# Point Lay Wind-Diesel Conceptual Design Report


9 January 2015

This report prepared for

North Slope Borough

by

WHPacific

and

V3 Energy LLC

This report was written by Douglas Vaught, P.E. of V3 Energy, LLC under contract to WHPacific Solutions Group for development of wind power in the village of Point Lay, Alaska. This analysis is part of a wind energy design project for the North Slope Borough and funded by the Alaska Energy Authority.

# Contents

# Introduction

North Slope Borough is the electric utility for the City of Point Lay. In 2009 North Slope Borough contracted WHPacific to install met towers and perform wind resource assessment analyses in five Borough communities: Point Hope, Wainwright, Atqasuk, Kaktovik, and Anaktuvuk Pass (a wind resource assessment was previously completed by U.S. DOE for Point Lay). This was followed in 2011 with a contract to WHPacific to write feasibility studies for the villages of Point Hope, Point Lay, and Wainwright. WHPacific subcontracted V3 Energy, LLC to assist with both efforts. In 2013 North Slope Borough contracted WHPacific Solutions Group to complete the conceptual design phase of the project in anticipation of Alaska Energy Authority authorizing wind power design projects for the three communities.

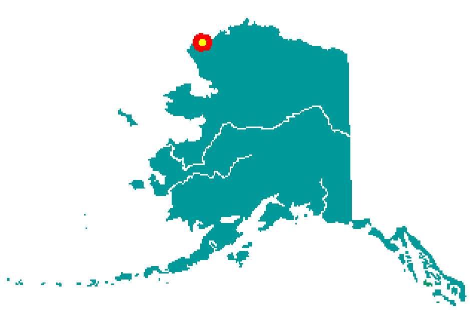
WHPacific Solutions Group has contracted V3 Energy, LLC to re-evaluate the wind resource assessment and feasibility study for each community, update the power systems modeling with a selection of appropriate village-scale wind turbines, and perform preliminary economic analyses of the proposed projects. This conceptual design report for the village of Point Lay is a culmination of that effort.

## Project Management

The North Slope Borough, Department of Public Works, has executive oversight of this project. North Slope Borough and the City of Point Lay wish to install wind turbines in Point Lay primarily to reduce diesel fuel consumption and save money, but also to:

- Reduce long-term dependence on outside sources of energy
- Reduce exposure to fuel price volatility
- Reduce air pollution resulting from reducing fossil fuel combustion
- Reduce possibility of spills from fuel transport & storage
- Reduce North Slope Borough's carbon footprint and its contribution to climate change.

# Point Lay



Point Lay is one of the more recently established Inupiaq villages on the Arctic coast and has historically been occupied year-round by a small group of one or two families. They were joined in 1929-30 by several more families from Point Hope. The deeply-indented shoreline has prevented effective bowhead whaling, but the village participates in beluga whaling. In 1974, the village moved from the old site on a gravel barrier island just offshore. The old village site is now used as a summer hunting camp. Some residents of Barrow and Wainwright relocated to Point Lay in the mid-1970s. Later that decade, due to seasonal flooding from the Kokolik River, the village relocated again to a site near the Air Force Distance Early Warning station to the south. Homes were relocated to the new town site.

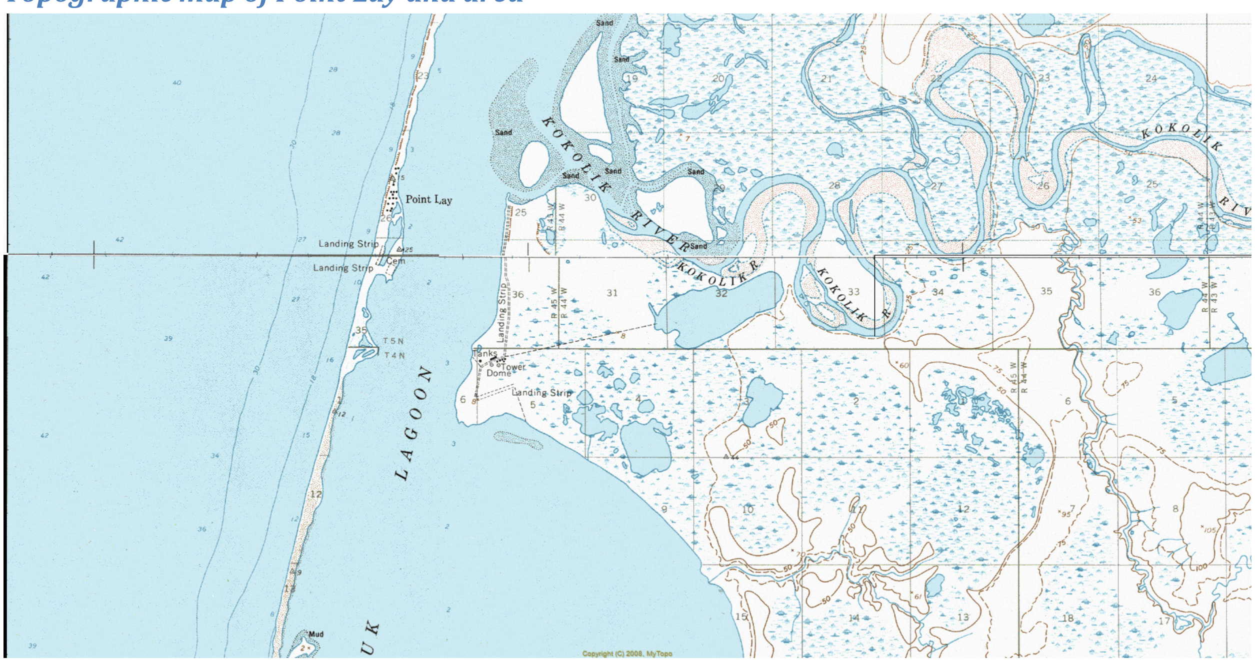
Point Lay is a traditional Inupiat Eskimo village, with a dependence upon subsistence activities. The sale and importation of alcohol is banned in the village. According to Census 2010, there were 70 housing units in the community and 60 were occupied. Its population of 189 people is 88 percent Alaska Native, 10 percent Caucasian, and 2 percent Hispanic, Pacific Islander, multi-racial and other.

Water is obtained from a lake near the community and is treated and stored in a tank. Households have water delivered to home tanks, which allows running water for the kitchen. Electricity is provided by North Slope Borough. There is one school located in the community, attended by 87 students. Local hospitals or health clinics include Point Lay Clinic. Emergency Services have coastal and air access. Emergency service is provided by 911 Telephone Service volunteers and a health aide. Auxiliary healthcare is provided by Point Lay Volunteer Fire Dept. (907-833-2714). A public 4,500' long by 100' wide gravel airstrip, owned by the U.S. Air Force, provides Point Lay's only year-round access. Marine and land transportation provide seasonal access.

Most year-round employment opportunities are with the borough government. Subsistence activities provide food sources. Seals, walrus, beluga, caribou, and fish are staples of the diet.

Note that information regarding Point Lay is drawn from the Alaska Community Database Community Information Summaries (CIS) which can be found at http://www.dced.state.ak.us/dca/commdb/CIS.cfm. Regarding the American Community Survey information, MOE refers to *margin of error*.

### *Topographic map of Point Lay and area*



### *Google Earth image of Point Lay*


## Wind Resource Assessment

The wind resource measured in Point Lay is very good, measured at high wind power class 4 (good) to low wind power class 5 (excellent). In addition to strong average wind speed and wind power density, the site experiences highly directional prevailing winds and low turbulence.

A thirty meter NRG met tower was supplied to the Point Lay's Cully Corporation in 2006 by the National Renewable Energy Laboratory's (NREL) under their anemometer loan program. A number of details of the project are not known, including the rationale for choosing the test site, but the location of the tower is desirable for a wind resource assessment as it is well away from obstructions such as buildings and well exposed to winds from all directions. Although data collection in 2006 and 2007 was slightly short of twelve months, the met tower was returned to operational status in June 2011, enabling additional data collection to strengthen the earlier data set.

### Met tower data synopsis

| | |
|---|---|
| Data dates | October 5, 2006 to September 11, 2007 |
| Wind power class | High 4 (good) to low 5 (excellent) |
| Power density mean, 30 meters | 403 W/m$^2$ |
| Wind speed mean, 30 meters | 6.63 m/s |
| Weibull distribution parameters | k = 1.74, c = 7.44 m/s |

| | |
|---|---|
| Wind shear power law exponent | 0.142 (moderate), June to September data only |
| Roughness class | 0.54 (snow surface), June to September only |
| IEC 61400-1, 3rd ed. classification | Class III-c (likely, based on nearby Wainwright data) |
| Turbulence intensity, mean | 0.072 (at 15 m/s) |
| Calm wind frequency | 23% (less than 3.5 m/s) |

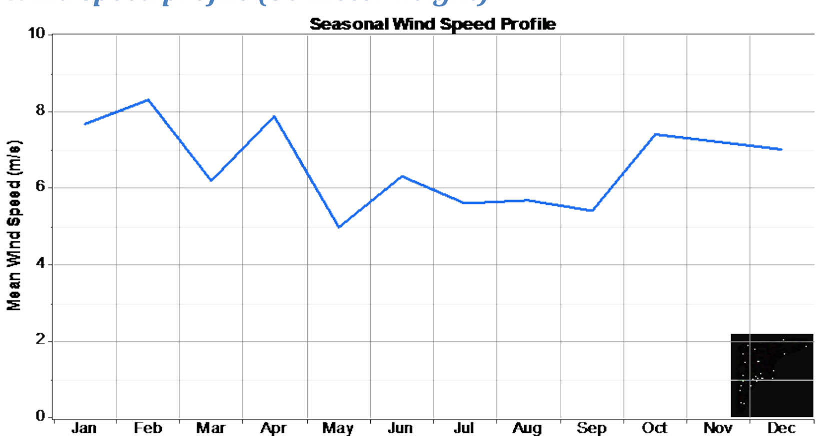
## Data Recovery

Specific sensor data recovery problems typical of Alaska met tower operations, such as freezing rain, hoarfrost, and rime icing, likely occurred to some extent during the nearly one year met tower study in Point Lay, but original data was not available, other than in an Excel file with data from June 7 through September 11, 2007. Although this three month data set could be reviewed for data loss typically due to atmospheric icing conditions, such weather does not occur during the months of June, July, August and (early) September. All met tower data (including that not included in the Excel file download of original data) is summarized in several WindPRO software reports prepared by the National Renewable Energy Laboratory.

