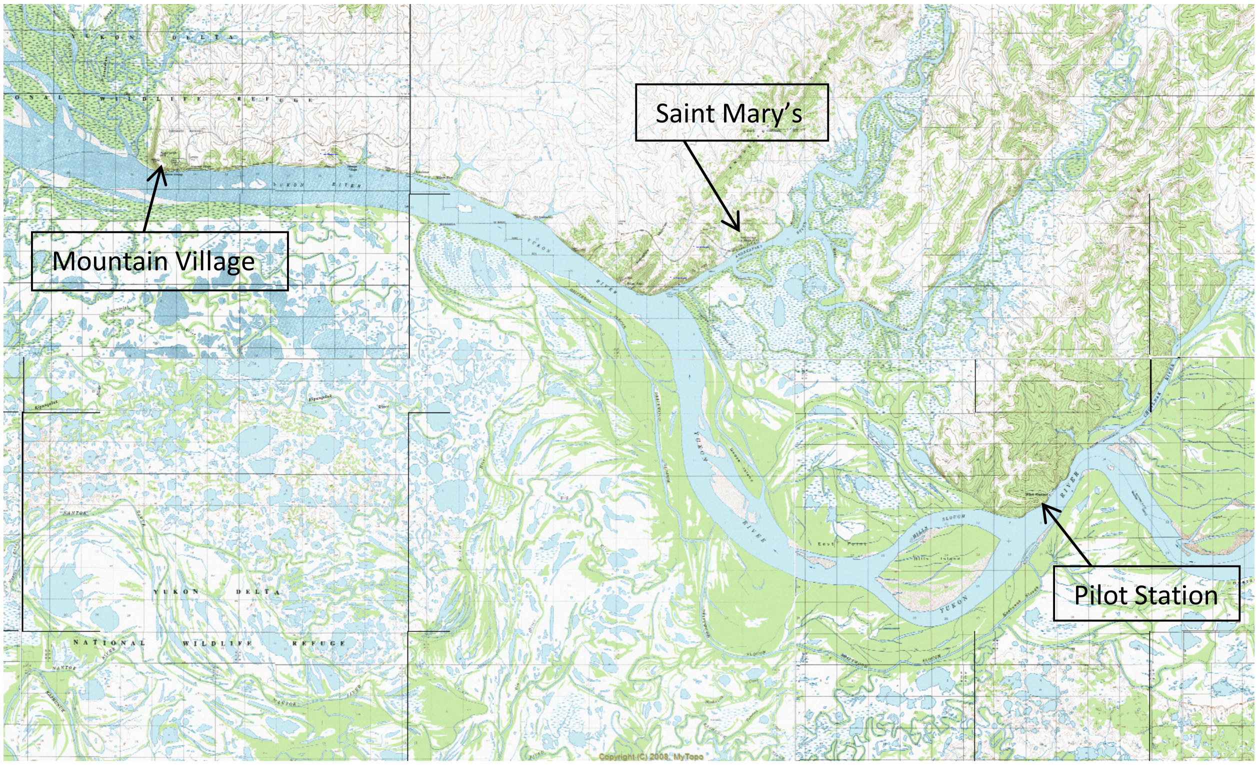
St. Mary's (pop. 554) is located on the Andreafsky River, just north of its confluence with the Yukon River and 130 miles northwest of Bethel in the West Hampton Census Area. Mountain Village (pop. 835) lies on the Yukon River eighteen miles west of Saint Mary's. Pilot Station (pop. 583) is located on the Yukon River twelve direct-line and twenty river miles upriver or southeast of Saint Mary's.

Pitka's Point (pop. 93), which is already intertied (via single phase distribution) with St. Mary's, is located four miles south of St. Mary's on the Yukon River.

A gravel road connects St. Mary's to Pitka's Point with a branch road to the Saint Mary's airport. The road to the airport continues a further sixteen (road) miles to Mountain Village. The existing electrical intertie connecting Saint Mary's to Pitka's Point (single phase), with a branch line serving the Saint Mary's airport (a separate single phase) is located in an easement alongside the roads. Saint Mary's and Pilot Station are not connected by a road or any other infrastructure improvement.

This case proposes to intertie Saint Mary's to both Mountain Village and Pilot Station and upgrade the Saint Mary's powerplant to serve as the primary operations center. The present Mountain Village and Pilot Station powerplants would be decommissioned and the villages equipped with standby powerplants.

Topographic Map of Saint Mary's, Mountain Village and Pilot Station



Electric Loads and Generation

The diesel generators in the Saint Mary's powerplant do not have sufficient capacity at present to power Saint Mary's (plus Pitka's Point), Mountain Village *and* Pilot Station if intertied with consideration of N-1 criteria where the largest generation unit is out-of-service. For Saint Mary's, loss of the largest generation unit, a 908 kW capacity Caterpillar 3512 diesel generator, would result in two remaining diesel generators to meet load demand: a 499 kW Cummins QXS15 and a 611 kW Caterpillar 3508. Combined capacity of these two diesel generators is 1,110 kW, which is not sufficient to meet a possible combined village peak load demand of approximately 1,540 kW. The N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

If Saint Mary's is intertied to Mountain Village and Pilot station with Saint Mary's as the primary or base powerplant and Mountain Village and Pilot Station equipped with standby powerplants, the Saint Mary's powerplant must be expanded with additional diesel generator unit(s) to accommodate the combined electrical load of all three villages.

St. Mary's, Mountain Village and Pilot Station Generator and Load Data

	Saint Mary's		Mountain Village		Pilot Station		Intertied (Saint Mary's as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	499	2006	350	1984	397	1988	499	2006
2	611	1987	505	2005	499	2005	611	1987
3	908	1995	601	1982	314	2006	908	1995
Total	2,018		1,456		1,210		2,018	
Avg Load (kW)	368		324		202		894	
Peak Load (kW)	616		542		381		1,539	
Firm Capacity (N-1)	1,110		1,055		583		1,110	

Renewable Energy Options

Practical renewable energy options for electricity generation in Saint Mary's and Mountain Village are limited to wind power, although potential exists for the development of hydrokinetic power in the Yukon River to serve village power needs. AVEC began the process of wind power development in Saint Mary's and surrounding villages in 2007 with a reconnaissance effort to select suitable wind sites. Several potential wind power sites at or near Saint Mary's were identified but two were selected that were thought to have the most potential: a bluff site overlooking the Yukon River on Pitka's Point Native Corporation land immediately northeast of the village of Pitka's Point, and a site on Saint Mary's Corporation Land at lower elevation approximately one mile to the northeast of the Pitka's Point site.

In Mountain Village, a prospective wind site was identified on a plateau about two miles east of the airport, between the Yukon River and the road to Saint Mary's. For Pilot Station, a good prospective wind site was identified on the ridge just north of the village, but it was never measured due to Native Allotment land ownership restrictions and future airspace restrictions with FAA's planned new airport.

Met towers were installed on the Pitka's Point site in 2007, the Saint Mary's site in 2008, and the Mountain Village site in 2009. Despite some problems with damage due to icing conditions in Saint

Mary's, all three wind measurement projects were successfully concluded. The Pitka's Point site is outstanding with a Class 6 wind resource while the Saint Mary's site, measured at Class 4, is also very good, but not the equivalent of the nearby Pitka's Point site. Modeling of the Pitka's Point wind data confirmed the significant variability of the wind resource surrounding the two met Saint Mary's area met tower sites. The Mountain Village site measured an excellent Class 5 wind resource, the near equivalent of the Pitka's Point site with respect to wind power, but with fewer icing events.

It is assumed that without an intertie, wind power development for Saint Mary's (plus Pitka's Point) alone would consist of four Northwind 100 (100 kW) wind turbines located at the Pitka's Point site and connected to the distribution line that connects Saint Mary's to Pitka's Point and the Saint Mary's airport. It is also that without an intertie, wind power development for Mountain Village would consist of four Northwind 100 (100 kW) wind turbines located at the Mountain Village site east of the airport and connected to Mountain Village with approximately three miles of new distribution line.

If intertied, the large combined electric and (potential) thermal loads would enable increased wind power capacity and/or installation of more powerful wind turbines than the Northwind 100. AVEC proposed via the Alaska Energy Authority Renewable Energy Fund Round process installation of one EWT 52-900 (900 kW) wind turbine to be located at the Pitka's Point site to serve a combined Saint Mary's and Pilot Station load. The EWT turbine has a lower per kilowatt capacity installed cost than the Northwind 100 turbine and has additional advantages such as variable pitch control rotors and scalable power output, via pitch control, to tune the turbine to a lower maximum power output should less capacity be necessary to manage the electric and thermal loads.

Intertie Route

The proposed Saint Mary's to Mountain Village intertie route for the most part follows the existing gravel roadway between the Saint Mary' airport and the Mountain Village airport. This roadway, with additional tundra protection in some areas, may allow for summer season construction. The road generally follows higher and better drained topography but crosses surface drainages, ponded wet areas, or other low lying areas. The intertie alignment may in some sections cross undisturbed areas to reduce overall length and to straighten the line.

Route designs for a Saint Mary's to Pilot Station intertie were recently developed for AVEC by CRW Engineering Group, LLC. Two options were considered: a shorter lowlands route and a longer uplands route. Details of the decision process are documented elsewhere, but ultimately the longer and mostly uplands route was favored and forwarded as a construction funding proposal to Alaska Energy Authority in the 2012 Renewable Energy Fund Round 6 process.

Mountain Village-Saint Mary's-Pilot Station Intertie Route

Assumptions and Special Issues

Although Saint Mary's and Mountain Village have roughly equivalent populations and electrical load demands, this case intends that Saint Mary's host the primary power plant and Mountain Village be equipped with a standby generator and fuel storage for emergency mode operation. Saint Mary's is the more centrally located of the two villages with respect to AVEC's larger options to extend the intertie to Pilot Station. With the Pitka's Point wind site identified as the primary location for wind turbines, the relative ease of travel to Saint Mary's with direct flight service from Anchorage, and the superior present condition of the Saint Mary's powerplant, centralizing power generation in Saint Mary's is the optimal solution.

Given the larger size of Saint Mary's population, the larger power plant, and the superior airport, this case intends that Saint Mary's would host the primary power plant and Pilot Station would be equipped with a standby generator and fuel storage for emergency mode operation in event of loss of the intertie or a similar emergency event. Also, flooding potential at the Pilot Station power plant and cost issues to relocate the power plant and tank farm support the decision to base power generation in Saint Mary's.