## Wind Speed

Wind data collected from the met tower and summarized in the NREL WindPRO reports, from the perspective of both mean wind speed and mean power density, indicates an excellent wind resource. Note that temperature data was not included in the analysis of power density. Given the extremely cold temperatures, and hence high air densities, of Point Lay, true wind power density will be higher yet, categorizing Point Lay more solidly as wind power class 5. For purposes of analysis, wind data monthly wind speed summaries contained in the 30 meter WindPRO report, along with other statistical data gleaned from the three-month Excel data, was used to synthesize a virtual data set. This enabled certain mathematic and graphical analyses not contained in the WindPRO reports.

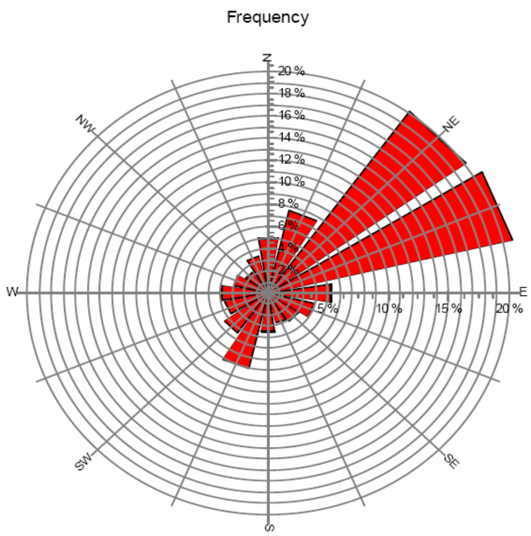
### *Wind speed profile (30 meter height)*




## Wind Rose

Wind frequency rose data (from NREL's WindPRO report) indicates highly directional winds from northeast to east-northeast. Although the NREL report did not show a power density rose, Wainwright data confirms the Point Lay directional frequency and indicates that power winds are nearly exclusively northeast to east-northeast, which presumably is representative of Point Lay.

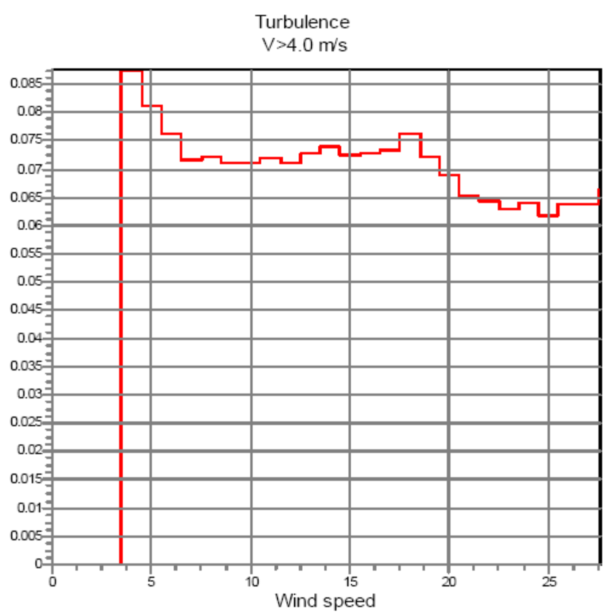
### *Wind frequency rose*

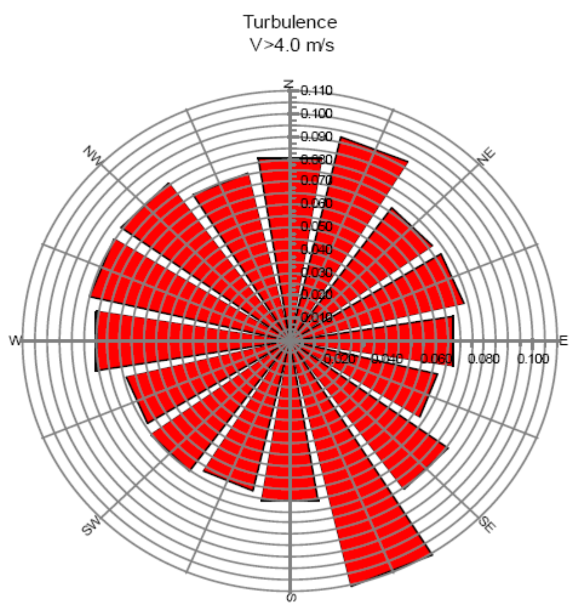



## Turbulence Intensity

From the NREL report, turbulence intensity at the Point Lay test site is well within acceptable standards with an IEC 61400-1, 3rd edition (2005), classification of turbulence category C, which is the lowest defined. Mean turbulence intensity at 15 m/s is 0.072

### *Turbulence graphs*




The complete V3 Energy, LLC wind resource assessment report of Point Lay is forwarded with this conceptual design report.

## Cold Climate Considerations of Wind Power

Point Lay's harsh climate conditions is an important consideration should wind power be developed in the community. The principal challenges with respect to turbine selection and subsequent operation is severe cold and icing. Many wind turbines in standard configuration are designed for a lower operating temperature limit of -20° C (-4° F), which clearly would not be suitable for Point Lay, nor anywhere else in Alaska. A number of wind turbine manufacturers offer their turbine in an "arctic" configuration which includes verification that structural and other system critical metal components are fatigue tested for severe cold capability. In addition, arctic-rated turbines are fitted with insulation and heaters in the nacelle and power electronics space to ensure proper operating temperatures. With an arctic rating, the lower temperature operating limit generally extends to -40° C (-40° F). On occasion during winter Point Lay may experience temperatures colder than -40° C which would signal the wind turbines to stop. Temperatures below -40° C are relatively infrequent however and when they do occur, are generally accompanied by lighter winds.

A second aspect of concern regarding Point Lay's arctic climate is icing conditions. Atmospheric icing is a complex phenomenon characterized by astonishing variability and diversity of forms, density, and tenacity of frozen precipitation, some of which is harmless to wind turbine operations and others highly problematic. Although highly complex, with respect to wind turbines and aircraft five types of icing are recognized: clear ice, rime ice, mixed ice, frost ice, and SLD ice (www.Wikipedia.org/wiki/icing_conditions).

- Clear ice is often clear and smooth. Super-cooled water droplets, or freezing rain, strike a surface but do not freeze instantly. Forming mostly along the stagnation point on an airfoil, it generally conforms to the shape of the airfoil.
- Rime ice is rough and opaque, formed by super-cooled drops rapidly freezing on impact. Often "horns" or protrusions are formed and project into the airflow.
- Mixed ice is a combination of clear and rime ice.
- Frost ice is the result of water freezing on unprotected surfaces. It often forms behind deicing boots or heated leading edges of an airfoil and has been a factor airplane crashes.
- SLD ice refers to ice formed in super-cooled large droplet (SLD) conditions. It is similar to clear ice, but because droplet size is large, it often extends to unprotected parts of a wind turbine (or aircraft) and forms large ice shapes faster than normal icing conditions.

*SLD ice on an airplane*

# Wind Project Sites

North Slope Borough requested that two wind turbine sites be identified in Point Lay. On June 24, 2011, Ross Klooster of WHPacific, Doug Vaught of V3 Energy LLC, and Max Ahgeak of North Slope Borough Public Works Dept. traveled to Point Lay and met with City of Point Lay and Cully Corporation representatives to discuss the wind power project and to identify the two sites. This was accomplished by reviewing maps and ownership records and then driving and walking to a number of locations near the village to assess suitability for construction and operation of wind turbines. Two sites on Cully Corporation land were chosen, identified as Site A and Site B in the Google Earth image below. The Cully Corporation owns much of the land surrounding Point Lay and has championed wind power in Point Lay for a number of years, including working with NREL in 2006 for the met tower that measured the local wind resource.

A new site option – Site C – has recently been identified as a possible alternative to Sites A and B. This site is south of the community landfill about 3.6 km (2.2 mi) straight-line distance from the Point Lay.

***Point Lay wind power site options, Google Earth image***


## Site A

Site A is located on a low, well-exposed north-south trending hill immediately north of the village and immediately south of the mouth of the Kokolik River. Site A presents a number of positive features for a wind power site including clear exposure to winds from all directions, relative proximity to existing three-phase power distribution, and dry tundra. The FAA notice criteria tool indicates possible navigation signal interference (refer to Appendix A), but this is a resolvable problem as FAA made a

Determination of No Hazard for wind turbines up to 195 ft. (60 meters) above ground level in a 2011 analysis.

Less desirable features of Site A include its proximity to Point Lay residences, its near-parallel orientation with prevailing winds which increases spacing requirements and limits future expansion, and avian concerns with nearness to the Kokolik River. Additionally, development of wind power at Site A precludes residential development along this ridge, which appears to be the natural direction of future housing expansion for the village.

***Point Lay Site A (view to east)***


## Site B

Site B is located in a well exposed area south of the village between the village and the airport. Positive features of Site B for wind power development are that it is on the "industrial" side of Point Lay, has good wind exposure in all directions, is very near existing three-phase power distribution, and would require minimal access improvements.

Less desirable features of Site B include possible restricted hub height due to proximity to the airport and possible navigation signal interference, although the latter likely is resolvable (refer to Appendix B), and possible site size constraint (when considering only land west of the airport-village access road) which may restrict future wind power expansion. Another potentially undesirable aspect of Site B given its location near south of the community is possible turbine rotor blade sun shadow flicker during certain times of the year. A flicker analysis would be required to determine the extent of this potential problem.

*Point Lay Site B (view to east)*


## Site C

Site C on a moderately-sized plateau of higher ground immediately south of the community landfill. Positive features of Site C for wind power development is that it is quite far from the community hence presents much less visual and noise impact as Sites A and B, it has good wind exposure from all directions, is relatively dry, is quite large for future expansion, and likely presents less avian concerns than nearer the lagoon and Kokolik River.

Drawbacks of Site C are its distance from existing electrical distribution, U.S. military and Arctic Slope Regional Corporation land ownership boundaries at the site that would require negotiation to enable development, and possible airport navigation signal interference (refer to Appendix C), although the latter issue likely is resolvable.

Of special concern with Site C is Point Lay's low 4,160 V distribution system voltage. Two NPS 360-39 wind turbines generating a peak 720 kVA of power will result in a 100 amp current. With line impedance, a 260 V voltage drop from the turbine site to the village is anticipated. This exceeds that which can be supported by the wind turbines, and hence corrective measures would be necessary. Three possible options, all costing approximately $100,000, are:

1. Install a voltage regulator in the distribution system near the village
2. Near the village distribution system connection point, install a small substation in the wind turbine power line to increase the line voltage to 12,470 V. This would reduce voltage drop to 3%, which could be eliminated by transformer tap adjustment.
3. Install a booster transformer, which would compensate for the voltage drop.

### *Point Lay Site C (view to northwest)*


### *Point Lay wind turbine site options table*

| Site | Advantages | Disadvantages |
|---|---|---|
| A | • Cully Corp. land<br>• Site large enough to accommodate several turbines<br>• Dry site; likely good geotech conditions<br>• Relatively unrestricted turbine height<br>• Short road and distribution line required | • Natural direction of village expansion<br>• Turbines will be in view and possible auditory range of village residents<br>• Possible avian conflicts with near proximity to mouth of the Kokolik River<br>• Somewhat limited space for future expansion |
| B | • Cully Corp. land<br>• Short road and distribution line required<br>• Location is on the "industrial" side of the village with reduced viewshed and possible fewer noise issues<br>• Relatively dry site; likely good geotech conditions | • Proximity to the airport; possible navigation signal interference; possible height restrictions<br>• Somewhat limited space for future expansion<br>• Possible turbine flicker (shadow from moving blades) with low-angle sun<br>• Site is immediately downwind of the village with prevailing NE wind direction |
| C | • Arctic Slope Regional Corp. land (partial)<br>• Minimal visual and noise issues due to distance from community | • Up to 3.5 km (2.2 mi) of new distribution line required; additional line requires 3-phase upgrade<br>• Portions of new distribution near runway likely must be buried to |

| | | |
|---|---|---|
| | • Short road extension (from landfill) required<br>• Large area, lots of room for future expansion<br>• Relatively dry site; likely good geotech conditions | not interfere with ILS approach minimums<br>• Mitigation necessary to minimize voltage drop from turbine site to village<br>• Site was not discussed during July, 2011 site selection visit<br>• Site option was not addressed in ABR, Inc. avian study<br>• Transfer of/easement through U.S. military land may be required |

### Other Site Options

Other than variations of Sites A, B, and C, the only other possible area for wind turbines in Point Lay is the terrain east of the village near the water supply lagoon. Although expansive and easily large enough to contain many wind turbines, it is characterized by very marshy and wet conditions which would require considerable fill material for construction. Additionally, alignment of the airport runway precludes high constructed obstructions, such as wind turbines, unless they are quite distant. For this reason, WHPacific Solutions Group and V3 Energy, LLC do not consider terrain east of Point Lay to be practical for wind power development.

### Recommended Site Option

WHPacific Solutions Group and V3 Energy, LLC recommend Site C as the preferred site option for a wind power project in Point Lay, presuming a satisfactory FAA obstruction determination. Although Site C would be the most expensive site option to develop, the non-resolvable disadvantages of Sites A and B weigh against them, comparatively.

It should be noted, however, that the Site C option has not been presented to Arctic Slope Regional Corporation representatives and the residents of Point Lay and possibly there are problems and/or objections to this site that WHPacific Solutions Group and V3 Energy, LLC are not yet aware of.

## Wildlife/Avian Study

North Slope Borough commissioned ABR, Inc. of Fairbanks, Alaska to summarize the biological resources of Point Hope, Point Lay and Wainwright, including both plant and animal species to support the wind project development effort. ABR's work is documented in a report titled: *Site Characterization and Avian Field Study for the Proposed Community-Scale Wind Project in Northern Alaska*.

The ABR study states: The objectives of the Site Characterization Study (SCS) were to: (1) compile and review existing land cover map products to prepare generalized land cover maps; (2) characterize the biological resources present; (3) summarize the potential exposure of biological (particularly avian) resources to impacts; and (4) identify field studies to identify site-specific risks to biological resources (particularly birds). The objectives of the field studies conducted in 2013 were to: (1) describe temporal and spatial patterns of habitat use of all birds within and near proposed wind-sites; and (2) provide a summary of the exposure of focal species to collision risk at each proposed site. This final report summarizes the SCS and field data to describe the relative exposure of the focal species to the proposed wind-energy development at the 3 villages.

In Point Lay, the 2 sites are located close to one another. Site A is surrounded by water bodies that often are attractive to birds, and their corresponding use of these habitats is evident in the flight patterns recorded in the spring. Birds move from Kasegaluk Lagoon eastward up the Kokolik River and nest in the drained-lake basin on the western side of the site. Site B also is located near Kasegaluk Lagoon, but much of the area around it already is occupied by village structures. The proximity of Site B to the airstrip may be a navigation hazard for aircraft, but it also reduces the availability of preferred wildlife habitat because so much of the area consists of existing roads and gravel pads. Based on an evaluation of the habitat at both locations and the recorded bird movements at Site A (but not Site B), we may expect Site B to have fewer avian issues with the proposed development.

The reader is cautioned to note that the ABR report is complex and that the preceding paragraphs do not adequately summarize ABR's conclusions; they are included in this CDR for reference only. The reader is strongly encouraged to consult the ABR report for a complete understanding of the plant and wildlife species of concern and potential impacts of a wind study in Point Lay.

The complete ABR, Inc. site characterization and avian field study report of the proposed Point Lay wind farm is forwarded with this conceptual design report.

## Geotechnical Report

WHPacific commissioned Golder Associates of Anchorage, Alaska to perform a non-field study assessment of likely geotechnical conditions in Point Hope, Point Lay, and Wainwright in order to identify potential hazards and provide conceptual foundation recommendations for the proposed wind tower sites in the three communities. Golder's work is documented in a report titled: *Geotechnical Review and Feasibility Studies for Wind Turbines: Point Hope, Point Lay, and Wainwright, Alaska*, dated January 27, 2012.

The Golder report states the following regarding Point Lay: Point Lay is on the coast of the Chukchi Sea, situated on ice-rich soils between a beach ridge and a lagoon. The lagoon and barrier beach protect the village from direct ocean current erosion, but some bank deterioration, aided by thermal erosion, is occurring. Point Lay lies within the Arctic Coastal Plain physiographic province, which is typified by gently topography, ice-bonded permafrost soils, wet tundra, oriented thaw lakes, and meandering stream channels.

The tundra plain in the Point Lay area has little relief, and surficial drainage is poorly defined. A low hill near the northern end of the village provides minimal surface drainage, but water ponding is common between the gravel pads in several parts of town. Drifting snow is a continuous problem throughout the winter months and snow storage at the edge of gravel pads contributes to the standing water in the spring and early summer.

The village has been built directly on the tundra. Some smaller structures are built on at-grade sills on a gravel fill pad but most buildings are pile supported. A 2 foot to 4 foot gravel overlay is commonly used for roadways, parking and staging areas.

The soils underlying Point Lay are very icy. The surficial organic mat of live moss and peat is underlain by organic silt with high ice contents. Below about 10 feet the brown organic silt is interbedded with gray silt with sand and fine gravel, probably of estuarine origin. Old beach deposits of sand and sandy gravel are present at depths below an average of about 15 feet, but as shallow as about 10 feet in some areas. The coarse granular material is well rounded and may contain saline pore water.