St. Mary's, Mountain Village and Pilot Station Cost Assumptions Table

	Without Intertie			With Intertie		
	Saint Mary's	Mountain Village	Pilot Station	Saint Mary's	Mountain Village	Pilot Station
Energy (MWh/yr)	3,220	2,839	1,770	6,116		
Fuel Price ($/gal)	4.27	3.96	3.71	4.27		
Efficiency (kWh/gal)	13.83	14.57	13.06	14.00		
Non-fuel Expense ($/yr)	$683,198	$690,979	$421,302	$1,515,479		
Powerplant Cap. Cost	$5,000,000	$5,000,000	$7,045,000	$5,400,000	$750,000	$1,006,000
Bulk Fuel Cap. Cost	$4,500,000	$3,500,000	$4,930,000	$9,000,000		
Wind Farm Cap. Cost	$4,080,000	$4,800,000	$0	$6,153,991		
Intertie Cap. Costs					$7,449,000	
					$6,500,000	

The following table documents the assumptions of the St. Mary's-Mountain Village-Pilot Station intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix H.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Saint Mary's	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 300,000 gal of required storage capacity at $15.00/gallon for pile construction.
	Wind Farm	2014	Four NW100 wind turbines at the Pitka's Point wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Mtn. Village	Powerplant	2014	Based on cost of construction of new powerplants in Chevak and Brevig Mission.
	Bulk Fuel Facility	2014	Based on 250,000 gal of required storage capacity at $14.00/gallon for on-grade construction.
	Wind Farm	2014	Four NW100 wind turbines at the Mountain Village wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW, plus three miles new distribution at $200,000 per mile.
Pilot Station	Powerplant	2014	Based on May 2014 estimate by CRW for new relocated powerplant.
	Bulk Fuel Facility	2014	Based on May 2014 estimate by CRW for new relocated bulk fuel facility (AVEC portion).
With Intertie			

Village	Capital Cost Item	Cost Year	Basis
Saint Mary's	Powerplant	2014	2012 CAPSIS request for construction of a St. Mary's regional power plant to power St. Mary's, Pitka's Point, Mtn. Village, and Pilot Station.
	Bulk Fuel Facility	2014	2012 CAPSIS request; based on 650,000 gal of required storage capacity at $13.80/gallon for pile construction.
	Wind Farm	2014	Larger EWT 52-900 turbine possible with the combined load of Saint Mary's and Mountain Village if intertied. Cost estimate by CRW Engineering Group for AVEC's Renewable Energy Fund Round 6 design proposal. Turbine would be located at the Pitka's Point wind power site.
Mtn. Village	Powerplant	2014	Based on standard cost for a standby power module constructed on grade.
Pilot Station	Powerplant	2014	Based on May 2014 estimate by CRW for a standby power module constructed on grade.
	Bulk Fuel Facility	2014	Based on May 2014 estimate by CRW for new relocated bulk fuel facility to serve standby powerplant (AVEC portion).
Intertie		2014	Mountain Village to Saint Mary's intertie construction cost estimate by STG, Inc. for AEA Renewable Energy Fund Round 6 design proposal. Saint Mary's to Pilot Station intertie construction cost estimate, updated to present, by CRW Engineering for AEA Renewable Energy Fund Round 6 construction proposal for upload route design.

Economic Analysis

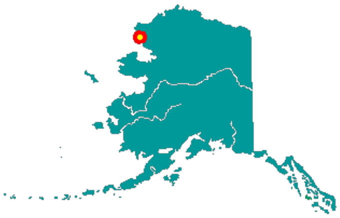
The economic benefit of a distribution intertie connecting both Mountain Village and Pilot Station to Saint Mary's is presented in the table below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbine configurations as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the St. Mary's-Mountain Village-Pilot Station 50- year economic benefit table, with and without consideration of wind power development it is economically beneficial to intertie Mountain Village, Pilot Station and Saint Mary's. As expected, the economic benefit decreases with a non-zero discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority's default value for Renewable Energy Fund proposal analysis.

St. Mary's-Mountain Village-Pilot Station 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	377.4	337.3	1.12
	3	192.0	174.1	1.10
No	0	388.0	365.0	1.06
	3	194.5	185.7	1.05

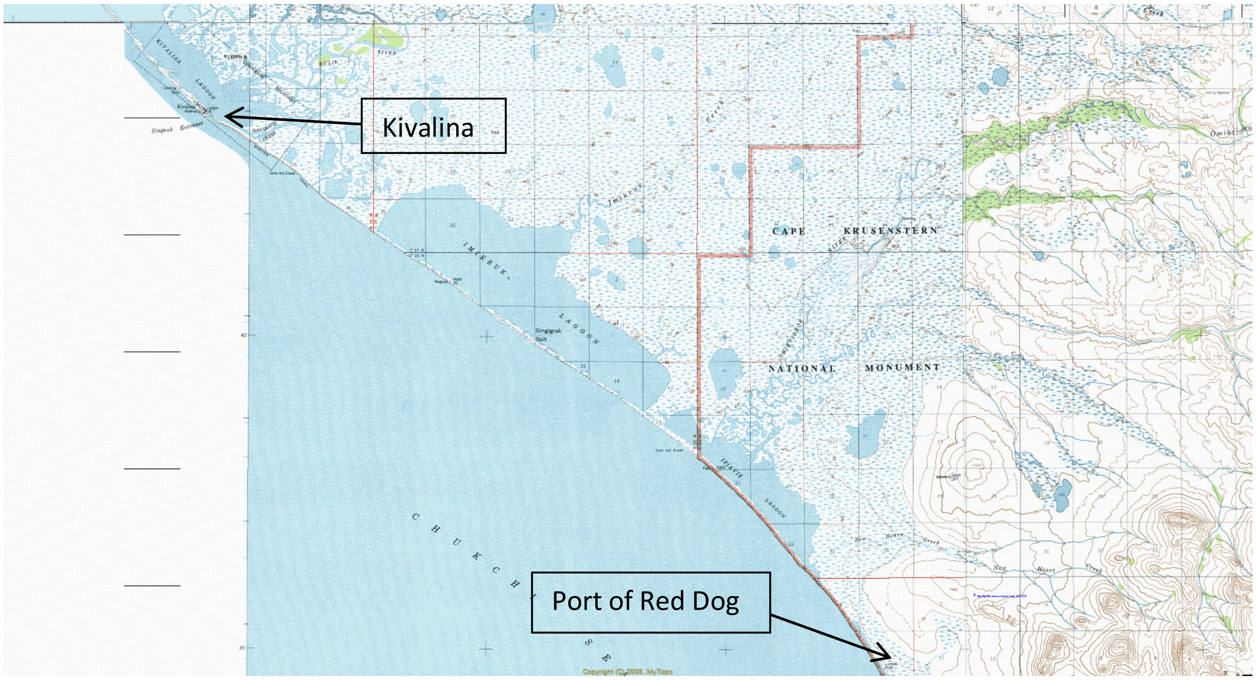
Port of Red Dog-Kivalina



Kivalina (pop. 386) is at the tip of an eight-mile barrier island located between the Chukchi Sea and Kivalina River in the Northwest Arctic Borough. It lies 80 air miles northwest of Kotzebue. The Port of Red Dog serves as the storage and shipping port for zinc and lead ore mined and processed at Red Dog Mine located approximately fifty miles to the northeast and destined for smelters worldwide. Red Dog Mine and the Port of Red Dog are linked by a restricted-access, all-season gravel haul road. Red Dog Mine and Port of Red Dog are located within the Cape Kruesenstern National Monument and were constructed by special authority of the United States Congress to enable access to the Red Dog Mine zinc and lead deposit.

This case proposes to intertie Red Dog Port and Kivalina. Port of Red Dog will be the primary operations center and the present Kivalina powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Port of Red Dog and Kivalina



Electric Loads and Generation

The diesel generators in the Port of Red Dog powerplant do not appear to have sufficient capacity at present to power Port of Red Dog and Kivalina if intertied with consideration of N-1 criteria where the largest generation unit is out-of-service. For Port of Red Dog, loss of the largest generation unit, a 1,285 kW capacity Caterpillar diesel generator, would result in three remaining diesel generators to meet load demand: 650 kW Caterpillars. Combined capacity of these three diesel generators is 1,950 kW, which is not sufficient to meet a possible combined village peak load demand of approximately 2,253 kW. This analysis is nuanced however in that contrary to the typical seasonal load profile of Alaska villages, peak

Port of Red Dog loads occur during the summer shipping season, which is a time of low electric load in Kivalina. Note that the N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

If Port of Red Dog is intertied to Kivalina with Port of Red Dog as the primary or base powerplant and Kivalina equipped with standby powerplants, possibly the Port of Red Dog powerplant must be expanded with additional diesel generator unit(s) to accommodate the combined electrical load.

Red Dog Port Site and Kivalina Generator and Load Data

	Red Dog Port		Kivalina		Intertied (Red Dog Port as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	1,285		229	1996	1,285	
2	650		337	1977	650	
3	650		250	1990	650	
4	650		363	2004	650	
Total	3,235		1,179		3,235	
Avg Load (kW)	929		142		1,071	
Peak Load (kW)	1,988		265		2,253	
Firm Capacity (N-1)	1,950		816		1,950	

Renewable Energy Options

Practical renewable energy options for electricity generation at Port of Red Dog and the village of Kivalina are limited to wind power. Both locations have been monitored for wind resource. For Port of Red Dog, wind measurement instrumentation was installed on a communication tower in October 2008. In Kivalina, a met tower located on the mainland approximately two miles east of the village was installed in May 2011. For both locations, at the writing of this report wind measurement is still active and ongoing.

It is not clear at present which site is most suitable to locate wind turbines. Ideally, wind turbines would be located at Port of Red Dog as it has superior operational capability, but comparison of the wind resource between Port of Red Dog and Kivalina highlights some subtle differences. Although in most respects the wind resource at Port of Red Dog is more robust than at Kivalina with respect to average wind speed, wind power density, and potential wind turbine capacity factor, the Port of Red Dog winds tend toward a distribution comprised mostly of lower speed winds but interspersed with periods of very high winds. Kivalina, on the other hand, experiences a more normal distribution of wind speeds over time with slightly lower average but more constant winds than at Port of Red Dog. Comparing possible wind turbine performance at the two sites, energy production would actually be slightly higher at Kivalina than Port of Red Dog.

Another consideration is the to date un-measured wind resource at the likely location of the new village of Kivalina, which is approximately seven miles northeast of the present location of the village. Should Kivalina be relocated, site options on the flats or in the low hills near the new site may prove developable. This eventuality though is far enough into the future that the short-term analysis of comparative wind resource between Port of Red Dog and Kivalina will most likely concentrate on the sites presented above.

Intertie Route

An intertie to connect Port of Red Dog to Kivalina is conceptual at present, but initial planning has taken place to compare benefits, costs and risk of an overland route versus and undersea route. In many respects, an overland route is more complex in that it is not possible to follow the shortest route between Port of Red Dog and Kivalina due the presence of large lagoons that would force the route to the east. Also of issue is land status with routing that must cross portions of Cape Kreusenstern National Monument that are outside the land use agreement negotiated for the development and operation of Red Dog Mine.

An underwater route, however, presents its own set of challenges with a short construction season, expensive deployment of equipment and most importantly, shallow seawater depth near shore. This latter issue is a concern with respect to ice scouring – the potential for pack ice to raft and turn on edge, which can drag the seafloor in shallow seas and damage underwater infrastructure.