Massive ice with silt inclusions is common in association with the organic silt, and generally is observed in the upper 10 feet. The coarse-grained deposits contain some interstitial ice; however, massive ice is uncommon.

Two sites for the wind turbine have been identified in Point Lay. Site "A" is on the north end of the community, while the Site "B" is on a bluff to the southwest of the community. Both sites appear to be located on relatively undisturbed tundra. Subsurface conditions are similar in most areas of the village, and are typified by icy soils with massive ice underlying much of the area. Beneath icy fine-grained soils, coarse grained beach deposits are observed generally from 15 feet below ground surface. Elevated pore water salinity contents have been measured in samples near the 20 foot depth, however typically range between 1 and 10 ppt. Pore water salinities on the order of 100 ppt have been reported in the village. Active layer thickness is likely within the range of 1 foot to 3 feet. The proximity of the wind turbine sites to landforms and topography that may encourage snow drifting may increase the thickness of the active layer and may also result in relatively warmer ground temperatures beneath the sites.

The tower site subsurface conditions will most likely consist of very icy silt to massive ice under the tundra. The tundra mat must be protected during the tower construction and for operations and maintenance access. A gravel pad should be included with the project for construction and regular maintenance. The gravel pad should be 4 to 5 feet thick but a thinner section may be feasible if rigid insulation is placed within the pad fill.

An adfreeze pile foundation system should be used for the tower foundation with an above grade pile cap/tower base system. Cast-in-place concrete, pre-cast concrete and steel frame pile cap/tower base systems have been used in permafrost regions.

The complete Golder Associates geotechnical review report of the proposed Point Lay wind farm is forwarded with this conceptual design report.

## Noise Analysis

As part of a 2007 Powercorp Alaska, LLC Preliminary Wind Feasibility Report of Kaktovik, Point Hope and Point Lay, Michael Minor & Associates of Portland, Oregon was commissioned to complete a desktop analysis of the expected noise impact of wind turbines at Site A (this was the only site considered at that time). This work was documented in a report titled: *Noise Analysis Memorandum, Point Lay Wind Farm*, dated March 6, 2012.

The noise analysis memorandum summary stated: This project will install a wind turbine generator farm outside of Point Lay Alaska. The project proposed to use one Vestas V47, three Vestas V27's, or one Fuhrländer 600 wind generator(s). The wind turbine nearest to the southern edge of town will be located approximately 3800 feet to the south. Noise due to the operation of the wind turbines is expected to be audible in the town, although the overall noise levels are low, and are not projected to exceed 29 to 34 dBA. In addition, the noise from the wind turbines should not exceed the ambient by more than 1 to 5 dBA except in extreme cases accompanied by high winds, low ambient noise levels and frozen ground.

The complete Michael Minor & Associates noise analysis memorandum of the Point Lay wind farm is forwarded with this conceptual design report.

# Permitting and Environmental Review

The environmental permitting requirements listed below are discussed in *Alaska Wind Energy Development: Best Practices Guide to Environmental Permitting and Consultations*, a study prepared by URS Corporation for the Alaska Energy Authority in 2009.

## Alaska Pollution Discharge Elimination System

State regulations (18 AAC 83) require that all discharges to surface waters, including storm water runoff, be permitted under the Alaska Pollution Discharge Elimination System (APDES). The goal of the program is to reduce or eliminate pollution and sediments in stormwater and other discharges to surface water. Under the state APDES program, projects that disturb one or more acre of ground are subject to the terms of the Alaska Construction General Permit (CGP) and are required to develop a project Storm Water Pollution Prevention Plan (SWPPP) outlining measures to control or eliminate pollution and sediment discharges. The proposed projects in Point Hope, Point Lay and Wainwright are likely to disturb more than one acre of ground during the construction of proposed wind turbines, supporting infrastructure and access roads and would be subject to the requirements of the CGP. Prior to construction, the contractor would be required to file a Notice of Intent (NOI) with the Alaska Department of Environmental Conservation (ADEC) prior to submitting the project SWPPP. ADEC would issue an APDES permit following the public comment period.

## US. Fish and Wildlife Service/National Marine Fisheries Service

Both the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) list Threatened and Endangered (T&E) that may occur in the vicinity of Point Hope, Point Lay, and Wainwright, Alaska. T&E species listed by the USFWS in the vicinity of the project area may include the short tailed albatross, polar bear, Steller's eider, spectacled eider. Candidate species that may be found in the area include the yellow billed loon, Kittlitz's murrelet, and the Pacific walrus. While NMFS lists marine T&E species, the bearded seal and ring seal may haul on beaches in the vicinity of the project area. A discussion with the USFWS will be initiated, and at a minimum, a letter and a map will be sent requesting their opinion regarding the level of consultation needed to proceed with the construction of the project.

USFWS regulations and guidance under the Migratory Bird Treaty Act prohibits the taking of active bird nests, eggs and young. In their Advisory: Recommended Time Periods for Avoiding Vegetation Clearing in Alaska in order to protect Migratory Birds, USFWS has developed “bird windows” statewide that prohibit clearing activity. The bird window for the Northern region of Alaska, including the communities of Point Hope, Point Lay and Wainwright is June 1st – July 31st for shrub and open type habitats (tundra and wetlands) and May 20th – September 15th for nesting seabird colonies. The clearing window for black scoter habitat is through August 10th. Clearing prior to these dates is allowed. If clearing has already occurred then construction may proceed during these dates.

USFWS Wind Turbine Guidelines Advisory Committee developed guidelines and recommendations for wind power projects to avoid impacts to birds and bats. These recommendations have been released to the public as draft U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines and will be referred to during design and construction of a wind turbine project in Point Hope, Point Lay and Wainwright.

In February 2014, ABR Inc. completed a report prepared for the North Slope Borough titled “Site Characterization and Avian Field Study for the Proposed Community-Scale Wind Project in Northern Alaska”. The study was for the communities of Point Hope, Point Lay and Wainwright. The ABR study characterized habitat, bird abundance, migration and nesting movements of observed species and analysis of the impacts on species of concern, specifically spectacled eiders (endangered), Steller’s eiders (endangered) and yellow-throated loons (threatened). The site characterization was focused on a one-mile radius study area surrounding each of the proposed turbine locations in each of the communities. The study concluded that both the most abundant bird species and those with limited populations like the Steller’s and spectacled eiders are most at risk from wind infrastructure. The ABR report states impacts to Steller’s eiders should be considered in all three project areas. Spectacled eiders were not recorded near any of the proposed turbine locations and concluded the risk to this species are low. Yellow billed loons, a USFWS species of concern, were active in Point Hope, were active to a lesser extent in Point Lay, and not recorded in Wainwright. Red throated loons, which is a BLM Alaska Natural Heritage Program “watch” species, were absent from Point Hope but were observed in Point Lay and Wainwright. Red throated loons were the most observed among the focal species discussed in the report and were often observed flying low, below the rotor swept area (RSA). The report concludes that post-construction monitoring data suggests wind infrastructure operates in rural Alaska with limited direct impacts to bird species; however, some impacts would be expected due to migration and breeding movements. Turbine selection and temporal adjustments to operation could mitigate potential impacts.

## Federal Aviation Administration

Prior to turbine construction an FAA Notice of Proposed Construction or Alteration (Form 7460-1) must be completed. Filing a 7460-1 may result in additional discussions with the FAA regarding turbine siting and appropriate lighting requirements that would need to be incorporated into the project specifications.

## U.S. Army Corps of Engineers

The US Army Corps of Engineers (USACE) requires a permit for the placement of fill in "waters of the United States", including wetlands and streams, under Section 404 of the Clean Water Act (CWA). The proposed wind turbine site(s) and supporting infrastructure in Point Hope, Point Lay and Wainwright may be all, or partially located on wetlands. The project must receive a Section 404 permit from the Alaska District USACE and an accompanying U.S. Environmental Protection Agency (EPA) Section 401 Water Quality Certification if the project is situated on, or will impact waters of the US. Currently, Individual Permits and Nationwide 12 permits are being issued for wind power projects in Alaska. An individual permit would be required for activities related to the construction of access roads or pads in wetlands. A Nationwide 12 Permit would be appropriate for activities related to utility installation (i.e. power lines). Depending on the site selection and potential impacts, a jurisdictional determination (wetland delineation) may be necessary to obtain a Section 404 permit.

## Alaska Department of Fish and Game

The Alaska Department of Fish and Game (ADF&G) oversees activities that may have an impact on fish habitat and anadromous fish streams. An ADF&G Title 16 Fish Habitat Permit would be required if the proposed project includes construction of access roads and infrastructure that may impact fish habitat or would involve installing a culvert in a fish stream.

## State Historic Preservation Office

Consultation with the State Historic Preservation Office (SHPO) for State of Alaska-funded projects is required under the State Historic Preservation Act. The act requires that all state projects be reviewed for potential impacts to cultural and historic resources. During the permitting phase of the project prior to construction, consultation with the SHPO would be initiated to determine if the project may impact these resources. The extent of needed infrastructure (pads and new roads) and the presence of known archaeological sites in the vicinity of the project area may trigger the SHPO to recommend an archaeological survey of the site.