Port of Red Dog-Kivalina Intertie Route

Assumptions and Special Issues

Kivalina is located on the southeastern tip of a barrier island that separates Kivalina Lagoon from the Chukchi Sea. The island is very narrow; only about 675 feet wide throughout the village. In recent years, a warming climate has resulted in increasingly delayed ice pack formation in the Chukchi Sea. The result is that Kivalina is now exposed to the full fury of wind-drive storm waves from early season winter storms, where in the past shore-fast ice protected the village. As a consequence, Kivalina has experienced severe erosion which is increasingly difficult to combat despite concerted effort by the U.S. Army Corp. of Engineers.

The global warming trend of increasing temperatures and reduced Arctic icepack is such that the risk of erosion, flooding, and ultimately loss of viability of the village has led village leadership to conclude that the future of Kivalina requires moving the village to a new location. The selected site is at Kisimigiuktuk Hill, about seven miles northeast of the present village site. Funding has been appropriated for the design of a new school and efforts are underway to find funding for an access road. It is likely that the AVEC power plant and tank farm would ultimately be moved to Kisimigiuktuk Hill after re-location of the school and village administration and other services. Options for an intertie linking Port of Red Dog to Kivalina are explored in a WHPacific and V3 Energy, LLC report entitled *Red Dog Port, Alaska to Kivalina, Alaska Transmission Line*, May 2014. Wind power options for Kivalina, both stand-alone (at its present location and at Kisimigiuktuk Hill) and intertied with Port of Red Dog are explored in a WHPacific and V3 Energy, LLC report entitled *Kivalina Wind-Diesel Conceptual Design Report,* May 2014. Cost analyses included in these reports are referenced in this study.

Port of Red Dog and Kivalina Cost Assumptions Table

	Without Intertie		With Intertie	
	Red Dog Port	Kivalina	Red Dog Port	Kivalina
Energy (MWh/yr)	8,138	1,250	9,413	
Fuel Price ($/gal)	4.00	4.22	4.00	
Efficiency (kWh/gal)	15.00	12.35	14.00	
Non-fuel Expense ($/yr)	$600,000	$293,464	$700,000	
Powerplant Cap. Cost	$0	$1,000,000	$1,000,000	$1,000,000
Bulk Fuel Cap. Cost	$0	$0	$0	
Wind Farm Cap. Cost	$4,080,000	$2,800,000	$6,120,000	
Intertie Cap. Cost			$7,280,000	

The following table documents the assumptions of the Port of Red Dog-Kivalina intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix I.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Port of Red Dog	Powerplant	2013	No modification necessary.
	Bulk Fuel Facility	2013	No extra capacity needed.
	Wind Farm	2013	Not considered.
Kivalina	Powerplant	2013	It is assumed that this will be financed as part of a village relocation effort to Kisimigiuktuk Hill.
	Bulk Fuel Facility	2013	It is assumed that this will be financed as part of a village relocation to Kisimigiuktuk Hill.

	Wind Farm	2013	Two NPS 100/21 turbines (200 kW capacity) at Kisimigiuktuk Hill at $13,800/kW installed cost.
With Intertie			
Port of Red Dog	Powerplant	2013	$1,000,000 is estimated for new controls and switchgear to accommodate Kivalina and wind turbines.
	Bulk Fuel Facility	2013	Expansion or modification of the Port of Red Dog bulk fuel storage infrastructure is not required to accommodate the Kivalina load.
	Wind Farm	2013	One EWT DW 52-900 wind turbine (900 kW capacity) at $7,200/kW installed cost.
Kivalina	Powerplant	2013	Assumed cost for construction of a standby powerplant.
Intertie		2014	Estimated cost of $13.5 million is the midpoint of a $12-$15M estimate for a 22 mile intertie.

Economic Analysis

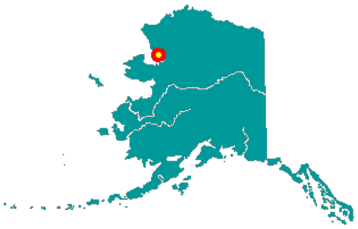
The economic benefit of a distribution intertie connecting Kivalina to Port of Red Dog is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As presented in the Port of Red Dog-Kivalina 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Port of Red Dog and Kivalina. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analyses.

Port of Red Dog-Kivalina 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	262.5	282.8	0.93
	3	124.9	141.2	0.88
No	0	275.6	293.0	0.94
	3	130.3	144.5	0.90

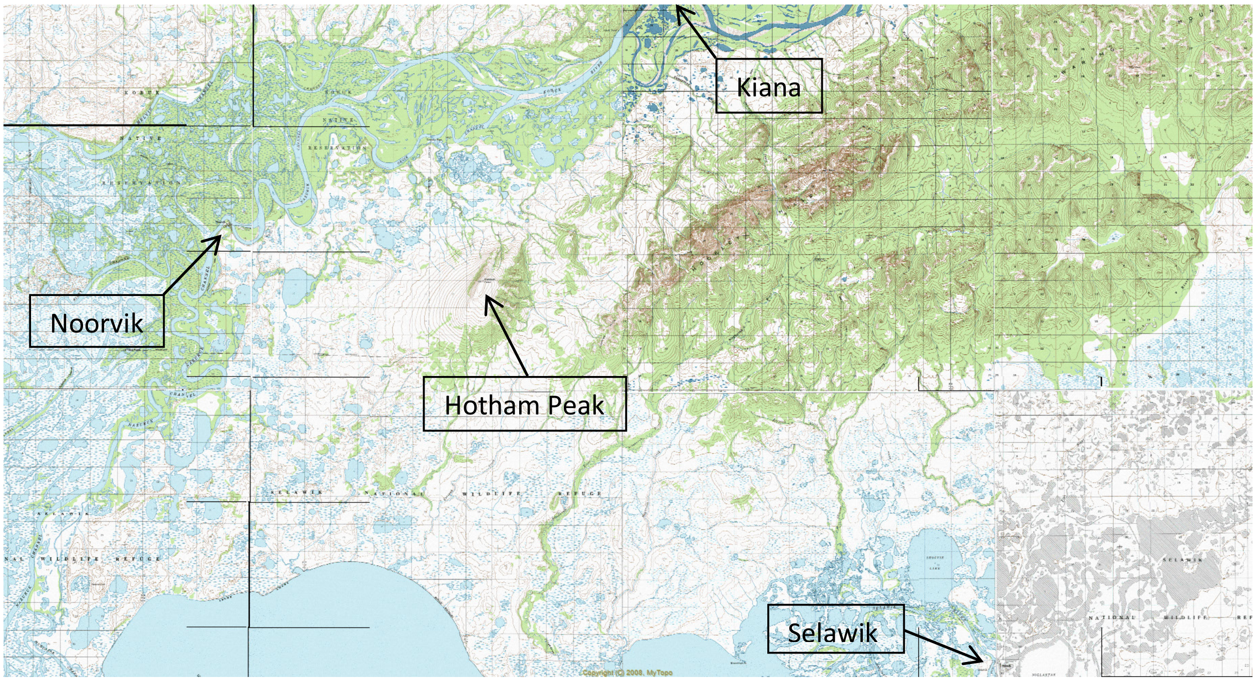
Noorvik-Selawik-Kiana



Noorvik (pop. 643) is located on the right bank of the Nazuruk Channel of the Kobuk River, 45 miles east of Kotzebue. The village is downriver from the 1.7-million acre Kobuk Valley National Park. Selawik (pop. 868) is located 33 miles southeast of Selawik at the mouth of the Selawik River, where it empties into Selawik Lake, about 90 miles east of Kotzebue in the Northwest Arctic Borough. The city is near the Selawik National Wildlife Refuge. Kiana (pop. 372) is located on the north bank of the Kobuk River 19 miles northeast of Noorvik.

This case proposes to intertie Noorvik to Selawik and Noorvik to Kiana and to upgrade the Noorvik powerplant to serve as the primary operations center with possible parallel operation with the Selawik powerplant in a primary generation mode. The present Kiana powerplant would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Noorvik, Selawik and Kiana



Electric Loads and Generation

The diesel generators in the Noorvik powerplant do not have sufficient capacity at present to power Noorvik, Selawik, and Kiana if intertied with consideration of N-1 criteria where the largest generation unit is out-of-service. For Noovik, loss of the largest generation unit, a 710 kW capacity MTU 12V2000 diesel generator, would result in two remaining diesel generators to meet load demand: a 363 kW Detroit Diesel S60K4c and a 499 kW Cummins K19G4. Combined capacity of these two diesel generators is 862 kW, which is not sufficient to meet a possible combined village peak load demand of approximately 1,500 kW. The N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

If Noorvik is intertied to Selawik and Kiana with Noorivk as the primary or base powerplant and Selawik and Kiana equipped with standby powerplants, the Noorvik powerplant must be expanded with additional diesel generator unit(s) to accommodate the combined electrical load of all three villages.

Selawik, Noorvik and Kiana Generator and Load Data

	Selawik		Noorvik		Kiana		Intertied (Selawik as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	363		363		324		363	
2	499		499		350		499	
3	824		710		499		824	
Total	1,686		1,572		1,173		1,686	
Avg Load (kW)	332		232		177		741	
Peak Load (kW)	628		466		401		1,495	
Firm Capacity (N-1)	862		862		674		862	

Renewable Energy Options

Selawik is equipped with four AOC 15/50 (50 kW) wind turbines that were installed in 2003. These wind turbines have performed poorly, due primarily to retraction and latching problems with the aerodynamic tip brakes on the rotor tips, but also problems with gearbox lubrication and supervisory controller function have been noted. Another, and perhaps most important, reason for poor generator performance in Selawik is that the wind regime in Selawik is marginal (Class 2). At the time of installation of the AOC 15/50 wind turbines, it was thought that winds in Selawik were comparable to those in Kotzebue, where several wind turbines were operational at the time, but this may not be the case.

The investigation of Noorvik for possible wind sites began about ten years ago with erection of a met tower approximately six miles east of the village on a prominent rise about two miles east of Hotham Peak. This site was chosen because of its presumed good wind exposure and because it is along the road to a quarry which is located at the foot of Hotham Peak. Results of this study indicated moderate winds at this site. Follow-on wind studies in Noorvik have focused on sites very near the village and the original met tower site six miles to the east. Comparative analysis is not completed, but the general conclusion is that the wind resource near the village is less vigorous for wind power development. The wind resource at the site six miles to the east is stronger, but the cost to extend power distribution to the site appears to negate the wind power advantage.

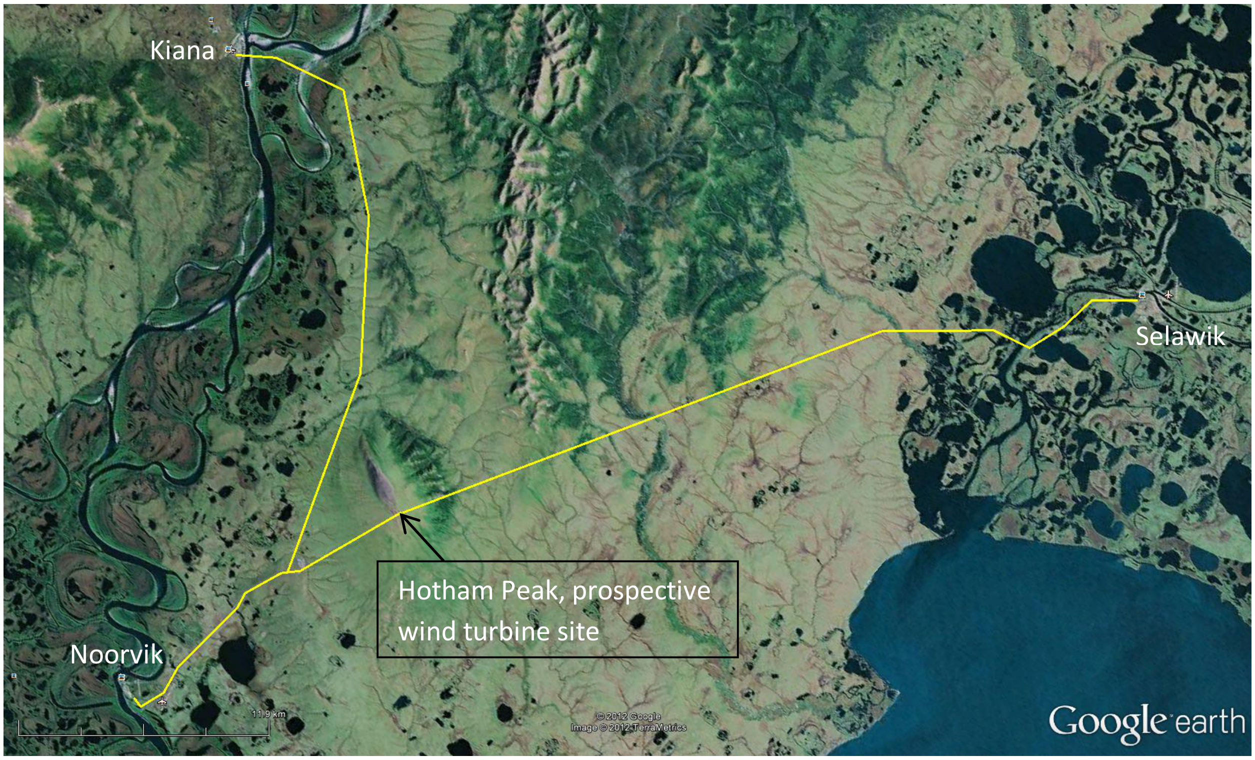
Kiana has not been monitored for its wind power resource. A ridge site near the village with possibly a good wind resource is not available due to proximity and orientation of the airport runway. Other wind sites may be possible in the hills west of the village, but access for development would be expensive and difficult.

Modeling of the Noorvik wind resource identified Hotham Peak as likely possessing an exceptionally good wind resource. Hotham Peak is reachable by all-terrain vehicle from the Noorvik rock quarry, but is too far away from Noorvik to be considered as a viable wind power site to power Noorvik alone. Hotham Peak could, however, possibly be developed with larger wind turbines if the load were expanded with interties to include Selawik and Kiana. Modeling indicates a likely Class 5 to Class 6 wind resource on the south-facing upper slope of the peak. A met tower on Hotham Peak would be needed to verify the resource.

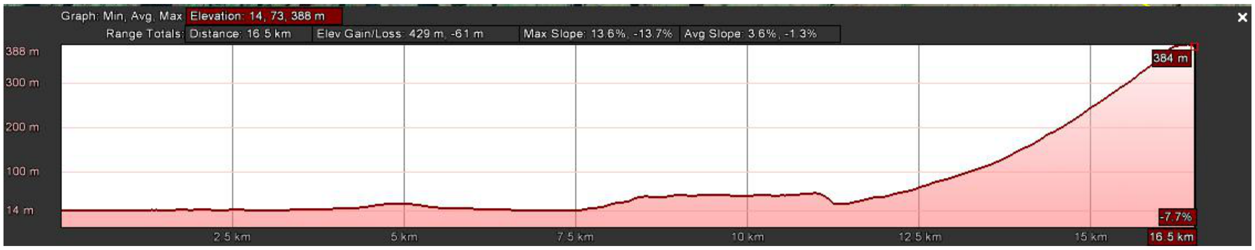
Intertie Routes

The intertie routes to electrically connect Selawik, Noorvik and Kiana would be comprised of a 32 mile main route linking Noorvik to Selawik via the wind power site on Hotham Peak and a fifteen mile auxiliary route connecting Kiana to a location on the Selawik-Noorvik intertie at or near the Noorvik met tower site approximately two miles west of Hotham Peak. The route immediately east of Noorvik would presumably follow the Noorvik quarry road to the quarry and possibly along a road easement to the Hotham Peak wind power site. Beyond Hotham Peak, however, the proposed route crosses mostly undeveloped upland landscape, expect for near Selawik where the route crosses extremely marshy terrain. The proposed Noorvik to Kiana intertie route (from the start point several miles east of Noorvik) would cross undeveloped terrain that would be upland to the extent possible but would require traversing the marshy terrain of the Kobuk River valley and a crossing of the river itself.

Selawik-Noorvik-Kiana Intertie Route



Noorvik-Hotham Peak Intertie Route Elevation Profile



Hotham Peak-Selawik Intertie Route Elevation Profile

Noorvik-Kiana Intertie Route Elevation Profile

Assumptions and Special Issues

The Kobuk River, on the shores of which Noorvik and Kiana are located, is often open earlier and freezes later than freshwater Selawik Lake. This provides a longer fuel delivery season to Noorvik than is available to Selawik because lake ice restricts the season for barge-delivered fuel compared to villages located on Kobuk River.

This case assumes a new power plant at Noorvik with sufficient generation and fuel storage capacity to provide electricity by interties to Kiana and Selawik. Noorvik appears to have sufficient land available for a sub-regional power plant and tank farm.

The electrical intertie to Selawik would route near Hotham Peak, a potential high value wind generation site. An existing road to a quarry at the foot of Hotham Peak would substantially decrease development costs of wind power on Hotham Peak. Note also that the wind resource in and near Noorvik and in Selawik is quite modest, and present analysis indicates a low likelihood of a developable wind resource in Kiana. Development of wind power on Hotham Peak, however, would only be cost effective if tied to a larger load demand than Noorvik alone, hence the value of interties to Selawik and Kiana.

The Selawik power plant and tank farm were newly built in 2003 and are in excellent condition but the facility is too small to power all three villages without an expansion. An alternative however with respect to Noorvik as the base plant is to operate Selawik in parallel with Noorvik. Through continued operation at a set base load the Selawik plan could continue to provide reliable recovered heat to the local water plant. Such operation would also reduce the fuel storage requirement at Noorvik from about 500,000 gallons to less than 420,000 gallons. Fuel storage of less than 420,000 gallons would not be subject to “C” Plan requirements of ADEC. “C” Plan facilities of 420,000 gallons of fuel storage or greater have additional training and drill requirements that must be considered in the cost of facility operation.

Selawik, Noorvik and Kiana Cost Assumptions Table

	Without Intertie			With Intertie		
	Noorvik	Selawik	Kiana	Noorvik	Selawik	Kiana
Energy (MWh/yr)	2,034	2,905	1,556	6,625		
Fuel Price ($/gal)	4.39	4.43	4.49	4.39		
Efficiency (kWh/gal)	13.07	13.61	12.69	14.00		
Non-fuel Expense ($/yr)	$487,121	$657,707	$366,040	$1,230,868		
Powerplant Cap. Cost	$5,100,000	$0	$4,200,000	$5,100,000	$0	$500,000
Bulk Fuel Cap. Cost	$6,800,000	$0	$2,550,000	$6,800,000		
Wind Farm Cap. Cost	$3,060,000	$4,080,000	$0	$5,600,000		
Intertie Cap. Costs				$12,800,000	Noorvik to Selawik	
				$6,000,000	Noorvik to Kiana	

The following table documents the assumptions of the Noorvik-Selawik-Kiana intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix J.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Noorvik	Powerplant	2013	Based on construction cost of new 2 MW power plant in Stebbins, adjusted for on-grade vs. pile construction.
	Bulk Fuel Facility	2013	Based on 400,000 gal of required storage capacity at $17.00/gallon for pile construction.
	Wind Farm	2013	Four NW100 wind turbines at the Noorvik Quarry Road wind power site based on AEA’s 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Selawik	Powerplant	2013	Selawik powerplant does not require an upgrade.
	Bulk Fuel Facility	N/A	New Selawik bulk fuel facility already constructed; hence not valued for this analysis.
	Wind Farm		Repower the existing Selawik wind farm (consisting of four AOC 15/50 wind turbines) with four NW100 wind turbines; cost estimate based on AEA’s 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Kiana	Powerplant	2013	Estimate based on relocation of the powerplant on a pile or triodetic foundation, similar to the

Village	Capital Cost Item	Cost Year	Basis
			powerplant constructed in Brevig Mission in 2010.
	Bulk Fuel Facility	2013	Based on 150,000 gal of required storage capacity at $17.00/gallon for pile construction.
With Intertie			
Selawik	Powerplant	2013	Selawik powerplant does not require an upgrade.
	Bulk Fuel Facility	2013	New Selawik bulk fuel facility already constructed; hence not valued for this analysis.
Noorvik	Powerplant	2013	Based on construction cost of new 2 MW power plant in Stebbins, adjusted for on-grade vs. pile construction; assumes parallel operation with Selawik power plant.
	Wind Farm	2013	Larger EWT 54-900 (900 kW) wind turbine located on Hotham Peak possible with the combined load of Selawik, Noorvik and Kiana if intertied. Cost estimate based on CRW Engineering Group for AVEC's Renewable Energy Fund Round 6 construction proposal for an EWT wind turbine in Saint Mary's.
Kiana	Powerplant	2013	Based on standard cost for a standby power module constructed on grade.
Intertie		2013	Estimated Selawik-to-Noorvik project cost based on a 32 mile route at $400,000 per mile; estimated Noorvik-to-Kiana project cost based on a 15 mile intertie route also at $400,000 per mile.

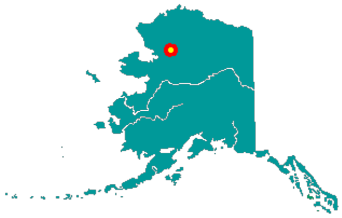
Economic Analysis

The economic benefit of a distribution intertie connecting Noorvik and Kiana to Selawik is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the Selawik-Noorvik-Kiana 50-year economic benefit table, with or without consideration of wind power development it is economically beneficial to intertie Selawik, Noorvik and Kiana. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analysis.