# Wind-Diesel Hybrid System Overview

There are now over twenty-four wind-diesel projects in the state, making Alaska a world leader in wind-diesel hybrid technology. There are a variety of system configurations and turbine types in operation and accordingly there is a spectrum of success in all of these systems. As experience and statewide industry support has increased so has overall system performance.

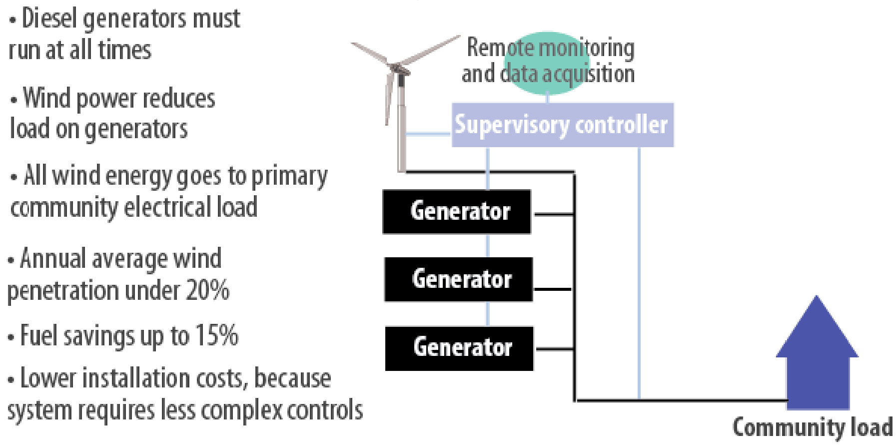
## Wind-diesel Design Options

Wind-diesel power systems are categorized based on their average penetration levels, or the overall proportion of wind-generated electricity compared to the total amount of electrical energy generated. Commonly used categories of wind-diesel penetration levels are low, medium, and high; occasionally very low is also defined as a category. Wind penetration level is roughly equivalent to the amount of diesel fuel displaced by wind power. Note however a positive correlation of system control and demand-management strategy complexity with wind power penetration.

### Low Penetration Configuration

Low (and extremely low) penetration wind-diesel systems require the fewest modifications to the existing system. However, they tend to be less economical than higher penetration configurations due to the limited annual fuel savings compared to fixed project costs, such as new distribution connection.

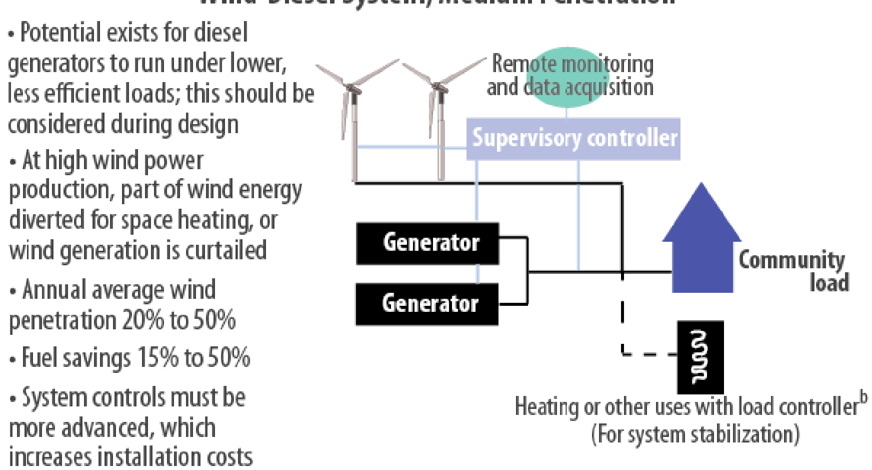
**Wind-Diesel System, Low Penetration[a]**




### Medium Penetration Configuration

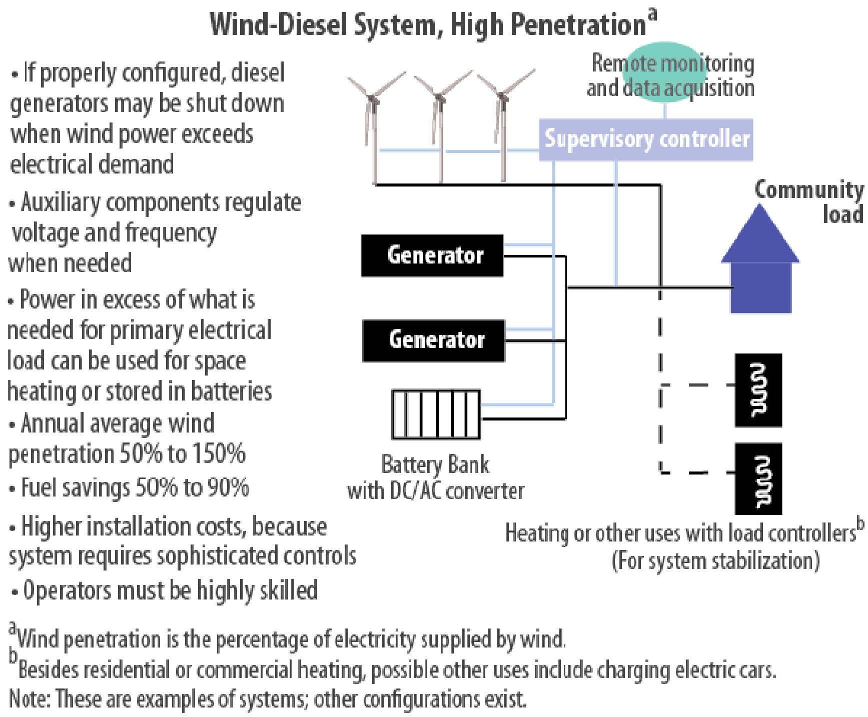
Medium penetration wind-diesel requires relatively sophisticated power quality control due to occasional circumstance of wind generation exceeding load demand and generally are with a full-time diesels-on requirement. Medium penetration is often chosen as a compromise between the minimal benefit of low penetration and the considerable complexity of high penetration, but experience has indicated that this may be misleading. Power quality can be difficult to maintain with typical medium penetration configuration design and upgrades necessary to improve power quality control edge enough toward high penetration that the greater economic benefits of high penetration wind are not captured due to insufficient wind turbine capacity.

**Wind-Diesel System, Medium Penetration[a]**



## High Penetration Configuration

High penetration configuration design typically enables diesels-off operation and uses a significant portion of the wind energy for thermal heating loads. The potential benefit of high penetration can be significant, but system complexity requires a significant investment in project commissioning, operator training, and strong management practices.




Wind-diesel penetration level are summarized table below in a table developed by Alaska Energy Authority. Note that instantaneous penetration level is much more important for system configuration design than average penetration. One way to appreciate instantaneous penetration and design is to consider the brakes of an automobile: they are designed for the maximum (or instantaneous) vehicle speed of, say, 120 mph, not the vehicle's typical day-to-day average speed of 45 mph. If the brakes were designed for average vehicle speed, one would be unable to stop when driving at highway cruising speeds, let alone maximum vehicle speed!

The annual contribution of wind energy, expressed as percentage of wind energy compared to load demand, is the average penetration level. This defines the economic benefit of a project.

### *Categories of wind-diesel penetration levels*

| Penetration Category | Wind Penetration Level | | Operating Characteristics and System Requirements |
|---|---|---|---|
| | Instantaneous | Average | |
| Very Low | <60% | <8% | • Diesel generator(s) runs full time<br>• Wind power reduces net load on diesel<br>• All wind energy serves primary load<br>• No supervisory control system |
| Low | 60 to 120% | 8 to 20% | • Diesel generator(s) runs full time |

| Penetration Category | Wind Penetration Level | | Operating Characteristics and System Requirements |
|---|---|---|---|
| | Instantaneous | Average | |
| | | | • At high wind power levels, secondary loads are dispatched to insure sufficient diesel loading, or wind generation is curtailed<br>• Relatively simple control system |
| Medium | 120 to 300% | 20 to 50% | • Diesel generator(s) runs full time<br>• At medium to high wind power levels, secondary loads are dispatched to insure sufficient diesel loading<br>• At high wind power levels, complex secondary load control system is needed to ensure heat loads do not become saturated<br>• Sophisticated control system |
| High (Diesels-off Capable) | 300+% | 50 to 150% | • At high wind power levels, diesel generator(s) may be shut down for diesels-off capability<br>• Auxiliary components required to regulate voltage and frequency<br>• Sophisticated control system |

### Recommended Penetration Configuration

In general, medium penetration is a good design compromise as it enables a relatively large amount of displaced fuel usage but requires only a moderate degree of system complexity. Medium penetration is the preferred system configuration of Alaska Village Electric Cooperative (AVEC), owner and operator of eleven wind-diesel systems statewide, and Alaska's leading utility developer of wind-diesel. AVEC's experience provides a useful guide for North Slope Borough as it develops wind energy for its communities.

It should be noted however that not all world-wide designers categorize wind penetration as does Alaska Energy Authority. Many collapse the penetration categories to just two: low and high. This simplification is in recognition that system design is dependent on the percentage of instantaneous, not average penetration. The nuances beyond that are diesels-off capability and inclusion of storage options. For village wind power, a project capable of off-setting a worthwhile amount of diesel fuel and providing real economic benefit to the community invariably must be high penetration by the alternate definition. With this in mind, limiting average penetration to a compromise level of 20 to 50 percent may, in some respects, make very little sense. With a design configuration capable of controlling 100 percent and higher instantaneous penetration, there is no particular reason to limit average penetration to a pre-determined percentage as with Alaska Energy Authority's definition of medium penetration.