Selawik-Noorvik-Kiana 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	327.8	289.4	1.13
	3	162.7	149.7	1.09
No	0	327.7	310.4	1.06
	3	160.9	158.3	1.02

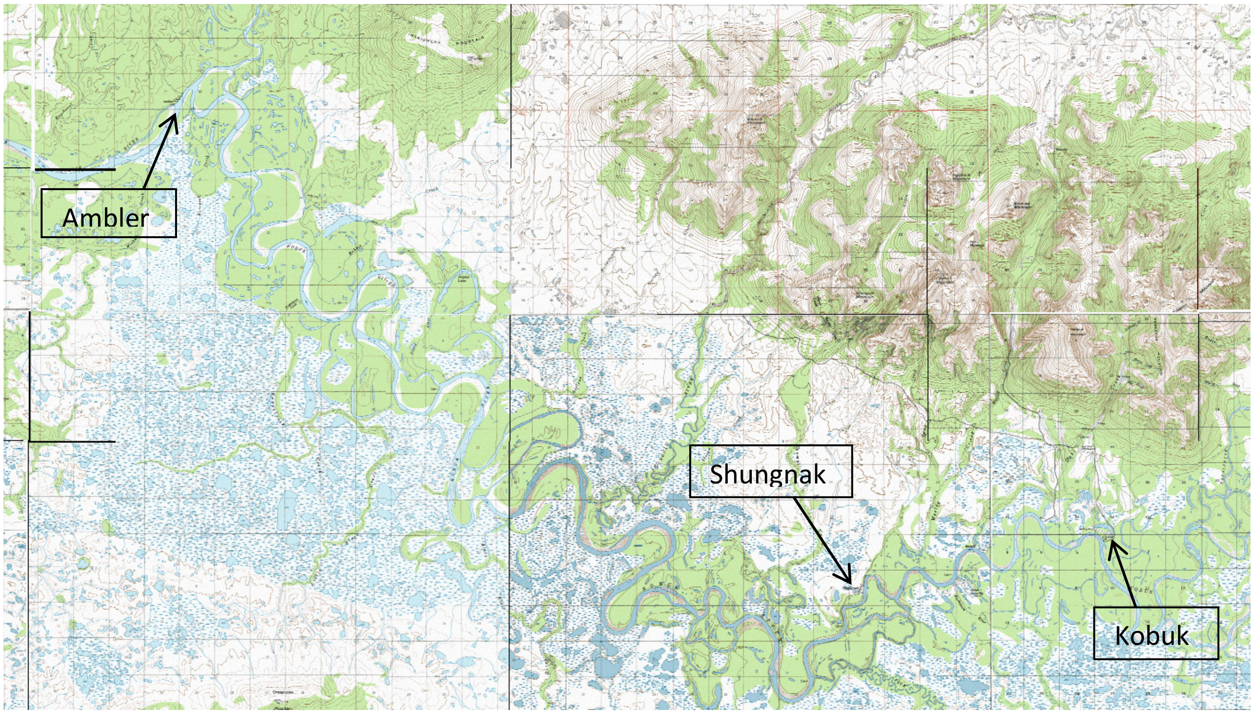


Ambler-Shungnak/Kobuk

Ambler (pop. 276) is located on the north bank of the Kobuk River, near the confluence of the Ambler and Kobuk Rivers in the Northwest Arctic Borough (NWAB). It lies 45 miles north of the Arctic Circle and 138 miles northeast of Kotzebue. Shungnak (pop. 261) is located on the west bank of the Kobuk River about 24 miles southeast of Ambler. The original settlement was ten miles further upstream near Kobuk. Kobuk (pop. 148) is located seven miles northeast of Shungnak and is the smallest village in the NWAB.

This case proposes to intertie Ambler to the existing Shungnak/Kobuk intertie and upgrade the Ambler powerplant to serve as the primary operations center. The present Shungnak powerplant, which also serves Kobuk, would be decommissioned and the village equipped with a standby powerplant.

Topographic Map of Ambler, Shungnak and Kobuk



Electric Loads and Generation

The diesel generators in the Ambler powerplant have sufficient capacity at present to power Ambler, Shungnak and Kobuk if intertied with sufficient excess capacity to meet N-1 criteria where the largest generation unit is out-of-service. For Ambler, loss of the largest generation unit, a 397 kW capacity Cummins K19G2 diesel generator, would result in two remaining diesel generators to meet load demand: a 363 kW Detroit Diesel S60K4 and a 271 kW Cummins K19G2. Combined capacity of these two diesel generators is 634 kW, which would just be sufficient to meet a combined village peak load demand of approximately 634 kW. Possible future load growth, however, may dictate the need to expand the Ambler powerplant with additional generation capacity should the village be intertied. Note that this N-1 analysis does not consider input of wind turbines and assumes that wind turbines, if installed, are off-line or wind energy is not available due to low wind conditions.

Ambler and Shungnak Generator and Load Data

	Ambler		Shungnak-Kobuk		Intertied (Ambler as base powerplant)	
Generator	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed	Installed Capacity (kW)	Year Installed
1	363		202		363	
2	271		335		271	
3	397		314			
4			397		397	
Total	1,031		1,248		1,031	
Avg Load (kW)	149		179		328	
Peak Load (kW)	289		345		634	
Firm Capacity (N-1)	634		851		634	

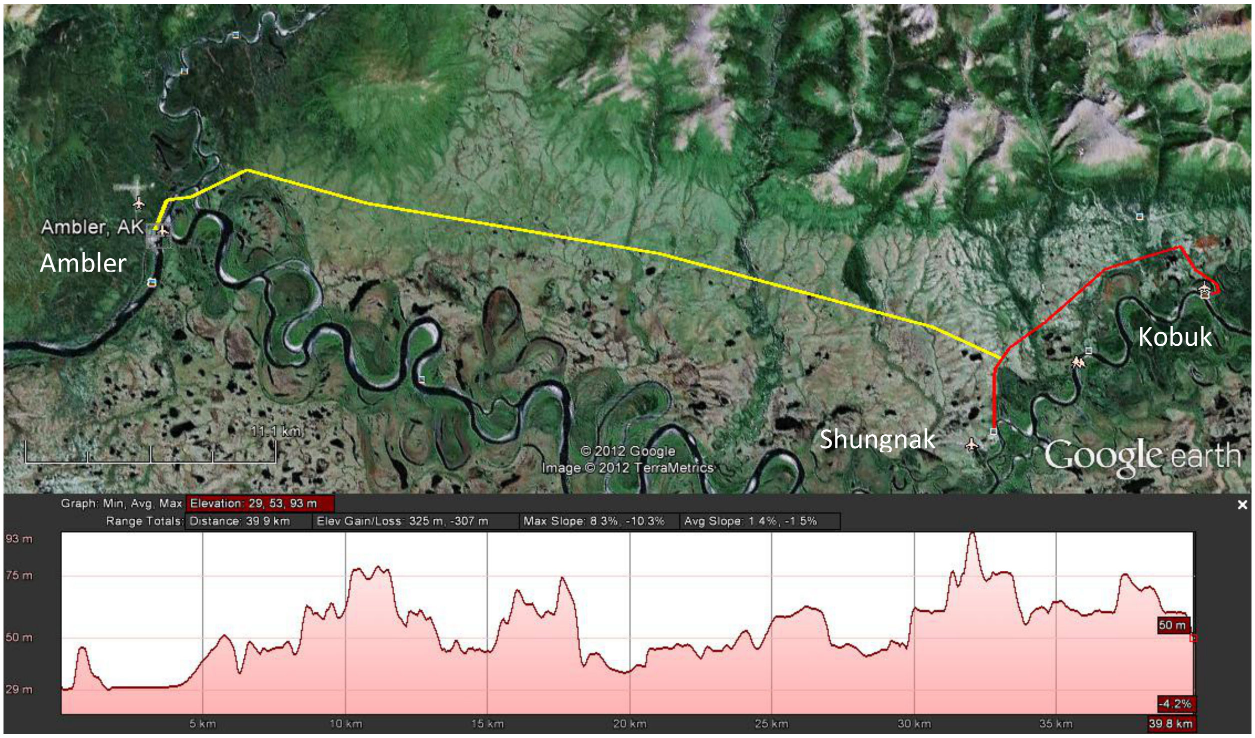
Renewable Energy Options

Wind and hydro power are possible renewable energy options for the upper Kobuk River villages. NANA Regional Corporation has initiated reconnaissance efforts to characterize the hydroelectric potential of the Kogoluktuk River near Kobuk and the wind power potential near Ambler. Either resource, if developed at the noted locations, could provide renewable energy to only the nearby village (Shungnak *and* Kobuk for hydropower as they are already intertied), but the resource could be further shared with an intertie connecting Ambler to Shungnak and Kobuk.

Intertie Route

A 25 mile intertie route to connect Ambler to Shungnak and Kobuk would traverse the base of the Cosmos Hills which mark the northern border of the Kobuk River Valley east of Ambler. One river crossing would be required (the Ambler River) and the intertie would intersect the existing Shungnak-to-Kobuk intertie at a point about two miles northeast of Shungnak. This intertie has been contemplated for many years and land easements are in place across the entire route to support eventual construction.

Ambler-Shungnak/Kobuk Intertie Route



Assumptions and Special Issues

Barge-delivered fuel up the Kobuk River to Shungnak have often been interrupted or made impossible by low water and silt deposits near the marine header at Shungnak. This has necessitated costly air deliveries of fuel to the Shungnak airport and transfer by pipeline to the power plant, school and other facilities. This appears to be a long term problem that may require dredging of the Kobuk River and its slough near Shungnak, or relocation of the marine headers, pipelines and tank farms to solve. Even if accomplished, gravel bars in the Kobuk River that can restrict barge movement upriver to Shungnak during periods of low water.

The village of Ambler, on the Kobuk River downstream from Shungnak and Kobuk, is easier to reach by barge. An alternative for supplying area electrical power needs is to build a regional power plant and associated tank farm at Ambler and connect by an intertie to Shungnak and Kobuk (which are already interconnected by a small intertie). The facilities at Ambler could be constructed on a gravel fill pad and could be located close to the Ambler Airport for ease of maintenance and support.

Ambler and Shungnak/Kobuk Cost Assumptions Table

	Without Intertie		With Intertie	
	Ambler	Shungnak-Kobuk	Ambler	Shungnak-Kobuk
Energy (MWh/yr)	1,309	1,569	2,910	
Fuel Price ($/gal)	5.18	5.32	5.18	
Efficiency (kWh/gal)	13.69	13.60	13.80	
Non-fuel Expense ($/yr)	$314,107	$374,027	$548,134	
Powerplant Cap. Cost	$6,000,000	$3,000,000	$6,000,000	$750,000
Bulk Fuel Cap. Cost	$10,000,000	$2,700,000	$10,000,000	
Wind Farm Cap. Cost	$2,100,000	$0	$4,200,000	
Intertie Cap. Cost			$11,740,000	

The following table documents the assumptions of the Ambler-Shungnak/Kobuk intertie benefit-to-cost spreadsheet model; highlights of which are listed in the cost summary table above. A more complete presentation of cost estimates for the intertie benefit-to-cost input page can be found in Appendix K.

Explanation of Capital Cost Estimates

Village	Capital Cost Item	Cost Year	Basis
Without Intertie			
Ambler	Powerplant	2013	Based on construction cost of new 2 MW power plant in Stebbins, adjusted for on-grade vs. pile construction.
	Bulk Fuel Facility	2013	Based on 300,000 gal of required storage capacity at $17.00/gallon for on-grade construction.
	Wind Farm	2013	Two NW100 wind turbines at the Ambler Hills wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Shungnak	Powerplant	2013	Estimate based on relocation of the powerplant on a pile or triodetic foundation, similar to the powerplant constructed in Brevig Mission in 2010.
	Bulk Fuel Facility	2013	Based on 150,000 gal of required storage capacity at $18.00/gallon for on-grade construction.
With Intertie			
Ambler	Powerplant	2013	Based on construction cost of new 2 MW power plant in Stebbins, adjusted for on-grade vs. pile construction.
	Bulk Fuel Facility	2013	Based on 300,000 gal of required storage capacity at $17.00/gallon for on-grade construction.

Village	Capital Cost Item	Cost Year	Basis
	Wind Farm	2013	Four NW100 wind turbines at the Ambler Hills wind power site based on AEA's 2012 Renewable Energy Fund default wind turbine cost of $10,200/kW.
Shungnak	Powerplant	2013	Based on standard cost for a standby power module constructed on grade.
Intertie		2014	Estimated 2012 CAPSIS project cost of $10M based on an approximate 24 mile route at $450,000 per mile. Additional CAPSIS request of $1M to repair existing Shungnak-to-Kobuk intertie.

Economic Analysis

The economic benefit of a distribution intertie connecting Ambler to Shungnak and Kobuk is presented below. The basic assumptions of this analysis, as described in the methods section of this report, are a fifty year project period, discount rates of zero and three percent for net present value calculations, and inclusion (or not) of wind turbines as described above. The calculated net present values are compared to yield benefit-to-cost ratios.

As indicated in the Ambler-Shungnak/Kobuk 50- year economic benefit table, with or without consideration of wind power development, it is economically beneficial to intertie Togiak and Twin Hills. As expected, the economic benefit decreases with an increasing discount rate as the benefits of the project are spread evenly over fifty years, but the costs are primarily borne in the early years. Not shown below, but as one would expect, with an increase in the value of the discount rate, the benefit-to-cost ratio decreases because future benefits are further devalued while up-front capital costs remain the same. A three percent discount rate was chosen as this is the Alaska Energy Authority default value for Renewable Energy Fund proposal analyses.

Ambler-Shungnak/Kobuk 50-year Economic Benefit

		Net Present Value		
Wind Turbines	Discount Rate, %	Without Intertie, $M	With Intertie, $M	Benefit/Cost
Yes	0	177.5	167.7	1.06
	3	91.2	90.6	1.01
No	0	177.5	167.7	1.06
	3	90.6	89.3	1.01

Appendix A: Emmonak-Alakanuk Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Emmonak to Alakanuk
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2013
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Emmonak
Load Center 2	Alakanuk
Load Center 3	Test Location 3
Primary Ops Ctr	Emmonak
Include Grants in Econ Analysis	No

Primary Ops Ctr: Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

	Depreciation Period	Without Intertie Replacement Period	Without Intertie Replacement Percentage	With Intertie Replacement Period	With Intertie Replacement Percentage	Future
Diesel Generation	15	15	20%	15	20%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Emmonak	Alakanuk	Test Location 3	
Generating Fuel Price ($/gallon)	$3.680	$4.110	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$3.680	$4.110	$0.000	
Sales:				
Base Year		2013		
Base Year Amount (kWh/year)	3,057,674	1,857,897	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	3,220,064	1,972,137	-	
Losses (Pct of Generation)	5.0%	5.8%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M				

	Without Intertie Emmonak	Without Intertie Alakanuk	With Intertie Emmonak	With Intertie Alakanuk
Energy (MWh/yr)	3,220	1,972	5,232	
Fuel Price ($/gal)	3.68	4.11	3.68	
Efficiency (kWh/gal)	13.53	12.44	13.80	
Non-fuel Expense ($/yr)	$767,671	$457,954	$1,085,625	
Powerplant Cap. Cost	$5,200,000	$4,800,000	$5,200,000	$1,000,000
Bulk Fuel Cap. Cost	$5,100,000	$3,600,000	$8,000,000	
Wind Farm Cap. Cost	$4,600,000	$2,040,000	$6,900,000	
Intertie Cap. Cost			$4,600,000	

	Without Interconnection	With Interconnection Emmonak to Alakanuk	With Interconnection Alakanuk to Test Location 3	
Interconnection Distrance (miles)		9.5		
Interconnection Cost		$4,600,000		
Cost per Mile		$484,211	$0	
Year Energized		2013	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Emmonak	Alakanuk	Test Location 3	Emmonak	Alakanuk	Test Location 3	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.53	12.44	13.00	13.80	14.00		
Generating Upgrades							
Capital Cost	$5,200,000	$4,800,000		$5,200,000	$1,000,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014	2014		
Annual Operating Costs (non fuel)	$767,671	$457,954		$1,085,625			
Bulk Fuel Upgades							
Capital Cost	$5,100,000	$3,600,000		$8,000,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	168,828	149,349	0	363,470		0	
Annual Operating Costs							
Wind							
Number of Turbines	4	2		6			
Capital Cost/Turbine	$1,150,000	$1,020,000		$1,150,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2014		2014			
Usable Energy per Turbine (kWh/year)	273,333	250,000		273,333			80% availability
Operating Costs ($/year)	$51,277	$23,450		$76,916			

Appendix B: Saint Mary's-Pilot Station Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	St. Mary's to Pilot Station
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2014
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Saint Mary's
Load Center 2	Pilot Station
Load Center 3	Test Location 3
Primary Ops Ctr	Saint Mary's
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	20%	15	20%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Saint Mary's	Pilot Station	Test Location 3	
Generating Fuel Price ($/gallon)	$4.270	$3.710	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.270	$3.710	$0.000	
Sales:				
Base Year		2014		
Base Year Amount (kWh/year)	3,083,325	1,685,467	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	3,220,283	1,770,301	-	
Losses (Pct of Generation)	4.3%	4.8%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ -			

	Without Intertie		With Intertie	
	Saint Mary's	Pilot Station	Saint Mary's	Pilot Station
Energy (MWh/yr)	3,220	1,770	5,026	
Fuel Price ($/gal)	4.27	3.71	4.27	
Efficiency (kWh/gal)	13.83	13.06	14.00	
Non-fuel Expense ($/yr)	$683,198	$421,302	$964,500	
Powerplant Cap. Cost	$5,000,000	$7,045,000	$5,400,000	$1,000,000
Bulk Fuel Cap. Cost	$4,500,000	$4,930,000	$6,500,000	
Wind Farm Cap. Cost	$4,080,000	$0	$6,153,991	
Intertie Cap. Cost			$6,500,000	

	Without Interconnection	With Interconnection		
		Saint Mary's to Pilot Station	**Pilot Station to Test Location 3**	
Interconnection Distrance (miles)		14.0		
Interconnection Cost		$6,500,000		
Cost per Mile		$443,000	$0	
Year Energized		2014	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Saint Mary's	**Pilot Station**	**Test Location 3**	**Saint Mary's**	**Pilot Station**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.83	13.06	13.00	14.00	14.00		
Generating Upgrades							
Capital Cost	$5,000,000	$7,045,000		$5,400,000	$1,000,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2018	2014		2018	2014		
Annual Operating Costs (non fuel)	$683,198	$421,302		$964,500			
Bulk Fuel Upgades							
Capital Cost	$4,500,000	$4,930,000		$6,500,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2018	2014		2018			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	167,215	142,558	0	206,519	0	0	
Annual Operating Costs							
Wind							
Number of Turbines	4			1			
Capital Cost/Turbine	$1,020,000			$6,153,991			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	273,333	250,000		2,483,950			80% availability
Operating Costs ($/year)	$51,277	$0		$116,497			

Appendix C: Saint Mary's-Mountain Village Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	St. Mary's to Mountain Village
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2014
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Saint Mary's
Load Center 2	Mountain Village
Load Center 3	Test Location 3
Primary Ops Ctr	Saint Mary's
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	20%	15	20%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Saint Mary's	Mountain Village	Test Location 3	
Generating Fuel Price ($/gallon)	$4.270	$3.960	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.270	$3.960	$0.000	
Sales:				
Base Year		2014		
Base Year Amount (kWh/year)	3,083,325	2,690,210	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	3,220,283	2,838,966	-	
Losses (Pct of Generation)	4.3%	5.2%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	Saint Mary's	Mountain Village	Saint Mary's	Mountain Village
Energy (MWh/yr)	3,220	2,839	6,116	
Fuel Price ($/gal)	4.27	3.96	4.27	
Efficiency (kWh/gal)	13.83	14.57	14.00	
Non-fuel Expense ($/yr)	$683,198	$690,979	$1,234,177	
Powerplant Cap. Cost	$5,000,000	$5,000,000	$5,400,000	$900,000
Bulk Fuel Cap. Cost	$4,500,000	$3,500,000	$7,800,000	
Wind Farm Cap. Cost	$4,080,000	$4,680,000	$6,153,991	
Intertie Cap. Cost			$7,449,000	

	Without Interconnection	With Interconnection		
		Saint Mary's to Mountain Village	**Mountain Village to Test Location 3**	
Interconnection Distrance (miles)		20.0		
Interconnection Cost		$7,449,000		
Cost per Mile		$372,450	$0	
Year Energized		2014	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Saint Mary's	**Mountain Village**	**Test Location 3**	**Saint Mary's**	**Mountain Village**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.83	14.57	13.00	14.00	14.00		
Generating Upgrades							
Capital Cost	$5,000,000	$5,000,000		$5,400,000	$900,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2018	2014		2014	2014		
Annual Operating Costs (non fuel)	$683,198	$690,979		$1,234,177			
Bulk Fuel Upgades							
Capital Cost	$4,500,000	$3,500,000		$7,800,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2018	2014		2014			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	167,215	135,324	0	287,413	0	0	
Annual Operating Costs							
Wind							
Number of Turbines	4	4		1			
Capital Cost/Turbine	$1,020,000	$1,170,000		$6,153,991			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	273,333	250,000		2,483,950			80% availability
Operating Costs ($/year)	$51,277	$46,900		$116,497			