## Wind-Diesel System Components

Listed below are the main components of a medium to high-penetration wind-diesel system:

- Wind turbine(s), plus tower and foundation
- Supervisory control system
- Secondary load (plus controller)

- Deferrable load
- Interruptible load
- Storage
- Synchronous condenser

### Wind Turbine(s)

Village-scale wind turbines are generally considered to be 50 kW to 500 kW rated output capacity. This turbine size once dominated with worldwide wind power industry but has long been left behind in favor of much larger 1,500 kW plus capacity turbines. Conversely, many turbines are manufactured for home or farm application, but generally these are 10 kW capacity or less. Consequently, few new village size-class turbines are on the market, although a large supply of used and/or remanufactured turbines are available. The latter typically result from repowering older wind farms in the United States and Europe with new, larger wind turbines.

### Supervisory Control System

Medium- and high-penetration wind-diesel systems require fast-acting real and reactive power management to compensate for rapid variation in village load and wind turbine power output. A wind-diesel system master controller, also called a supervisory controller, would be installed inside the Point Lay power plant or in a new module adjacent to it. The supervisory controller would select the optimum system configuration based on village load demand and available wind power.

### Synchronous Condenser

A synchronous condenser, also referred to as a synchronous compensator, is a specialized synchronous-type electric motor with an output shaft that spins freely. Its excitation field is controlled by a voltage regulator to either generate or absorb reactive power as needed to support grid voltage or to maintain the grid power factor at a specified level. A synchronous condenser or similar device is needed to operate in diesels-off mode with wind turbines equipped with asynchronous (induction) type generators. This is to provide the reactive power necessary for operation of the asynchronous generator.

### Secondary Load

A secondary or "dump" load during periods of high wind is required for a wind-diesel hybrid power system to operate reliably and economically. The secondary load converts excess wind power into thermal power for use in space and water heating through the extremely rapid (sub-cycle) switching of heating elements, such as an electric boiler imbedded in the diesel generator jacket water heat recovery loop. A secondary load controller serves to stabilize system frequency by providing a fast responding load when gusting wind creates system instability.

An electric boiler is a common secondary load device used in wind-diesel power systems. An electric boiler (or boilers), coupled with a boiler grid interface control system, could be installed in Point Lay to absorb excess instantaneous energy (generated wind energy plus minimum diesel output exceeds electric load demand). The grid interface monitors and maintains the temperature of the electric hot water tank and establishes a power setpoint. The wind-diesel system master controller assigns the setpoint based on the amount of unused wind power available in the system. Frequency stabilization is another advantage that can be controlled with an electric boiler load. The boiler grid interface will automatically adjust the amount of power it is drawing to maintain system frequency within acceptable limits.

## Deferrable Load

A deferrable load is electric load that must be met within some time period, but exact timing is not important. Loads are normally classified as deferrable because they have some storage associated with them. Water pumping is a common example - there is some flexibility as to when the pump actually operates, provided the water tank does not run dry. Other examples include ice making and battery charging. A deferrable load operates second in priority to the primary load and has priority over charging batteries, should the system employ batteries as a storage option.

## Interruptible Load

Electric heating either in the form of electric space heaters or electric water boilers could be explored as a means of displacing stove oil with wind-generated electricity. It must be emphasized that electric heating is only economically viable with excess electricity generated by a renewable energy source such as wind and not from diesel-generated power. It is typically assumed that 40 kWh of electric heat is equivalent to one gallon of heating fuel oil.

## Storage Options

Electrical energy storage provides a means of storing wind generated power during periods of high winds and then releasing the power as winds subside. Energy storage has a similar function to a secondary load but the stored, excess wind energy can be converted back to electric power at a later time. There is an efficiency loss with the conversion of power to storage and out of storage. The descriptions below are informative but are not currently part of the overall system design.

### Flywheels

A flywheel energy system has the capability of short-term energy storage to further smooth out short-term variability of wind power, and has the additional advantage of frequency regulation. The smallest capacity flywheel available from Powercorp (now ABB), however, is 500 kW capacity, so it is only suitable for large village power generation systems.

### Batteries

Battery storage is a generally well-proven technology and has been used in Alaskan power systems including Fairbanks (Golden Valley Electric Association), Wales and Kokhanok, but with mixed results in the smaller communities. Batteries are most appropriate for providing medium-term energy storage to allow a transition, or bridge, between the variable output of wind turbines and diesel generation. This “bridging” period is typically 5 to 15 minutes long. Storage for several hours or days is also possible with batteries, but this requires higher capacity and cost. In general, the disadvantages of batteries for utility-scale energy storage, even for small utility systems, are high capital and maintenance costs and limited lifetime. Of particular concern to rural Alaska communities is that batteries are heavy and expensive ship and most contain hazardous substances that require special removal from the village at end of service life and disposal in specially-equipped recycling centers.

There are a wide variety of battery types with different operating characteristics. Advanced lead acid and zinc-bromide flow batteries were identified as “technologically simple” energy storage options appropriate for rural Alaska in a July, 2009 Alaska Center for Energy and Power report on energy storage. Nickel-cadmium (NiCad) batteries have been used in rural Alaska applications such as the Wales wind-diesel system. Advantages of NiCad batteries compared to lead-acid batteries include a deeper discharge capability, lighter weight, higher energy density, a constant output voltage, and much better performance during cold temperatures. However, NiCad’s are considerably more expensive than lead-acid batteries, experience a shorter operational life (approx. 5 years vs. 20 years for lead-acid) and one must note that the Wales wind-diesel system had a poor operational history with NiCad batteries and has not been functional for a number of years.

Because batteries operate on direct current (DC), a converter is required to charge or discharge when connected to an alternating current (AC) system. A typical battery storage system would include a bank of batteries and a power conversion device. The batteries would be wired for a nominal voltage of roughly 300 volts. Individual battery voltages on a large scale system are typically 1.2 volts DC. Recent advances in power electronics have made solid state inverter/converter systems cost effective and preferable a power conversion device. The Kokhanok wind-diesel system is designed with a 300 volts DC battery bank coupled to a grid-forming power converter for production of utility-grade real and reactive power. Following some design and commissioning delays, the solid state converter system in Kokhanok should be operational by early 2015 and will be monitored closely for reliability and effectiveness.

## Wind-Diesel Philosophy

Installing wind turbines and creating a wind-diesel power system in an Alaskan village is a demanding challenge. At first glance, the benefits of wind power are manifest: the fuel is free and it is simply a manner of capturing it. The reality of course is more complicated. Wind turbines are complex machines and integrating them into the diesel power system of a small community is complicated. With wind-diesel, a trade-off exists between fuel savings and complexity. A system that is simple and inexpensive to install and operate will displace relatively little diesel fuel, while a wind-diesel system of considerable complexity and sophistication can achieve very significant fuel savings.

The ideal balance of fuel savings and complexity is not the same for every community and requires careful consideration. Not only do the wind resource, electric and thermal load profiles, and powerhouse suitability vary between villages, so does technical capacity and community willingness to accept the opportunities and challenges of wind power. A very good wind-diesel solution for one village may not work as well in another village, for reasons that go beyond design and configuration questions. Ultimately, the electric utility and village residents must consider their capacity, desire for change and growth, and long-term goals when deciding the best solution to meets their needs.

The purpose of this conceptual design report is to introduce and discuss the viability of wind power in Point Lay. As discussed, many options are possible, ranging from a very simple low penetration system to a highly complex, diesels-off configuration potentially capable of displacing 50 percent or more of fuel usage in the community. It is possible that North Slope Borough and Point Lay residents ultimately will prefer a simple, low penetration wind power system, or alternatively a very complex high penetration system, but from past discussions and work it appears that a moderate approach to wind power in Point Lay is preferable, at least initially.

With a moderately complex project design framework in mind, a configuration of relatively high wind turbine capacity with no electrical storage and no diesels-off capability was chosen. This provides sufficient wind capacity to make a substantive impact on fuel usage but does not require an abrupt transition from low to high complexity. Although conceptually elegant, there is a trade-off to consider with this approach. Installing a large amount of wind power (600 to 700 kW of wind capacity is recommended) is expensive, but without electrical or thermal storage some of the benefits of this wind power capacity may not be used to best advantage.

The thermodynamics of energy creation and use dictates that wind power is more valuable when used to offset fuel used by diesel generators to generate electricity than fuel used in fuel oil boilers to serve thermal loads. Referring to the energy production summaries for the turbine configurations under *Modeling Results*, one can see that the wind turbines are expected to produce relatively small amounts of excess electricity, even at 85 percent turbine availability. This excess electricity, although minimal, must be shunted via a secondary load controller to the diesel generator heat recovery loop or simple radiation heaters to avoid curtailing wind turbines during periods of high wind and relatively light electrical load.

Although perhaps not readily apparent in the report, this compromise of wind capacity versus complexity is contained within the economic benefit-to-cost tables. This compromise, which is endemic to wind-diesel, results in high capital costs, but usage of the energy generated is imperfect from an efficiency point of view. The most efficient usage of wind energy from a technical point of view – offset of electrical power, may be too expensive from a cost-benefit perspective.