Appendix D: Togiak-Twin Hills Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Togiak to Twin Hills
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Togiak
Load Center 2	Twin Hills
Load Center 3	Test Location 3
Primary Ops Ctr	Togiak
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Togiak	Twin Hills	Test Location 3	
Generating Fuel Price ($/gallon)	$4.180	$4.970	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.180	$4.970	$0.000	
Sales:				
Base Year		2011		
Base Year Amount (kWh/year)	2,936,019	200,494	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	3,079,379	299,744	-	
Losses (Pct of Generation)	4.7%	33.1%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	Togiak	Twin Hills	Togiak	Twin Hills
Energy (MWh/yr)	3,079	300	3,385	
Fuel Price ($/gal)	4.18	4.97	4.18	
Efficiency (kWh/gal)	13.82	12.39	13.82	
Non-fuel Expense ($/yr)	$737,788	$20,000	$757,788	
Powerplant Cap. Cost	$4,950,000	$1,200,000	$4,950,000	$489,000
Bulk Fuel Cap. Cost	$4,200,000	$500,000	$4,200,000	
Wind Farm Cap. Cost	$3,060,000	$0	$4,080,000	
Intertie Cap. Cost			$1,954,000	

	Without Interconnection	With Interconnection		
		Togiak to Twin Hills	Twin Hills to Test Location 3	
Interconnection Distrance (miles)		4.4		
Interconnection Cost		$1,954,000		
Cost per Mile		$441,000	$0	
Year Energized		2014	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Togiak	Twin Hills	Test Location 3	Togiak	Twin Hills	Test Location 3	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.82	12.39	13.00	13.82	14.00		
Generating Upgrades							
Capital Cost	$4,950,000	$1,200,000		$4,950,000	$489,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013	2013		
Annual Operating Costs (non fuel)	$737,788	$20,000		$757,788			
Bulk Fuel Upgades							
Capital Cost	$4,200,000	$500,000		$4,200,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	216,717	17,875	0	233,224	16,507	0	
Annual Operating Costs							
Wind							
Number of Turbines	3	0		4			
Capital Cost/Turbine	$1,020,000			$1,020,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	180,363	0		180,363			80% availability
Operating Costs ($/year)	$25,377	$0		$33,836			

Appendix E: New Stuyahok-Ekwok Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	New Stuyahok to Ekwok
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	New Stuyahok
Load Center 2	Ekwok
Load Center 3	Test Location 3
Primary Ops Ctr	New Stuyahok
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	20	100%	20	100%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	New Stuyahok	Ekwok	Test Location 3	
Generating Fuel Price ($/gallon)	$4.490	$4.460	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.490	$4.460	$0.000	
Sales:				
Base Year		2012		
Base Year Amount (kWh/year)	1,428,056	225,000	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	1,502,158	237,380	-	
Losses (Pct of Generation)	4.9%	5.2%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	New Stuyahok	Ekwok	New Stuyahok	Ekwok
Energy (MWh/yr)	1,502	237	1,744	
Fuel Price ($/gal)	4.49	4.46	4.49	
Efficiency (kWh/gal)	12.44	13.53	13.50	
Non-fuel Expense ($/yr)	$355,221	$25,000	$380,221	
Powerplant Cap. Cost	$4,000,000	$1,000,000	$4,000,000	$100,000
Bulk Fuel Cap. Cost	$1,870,000	$500,000	$1,870,000	
Wind Farm Cap. Cost	$4,080,000	$0	$5,100,000	
Intertie Cap. Cost			$4,872,888	

		With Interconnection		
	Without Interconnection	**New Stuyahok to Ekwok**	**Ekwok to Test Location 3**	
Interconnection Distrance (miles)		8.0		
Interconnection Cost		$4,872,888		
Cost per Mile		$343,750	$0	
Year Energized		2014	3000	Note: Year for first interconnect must be
Transmission Losses		2.0%	2.0%	before or same as second interconned
Annual Operating Costs		$20,000		
Grant (Percent)				

	New Stuyahok	**Ekwok**	**Test Location 3**	**New Stuyahok**	**Ekwok**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	12.44	13.53	13.00	13.50	14.00		
Generating Upgrades							
Capital Cost	$4,000,000	$1,000,000		$4,000,000	$100,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2023	2012		2023	2013		
Annual Operating Costs (non fuel)	$355,221	$25,000		$380,221			
Bulk Fuel Upgades							
Capital Cost	$1,870,000	$500,000		$1,870,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2011	2013		2011	2013		
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	115,943	18,370	0	132,739	16,796	0	
Annual Operating Costs							
Wind							
Number of Turbines	4	0		5			
Capital Cost/Turbine	$1,020,000	$1,020,000		$1,020,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	185,863	0		185,863			80% availability
Operating Costs ($/year)	$34,868	$0		$43,585			

Appendix F: Stebbins-Saint Michael Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Stebbins to Saint Michael
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Stebbins
Load Center 2	Saint Michael
Load Center 3	Test Location 3
Primary Ops Ctr	Stebbins
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Stebbins	Saint Michael	Test Location 3	
Generating Fuel Price ($/gallon)	$4.000	$4.040	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.000	$4.040	$0.000	
Sales:				
Base Year		2013		
Base Year Amount (kWh/year)	1,316,100	1,683,181	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	1,387,552	1,780,774	-	
Losses (Pct of Generation)	5.1%	5.5%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M				

	Without Intertie		With Intertie	
	Stebbins	Saint Michael	Stebbins	Saint Michael
Energy (MWh/yr)	1,388	1,781	3,204	
Fuel Price ($/gal)	4.00	4.04	4.00	
Efficiency (kWh/gal)	12.98	13.48	14.50	
Non-fuel Expense ($/yr)	$329,138	$421,623	$610,761	
Powerplant Cap. Cost	$4,000,000	$4,000,000	$5,400,000	$750,000
Bulk Fuel Cap. Cost	$2,520,000	$3,220,000	$5,200,000	$227,000
Wind Farm Cap. Cost	$4,324,000	$0	$5,000,725	
Intertie Cap. Cost			$3,763,000	

	Without Interconnection	With Interconnection		
		Stebbins to Saint Michael	**Saint Michael to Test Location 3**	
Interconnection Distrance (miles)		10.6		
Interconnection Cost		$3,763,000		
Cost per Mile		$355,000	$0	
Year Energized		2013	3000	Note: Year for first interconnect must be
Transmission Losses		2.0%	2.0%	before or same as second interconned
Annual Operating Costs		$20,000		
Grant (Percent)				

	Stebbins	**Saint Michael**	**Test Location 3**	**Stebbins**	**Saint Michael**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	12.98	13.48	13.00	14.50	14.00		
Generating Upgrades							
Capital Cost	$4,000,000	$4,000,000		$5,400,000	$750,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013	2013		
Annual Operating Costs (non fuel)	$329,138	$421,623		$610,761			
Bulk Fuel Upgades							
Capital Cost	$2,520,000	$3,220,000		$5,200,000	$227,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2012	2013		2013	2013		
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	32,989	137,929	0	133,260	0	0	
Annual Operating Costs							
Wind							
Number of Turbines	4	0		1			
Capital Cost/Turbine	$1,081,000	$1,055,000		$5,000,725			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013			
Usable Energy per Turbine (kWh/year)	256,400	234,400		1,448,423			80% availability
Operating Costs ($/year)	$48,101	$0		$67,931			

Appendix G: Brevig Mission-Teller Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Brevig Mission to Teller
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Brevig Mission
Load Center 2	Teller
Load Center 3	Test Location 3
Primary Ops Ctr	Brevig Mission
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	20	30%	20	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Brevig Mission	Teller	Test Location 3	
Generating Fuel Price ($/gallon)	$3.530	$4.080	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$3.530	$4.080	$0.000	
Sales:				
Base Year		2012		
Base Year Amount (kWh/year)	1,145,642	793,965	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	1,228,862	882,368	-	
Losses (Pct of Generation)	6.8%	10.0%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	Brevig Mission	Teller	Brevig Mission	Teller
Energy (MWh/yr)	1,229	882	2,129	
Fuel Price ($/gal)	3.53	4.08	3.53	
Efficiency (kWh/gal)	13.97	11.37	14.00	
Non-fuel Expense ($/yr)	$279,831	$204,955	$400,000	
Powerplant Cap. Cost	$3,900,000	$3,600,000	$4,236,000	$750,000
Bulk Fuel Cap. Cost	$1,620,000	$1,404,000	$2,262,000	
Wind Farm Cap. Cost	$0	$2,040,000	$6,120,000	
Intertie Cap. Cost			$4,700,002	

	Without Interconnection	With Interconnection		
		Brevig Mission to Teller	Teller to Test Location 3	
Interconnection Distrance (miles)		6.3		
Interconnection Cost		$4,700,002		
Cost per Mile		$746,032	$0	
Year Energized		2011	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Brevig Mission	Teller	Test Location 3	Brevig Mission	Teller	Test Location 3	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.97	11.37	13.00	14.00	14.00		
Generating Upgrades							
Capital Cost	$3,900,000	$3,600,000		$4,236,000	$750,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2010	2013		2010	2013		
Annual Operating Costs (non fuel)	$279,831	$204,955		$400,000			
Bulk Fuel Upgades							
Capital Cost	$1,620,000	$1,404,000		$2,262,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2012	2012		2010			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	90,587	40,715	0	60,861	0	0	
Annual Operating Costs							
Wind							
Number of Turbines		2			6		
Capital Cost/Turbine		$1,020,000			$1,020,000		
Grant (Percent)							
Year of Capital Cost Expenditure		2012			2012		
Usable Energy per Turbine (kWh/year)		207,052			222,367		80% availability
Operating Costs ($/year)	$0	$19,421		$0			

Appendix H: Saint Mary's-Pilot Station-Mountain Village Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	St. Mary's to Mtn Village to Pilot Stn
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2014
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Saint Mary's
Load Center 2	Mountain Village
Load Center 3	Pilot Station
Primary Ops Ctr	Saint Mary's
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Saint Mary's	Mountain Village	Pilot Station	
Generating Fuel Price ($/gallon)	$4.270	$3.960	$3.710	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.270	$3.960	$3.710	
Sales:				
Base Year		2014		
Base Year Amount (kWh/year)	3,083,325	2,690,210	1,685,467	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	3,220,283	2,838,966	1,770,301	
Losses (Pct of Generation)	4.3%	5.2%	4.8%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie			With Intertie		
	Saint Mary's	Mountain Village	Pilot Station	Saint Mary's	Mountain Village	Pilot Station
Energy (MWh/yr)	3,220	2,839	1,770	6,116		
Fuel Price ($/gal)	4.27	3.96	3.71	4.27		
Efficiency (kWh/gal)	13.83	14.57	13.06	14.00		
Non-fuel Expense ($/yr)	$683,198	$690,979	$421,302	$1,515,479		
Powerplant Cap. Cost	$5,000,000	$5,000,000	$7,045,000	$5,400,000	$750,000	$1,006,000
Bulk Fuel Cap. Cost	$4,500,000	$3,500,000	$4,930,000	$9,000,000		
Wind Farm Cap. Cost	$4,080,000	$4,800,000	$0	$6,153,991		
Intertie Cap. Costs					$7,449,000	
					$6,500,000	