It is important not to focus strictly on benefit-to-cost ratio of a particular configuration design or particular turbine option, but also consider a wider view of the proposed wind project for Point Lay. Installing approximately 500 kW capacity of wind power has considerable short-term benefit with reduction of diesel fuel usage, but more importantly it would provide a platform of sustainable renewable energy growth in Point Lay for many years to come. This could include enhancements such as additional thermal load offset, battery storage and/or use of a flywheel to enable diesels-off capability, creation of deferred heat loads such as water heating, and installation of distributed electrical home heat units (Steffis heaters or similar) controlled by smart metering. The latter, presently operational to a limited extent in the villages of Kongiganak, Kwigillingok, Tuntutuliak, has enormous potential in rural Alaska to not only reduce the very high fuel oil expenses borne by village residents, but also to improve the efficiency and cost benefit of installed and future wind power projects. These opportunities and benefits are tangible and achievable, but their cost benefit was not modeled in this report.

Lastly, it must be acknowledged that a wind power project in Point Lay will provide benefits that are not easily captured by economic modeling. These are the *externalities* of economics that are widely recognized as valuable, but often discounted because they are considered by some as soft values compared to the hard numbers of capital cost, fuel quantity displaced, etc. These include ideals such as long-term sustainability of the village, independence from foreign-sourced fuel, reduction of Point Lay's carbon footprint, and opportunities for education and training of local residents. Beyond these somewhat practical considerations, there is the simple moral argument that renewable energy is the right thing to do, especially in a community such as Point Lay that is in the vanguard of risk from climate change due to global warming.

## Point Lay Powerplant

Electric power (comprised of the diesel power plant and the electric power distribution system) in Point Lay is provided by North Slope Borough Public Works Department, the utility for all communities on the North Slope, with the exception of Deadhorse and Barrow. A new power plant in Point Lay, which became operational in July 2013 consists of four Caterpillar 3508C diesel generators, each rated at 600 kW output. North Slope Borough documentation has not yet been updated to indicate efficiency of the new power plant.

*Point Lay powerplant diesel generators and bays*

| Genset | Rated Capacity | Model | Installed New |
|---|---|---|---|
| 1 | 600 kW | Caterpillar 3508C | 2013 |
| 2 | 600 kW | Caterpillar 3508C | 2013 |
| 3 | 600 kW | Caterpillar 3508C | 2013 |
| 4 | 600 kW | Caterpillar 3508C | 2013 |

### Switchgear

With its new powerhouse, Point Lay has new switchgear using Allen Bradley PLC Device Net which interfaces devices via RS485 and 10/100 Ethernet. Refer to Appendix D for the Point Lay generator switchgear schematics.

### Geospatial Perspective of Electrical Load

The new powerplant is located in a new building located in the southeast corner of the village. Power is distributed via two 480 volt distribution feeders, supplied by two 1,600 amp circuit breakers from the common powerplant switchgear bus. The 480 V distribution feeders supply two 1.0 MVA main three-phase, pad-mounted, transformers located adjacent to the east side of the power plant. The main transformers transform the 480 V generated power to 4,160Y/2,400 V distributed power. Distributed power from each main transformer is supplied on the east side of the power plant to an overhead, three-phase power line to each aerial distribution feeder through pole-mounted cutout fuses. Refer to Appendix E for the Point Lay power distribution grid schematic.

A group-operated, pole-mounted, air-break switch maintained in a normally open position is located on a pole between the two overhead village feeder power line connections. This switch can be closed in an emergency to allow the entire village to be fed from one distribution transformer in the event of failure of a feeder circuit breaker, main transformer or underground feeder. In the event of failures or faults in overhead power lines, seven additional three-phase, group-operated, pole-mounted switches can be operated either open or closed to connect or disconnect portions of one feeder to the adjacent feeder, or to isolate portions of the power grid.

4,160Y/2,400 volt power in the west feeder supplies west village electrical services, including airport lighting and navigation, USAF Hangar, old White Alice Site facilities, Kali School, water treatment plant, waste water treatment plant, health clinic, washeteria, police department, fire station, store and other commercial and west village residential loads. The east feeder supplies power to the fuel station, SKW shop facilities, and east village residential loads. At present, the west distribution feeder supplies a significantly greater electrical load than the east distribution feeder. As configured, wind turbines at Site A would connect to the west distribution feeder, while wind turbines at sites B or C would connect to the east distribution feeder.

### Phase Balance of Electrical Load

At the present time WHPacific Solutions Group and V3 Energy, LLC do not have phase balance information of the Point Lay power system. Although the phases are presumed to be in balance, this will be examined during the design phase of the project.

### Transformers

The main transformers, serving each feeder at the power plant, are conservatively sized. In an emergency, each is capable of supporting the entire village load during peak winter loads. The distribution transformers are also believed to be liberally sized for demand with capacity of 150% of rated load during colder winter temperatures. This is based on experience with facility loads in general; there is no recorded data to confirm this.

### Phase and/or Transformer Capacity Location(s) for Additional Load

The generation and distribution systems have significant reserve capacity and redundancy. Power lines are #2 ACSR. At some point, NSB may upgrade distribution to 1/0 AAAC to increase conductor strength for snow and ice loading and to prevent problems related to electrolysis corrosion in Point Lay's salt air environment, but this is not scheduled at present.

### Condition of Distribution Lines, Transformers, Poles

North Slope Borough villages generally have some of the better maintained power systems in rural Alaska. The original power poles in Point Lay have largely been replaced over the years. Most of the secondary conductor has been replaced in the past five years and distribution transformers are being replaced with larger transformers to meet increasing residential demand.

### Parasitic and Other Losses

As documented in the 2013 PCE Report, distribution line loss in Point Lay for fiscal year 2013 was 2.0% and powerhouse consumption was a very high 11.6%, yielding a rather low 86.4% ratio of sold vs. generated energy. Recorded powerhouse consumption was also quite high (10.1%) in fiscal year 2012 and hence indicative of a potential problem with billing and/or recordkeeping, but this may instead be related to construction of the new powerhouse. This issue will be investigated during the design phase of the project and addressed as an integral component of the wind-diesel system design and operations plan.

## Wind Turbine Options

Turbine choice was oriented toward turbines that are large enough to match well with Point Lay's electrical load and wind penetration goals. Turbines that meet these criteria are generally in the 100 to 500 kW size range. The wind power industry, however, does not provide many options as village wind power is a small market worldwide compared to utility grid-connected projects where wind turbines are 1,000 kW and larger capacity, or home and farm applications where wind turbines are generally 10 kW or less capacity. For this project, three wind turbines are considered:

1. Aeronautica AW/Siva 250: 250 kW rated output; new
2. Northern Power Systems 360-39-30: 360 kW rated output; new
3. Vestas V27: 225 kW rated output; remanufactured

The choice of selecting new or remanufactured wind turbines is an important consideration and one which North Slope Borough is carefully considering at present through a separately-contracted evaluation effort which included visits to the offices and factories of Aeronautica, Northern Power, and Halus. There are advantages and potential disadvantages of each turbine, including cost, support and parts availability. Note however that the three wind turbines presented in this report have solid track records and good support capacity within Alaska. The turbine evaluation report will be forwarded separately from this conceptual design report.

### Aeronautica AW/Siva 250

Aeronautica Windpower, with offices in Plymouth, Massachusetts and production facilities in Portsmouth, New Hampshire, manufactures the AW/Siva 250 wind turbine in two rotor configurations: 29 meters for IEC wind class design IIA sites and 30 meters for IEC wind class IIIA sites. This turbine is a Siva (Germany) licensed design. For Point Hope, the 30 meter version likely would be most optimal. This turbine has a 30 meter rotor diameter, is rated at 250 kW power output, is stall regulated, has a gearbox-type drive system, and is equipped with asynchronous (induction type) dual-wound (50 kW and 250 kW) generators. Braking is accomplished by passive and hydraulically-actuated pivotable blade tips and hydraulic disc brakes. The turbine has active yaw control and is available with 30, 40, 45, and 50 meter tubular steel towers.

## *AW/Siva 250 specifications:*

| | | |
|---|---|---|
| **Operational Data** | | |
| Start-up wind speed | : 3-4m/sec | |
| Cut-out wind speed | : 25m/sec | |
| Nominal wind speed | : 14m/sec | |
| 50 year extreme gust | : 52.5m/sec | |
| IEC wind class design | : IIA/IIIA | |
| **Rotor** | | |
| Type | : Three bladed, horizontal axis | |
| Position | : Upwind | |
| Rotary direction | : Clockwise, looking from front | |
| Number of blades | : 3 | |
| Rotor diameter | : 29m/30m | |
| Swept area | : $661m^2/707m^2$ | |
| Power regulation | : Stall | |
| Rotor speed | : 40/24 rpm | |
| Hub type | : Ductile cast iron | |
| Weight of hub | : 2000kg | |
| Weight of rotor | : 4150kg | |
| **Blades** | | |
| Manufacturer | : LM Glasfiber | |
| Blade length | : 13.4m | |
| Type | : Self-supporting | |
| Material | : Fiberglass reinforced polyester | |
| Weight per blade | : 750kg | |
| **Generator** | | |
| Manufacturer | : ABB/equivalent | |
| Type | : Dual wound, Asynchronous | |
| Poles | : 4/6 poles | 6/8 poles |
| Synchronous speed | : 1006/1207 rpm | 757/908 rpm |
| Nominal Power | : 250kW | 50kW |
| Voltage | : 400/480 V AC | |
| Frequency | : 50/60 Hz | |
| Insulation class | : F | |
| Protection Class | : IP54 | |
| Thermal protection | : PT100/thermistor | |