	Without Interconnection	With Interconnection		
		Saint Mary's to Mountain Village	Saint Mary's to Pilot Station	
Interconnection Distrance (miles)		20.0	14.0	
Interconnection Cost		$7,449,000	$6,500,000	
Cost per Mile		$372,450	$464,286	
Year Energized		2014	2014	Note: Year for first interconnect must be
Transmission Losses		2.0%	2.0%	before or same as second interconned
Annual Operating Costs		$20,000	$20,000	
Grant (Percent)				

	Saint Mary's	Mountain Village	Pilot Station	Saint Mary's	Mountain Village	Pilot Station	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.83	14.57	13.06	14.00	14.00	14.00	
Generating Upgrades							
Capital Cost	$5,000,000	$5,000,000	$7,045,000	$5,400,000	$750,000	$1,006,000	
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014	2014	2014	2014	2014	
Annual Operating Costs (non fuel)	$683,198	$690,979	$421,302	$1,515,479			
Bulk Fuel Upgades							
Capital Cost	$4,500,000	$3,500,000	$4,930,000	$9,000,000		$573,000	
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014	2014	2014		2014	
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	167,215	135,324	142,558	423,168	0	0	
Annual Operating Costs							
Wind							
Number of Turbines	4	4		1			
Capital Cost/Turbine	$1,020,000	$1,200,000		$6,153,991			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	273,333	250,000		2,483,950			80% availability
Operating Costs ($/year)	$51,277	$46,900		$116,497			

Appendix I: Port of Red Dog-Kivalina Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Red Dog Port to Kivalina
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Red Dog Port
Load Center 2	Kivalina
Load Center 3	Test Location 3
Primary Ops Ctr	Red Dog Port
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Red Dog Port	Kivalina	Test Location 3	
Generating Fuel Price ($/gallon)	$4.000	$4.220	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.000	$4.220	$0.000	
Sales:				
Base Year		2011		
Base Year Amount (kWh/year)	8,138,040	1,155,388	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	8,138,040	1,249,837	-	
Losses (Pct of Generation)	0.0%	7.6%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	Red Dog Port	Kivalina	Red Dog Port	Kivalina
Energy (MWh/yr)	8,138	1,250	9,413	
Fuel Price ($/gal)	4.00	4.22	4.00	
Efficiency (kWh/gal)	15.00	12.35	14.00	
Non-fuel Expense ($/yr)	$600,000	$293,464	$700,000	
Powerplant Cap. Cost	$0	$0	$1,000,000	$1,000,000
Bulk Fuel Cap. Cost	$0	$0	$0	
Wind Farm Cap. Cost	$0	$2,760,000	$6,450,000	
Intertie Cap. Cost			$13,500,000	

		With Interconnection		
	Without Interconnection	**Red Dog Port to Kivalina**	**Kivalina to Test Location 3**	
Interconnection Distrance (miles)		22.0		
Interconnection Cost		$13,500,000		
Cost per Mile		$681,818	$0	
Year Energized		2014	3000	Note: Year for first interconnect must be before or same as second interconned
Transmission Losses		2.0%	2.0%	
Annual Operating Costs		$20,000		
Grant (Percent)				

	Red Dog Port	**Kivalina**	**Test Location 3**	**Red Dog Port**	**Kivalina**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	15.00	12.35	13.00	14.00	14.00		
Generating Upgrades							
Capital Cost	$0			$1,000,000	$1,000,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013	2013		
Annual Operating Costs (non fuel)	$600,000	$293,464		$700,000			
Bulk Fuel Upgades							
Capital Cost							
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	599,297	95,434	0	648,875	95,434	0	
Annual Operating Costs							
Wind							
Number of Turbines	0	2		1			
Capital Cost/Turbine	$1,020,000	$1,380,000		$6,450,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	189,216	537,703		1,806,551			85% availability
Operating Costs ($/year)	$0	$50,437		$84,727			

Appendix J: Noorvik-Selawik-Kiana Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Noorvik to Selawik to Kiana
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2012
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Noorvik
Load Center 2	Selawik
Load Center 3	Kiana
Primary Ops Ctr	Selawik
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Noorvik	Selawik	Kiana	
Generating Fuel Price ($/gallon)	$4.390	$4.430	$4.490	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$4.390	$4.430	$4.490	
Sales:				
Base Year		2012		
Base Year Amount (kWh/year)	1,942,929	2,726,216	1,437,294	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	2,034,128	2,905,446	1,555,614	
Losses (Pct of Generation)	4.5%	6.2%	7.6%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie			With Intertie		
	Noorvik	Selawik	Kiana	Noorvik	Selawik	Kiana
Energy (MWh/yr)	2,034	2,905	1,556	6,625		
Fuel Price ($/gal)	4.39	4.43	4.49	4.39		
Efficiency (kWh/gal)	13.07	13.61	12.69	14.00		
Non-fuel Expense ($/yr)	$487,121	$657,707	$366,040	$1,230,868		
Powerplant Cap. Cost	$5,100,000	$0	$4,200,000	$5,100,000	$0	$500,000
Bulk Fuel Cap. Cost	$6,800,000	$0	$2,550,000	$6,800,000		
Wind Farm Cap. Cost	$3,060,000	$4,080,000	$0	$5,600,000		
Intertie Cap. Costs				$12,800,000	Noorvik to Selawik	
				$6,000,000	Noorvik to Kiana	

	Without Interconnection	With Interconnection		
		Noorvik to Selawik	Noorvik to Kiana	
Interconnection Distrance (miles)		32.0	15.0	
Interconnection Cost		$12,800,000	$6,000,000	
Cost per Mile		$400,000	$400,000	
Year Energized		2015	2015	Note: Year for first interconnect must be
Transmission Losses		2.0%	2.0%	before or same as second interconned
Annual Operating Costs		$20,000	$20,000	
Grant (Percent)				

	Noorvik	Selawik	Kiana	Noorvik	Selawik	Kiana	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.07	13.61	12.69	14.00	14.00	14.00	
Generating Upgrades							
Capital Cost	$5,100,000	$0	$4,200,000	$5,100,000	$0	$500,000	
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013	2013	2013	2013	2013	
Annual Operating Costs (non fuel)	$487,121	$657,707	$366,040	$1,230,868			
Bulk Fuel Upgades							
Capital Cost	$6,800,000	$0	$2,550,000	$6,800,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013	2013	2013			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	150,142	202,313	125,112	466,850	347,523	115,539	
Annual Operating Costs							
Wind							
Number of Turbines	3	4	0	1			
Capital Cost/Turbine	$1,020,000	$1,020,000		$5,600,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2014	2014		2014			
Usable Energy per Turbine (kWh/year)	168,800	136,000		2,018,304			80% availability
Operating Costs ($/year)	$23,750	$25,514	$0	$94,658			

Appendix K: Ambler-Shungnak/Kobuk Intertie Route

- **B/C Calculation Spreadsheet Data Input Page**

Project Title	Denali Commission Report
Analysis Title 1	Ambler to Shungnak-Kobuk
Analysis Title 2	Subtitle 2
Cost Basis (Year)	2013
Cost Escalation (Percent)	
Non Fuel	2.00%
Fuel Escalation	
Years 1 - 5	2.00%
Years 6 - 10	1.50%
Year 11 and thereafter	1.00%
Discount Rate	3.00%
Locations:	
Load Center 1	Ambler
Load Center 2	Shungnak-Kobuk
Load Center 3	Test Location 3
Primary Ops Ctr	Ambler
Include Grants in Econ Analysis	No

Must be either Load Center 1 or Load Center 2 (Select from drop-down list)

Recovered Heat Revenues (Pct of Savings) 50%

		Without Intertie		With Intertie		
	Depreciation Period	Replacement Period	Replacement Percentage	Replacement Period	Replacement Percentage	Future
Diesel Generation	15	15	30%	15	30%	0%
Bulk Fuel Storage	30	30	25%	30	25%	0%
Wind	15	20	50%	20	50%	0%
Recovered Heat	15	20	100%	20	100%	0%
Interconnections	30			30	10%	0%

	Ambler	Shungnak-Kobuk	Test Location 3	
Generating Fuel Price ($/gallon)	$5.180	$5.320	$0.000	ISER 2013 med proj + SCC
Heating Fuel Price ($/gallon)	$5.180	$5.320	$0.000	
Sales:				
Base Year		2013		
Base Year Amount (kWh/year)	1,243,072	1,504,522	0	Load Growth entered on "Power Stats-Without Intertie" sheet.
Base Year Generation (kWh/year)	1,308,841	1,569,474	-	
Losses (Pct of Generation)	5.0%	4.1%	0.0%	
Existing Fuel Storage (gal)	-	-	-	
Wind Turbine O&M	$ 0.0469			
Diesel O&M	$ 0.0200			

	Without Intertie		With Intertie	
	Ambler	Shungnak-Kobuk	Ambler	Shungnak-Kobuk
Energy (MWh/yr)	1,309	1,569	2,910	
Fuel Price ($/gal)	5.18	5.32	5.18	
Efficiency (kWh/gal)	13.69	13.60	13.80	
Non-fuel Expense ($/yr)	$314,107	$374,027	$548,134	
Powerplant Cap. Cost	$5,100,000	$4,200,000	$5,100,000	$750,000
Bulk Fuel Cap. Cost	$5,100,000	$2,700,000	$5,100,000	
Wind Farm Cap. Cost	$2,040,000	$0	$4,080,000	
Intertie Cap. Cost			$11,740,000	

	Without Interconnection	With Interconnection		
		Ambler to Shungnak-Kobuk	**Shungnak-Kobuk to Test Location 3**	
Interconnection Distrance (miles)		24.0		
Interconnection Cost		$11,740,000		
Cost per Mile		$447,500	$0	
Year Energized		2013	3000	Note: Year for first interconnect must be
Transmission Losses		2.0%	2.0%	before or same as second interconned
Annual Operating Costs		$20,000		
Grant (Percent)				

	Ambler	**Shungnak-Kobuk**	**Test Location 3**	**Ambler**	**Shungnak-Kobuk**	**Test Location 3**	
Diesel Generation							
Fuel Efficiency (kWh gen/gallon)	13.69	13.60	13.00	13.80	14.00		
Generating Upgrades							
Capital Cost	$5,100,000	$4,200,000		$5,100,000	$750,000		
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013	2013		
Annual Operating Costs (non fuel)	$314,107	$374,027		$548,134			
Bulk Fuel Upgades							
Capital Cost	$5,100,000	$2,700,000		$5,100,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013			
Total Gallon after Upgrade							
Annual Fuel Usage (Maximum)	81,873	122,201	0	187,856	0	0	
Annual Operating Costs							
Wind							
Number of Turbines	2			4			
Capital Cost/Turbine	$1,020,000			$1,020,000			
Grant (Percent)							
Year of Capital Cost Expenditure	2013	2013		2013			
Usable Energy per Turbine (kWh/year)	126,144			126,144			80% availability
Operating Costs ($/year)	$11,832	$0		$23,665			