| | |
|---|---|
| **Transmission System** | |
| Gearbox Type | : Helical, 3 Stage |
| Material | : Ductile Cast Iron |
| Gearbox Cooling | : Oil Cooler |
| **Turbine Controller** | |
| **Manufacturer** | : Mita-Teknik As Denmark |
| Type | : Microprocessor based |
| Remote control | : Gateway SCADA |
| **Hydraulic system** | |
| Manufacturer | : AVN/Hydratech |
| Motor speed | : 1500 rpm |
| Nominal effect | : 3kW |
| Thermal protection | : Thermorelay/thermistor |
| **Yawing System** | |
| Type | : Active |
| Yaw control | : Wind vane |
| Yawing gear manufacturer | : Rossi/Bonfiglioli |
| Drives | : 2 x planetary |
| **Braking systems** | |
| **Aerodynamic Brake** | |
| Type | : Pivotable blade tips |
| Activation | : Passive & hydraulic |
| **Mechanical Brake** | |
| Type | : Disc Brake |
| Activation | : Hydraulic |
| **Tower** | |
| Manufacturer | : AW/Siva |
| Type | : Tubular |
| Hub Height | : 30/40/45/50m |
| Weight | : 18/28/34/38 t (approx) |
| Corrosion protection | : Hot dipped galvanized |
| **Warranty** | : 2 Years |

## Northern Power Systems 360-39 (NPS 360-39)

At 360 kilowatts of rated power, the new-to-the-market Northern Power 360-39 is an innovative wind turbine with gearless direct drive design, permanent magnet generator, and pleasing aesthetics. The turbine will be marketed in two versions: the NPS 360 for temperature climates and the NPS 360 Arctic for cold climates such as Alaska. Differences between the two include heaters and insulation for the Arctic version, plus certification that metal used in the tower and nacelle frame are appropriate for operation to -40° C (-40° F). Note that design characteristics of the NPS 360-39 will be very similar to the NPS 100 B model turbine which is well represented in Alaska.

According to Northern Power Systems, the proprietary permanent magnet generator is central to the design of the NPS 100 (and the new NPS 360) drivetrain. Permanent magnet generators offer high efficiency energy conversion, particularly at partial load, and require no separate field excitation system. Permanent magnet generators are lighter, more efficient, and require less assembly labor than competing designs. The Northern Power permanent magnet generator was designed in conjunction with its power converter to create an optimized solution tailored for high energy capture and low operating costs.

A key element of Northern Power's direct drive wind turbine design is the setpoint-controllable power converter used to connect the permanent magnet generator output to the local power system.

Northern Power designs and manufactures power converters for its wind turbines in-house, with complete hardware, control design, and software capabilities. In 2006, the American Wind Energy Association (AWEA) awarded its annual Technical Achievement Award to Northern Power's Chief Engineer, Jeff Petter. It recognized his expertise and leadership in the development of Northern Power Systems' FlexPhase™ power converter for mega-watt scale wind turbine applications. The FlexPhase power converter combines a unique, patent-pending circuit design with a high bandwidth control system to provide unique generator management, power quality, and grid support features. The FlexPhase converter platform offers a modular approach with a very small footprint and 20-year design life.

### *NPS 360-39 Class IIIA general information*

| | |
|---|---|
| Model | NPS 360-39 |
| Design Class | IEC 61400-1, 3rd ed., WTGS IIIA |
| Power Regulation | Variable speed, pitch control |
| Orientation | Upwind |
| Yaw Control | Active |
| Number of Blades | Three |
| Rotor Diameter | 39 meters |
| Rated Electrical Power | 360 kW |
| Cut-in/Cut-out Wind Speeds | 3 m/sec; 25 m/sec |
| Controller Type | PLC (programmable logic controller) |
| Hub Height; tower type | 30 meters; 3-section tubular steel monopole |

## Vestas V27

Halus Power Systems of San Leandro, California remanufactures the legacy suite of Vestas wind turbines, rated from 65 kW (the V15) to 600 kW (the V44). Of most interest to North Slope Borough is the V27 turbine. The V27 is a 27 meter rotor diameter, 225 kW rated output, pitch-controlled, gearbox-type drive system, asynchronous double-wound generator wind turbine originally built by Vestas A/S in Denmark. The turbine has active yaw control and is available with 30, 40, and 50 meter tubular steel towers. The V27 nacelle, tower, and blades can be shipped in standard shipping containers, eliminating the expense and risk of damage with break bulk shipping.

Braking and stopping are accomplished by full feathering of the rotor blades, which is a desirable feature of pitch-controlled wind turbines. An emergency stop activates the hydraulic disk brake, which is fitted to the high speed shaft of the gearbox. All functions of the turbine are monitored and controlled by the microprocessor-based control unit. Blade position (pitch angle) is performed by the hydraulic system, which also delivers hydraulic pressure to the brake system. Both are fail-safe in the sense that loss of hydraulic pressure results in feathering of the rotor blades and activation of the disk brake. Of interest with respect to the pitch system is the mechanical interlink of the three rotor blades contained in the hub nose cone. With this simple but ingenious design, it is not possible for the turbine blades to pitch differently from each other.

The V27 was Vestas' workhorse turbine for many years and thousands were installed worldwide. Design of the turbine pre-dates the IEC 61400-1 standards, but by present criteria the turbine can be considered Class II-A and possibly even Class I-A. The V27 is well regarded as a rugged, tough turbine with an outstanding operational history. Four V27 wind turbines are operational in Alaska: three on Saint Paul Island and one at the Air Force's Tin City Long Range Radar Site. Additionally, two V39 wind turbines (big brother of the V27) were installed by TDX Power in Sandpoint, Alaska and are operational. Because of the large numbers of Vestas turbines (legacy and new) deployed in North America, Vestas continues to maintain multiple facilities in the United States including a large manufacturing facility in Colorado and an office in Portland, Oregon. Vestas can provide technical support and spare parts for their legacy turbines (from V17 through V44) as needed. In addition, due to the large number of deployed turbines in North America and worldwide, spare parts are widely available from many suppliers.

## Wind-Diesel HOMER Model

Considering North Slope Borough's goal of displacing as much diesel fuel for electrical generation as possible and yet recognizing the present limitations of high penetration wind power in Alaska and North Slope Borough's desire to operate a highly stable and reliable electrical utility in Point Lay, only the medium penetration wind-diesel configuration scenario was modeled with HOMER software. Note that low penetration wind was not modeled as this would involve use of smaller farm-scale turbines that are not designed for severe cold climates, and low penetration would not meet North Slope Borough's goal of significantly displacing fuel usage in Point Lay.

As previously noted, a medium penetration wind-diesel configuration is a compromise between the simplicity of a low penetration wind power and the significant complexity and sophistication of the high penetration wind. With medium penetration, instantaneous wind input is sufficiently high (at 100 plus percent of the village electrical load) to require a secondary or diversion load to absorb excess wind power, or alternatively, to require curtailment of wind turbine output during periods of high wind/low electric loads. For Point Lay, appropriate wind turbines for medium wind penetration are generally in the 100 to 300 kW range with more numbers of turbines required for lower output machines compared to larger output models.

There are a number of comparative medium penetration village wind-diesel power systems presently in operation in Alaska. These include the AVEC villages of Toksook Bay, Chevak, Savoonga, Kasigluk, Hooper Bay, among others. All are characterized by wind turbines directly connected to the AC distribution system. AC bus frequency control during periods of high wind penetration, when diesel governor control would be insufficient, is managed by the sub-cycle, high resolution, and fast-switching capability of the secondary load controller (SLC). Ideally, the SLC is connected to an electric boiler serving a thermal load as this will enhance overall system efficiency by augmenting the operation of the fuel oil boiler(s) serving the thermal load.

### Powerplant

In July 2013, Point Lay retired use of their former powerplant, which had been equipped with five Caterpillar 3406B diesel generators and one Caterpillar 3412 diesel generator and began use of their new powerplant, equipped with four 600 kW Caterpillar 3508C diesel generators.

### *Diesel generator HOMER modeling information*

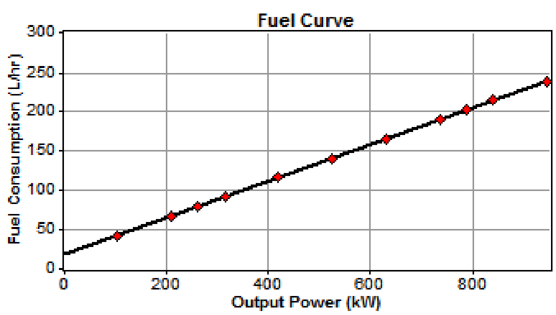
| Diesel generator | Cat 3508C |
|---|---|
| Power output (kW) | 600 |
| Intercept coeff. (L/hr/kW rated) | 0.0237 |
| Slope (L/hr/kW output) | 0.2377 |
| Minimum electric load (%) | 15.0% (90 kW) |
| Heat recovery ratio (% of generator waste heat energy available to serve the thermal load; when modeled) | 35 |

Notes: Intercept coefficient – the no-load fuel consumption of the generator divided by its capacity
Slope – the marginal fuel consumption of the generator

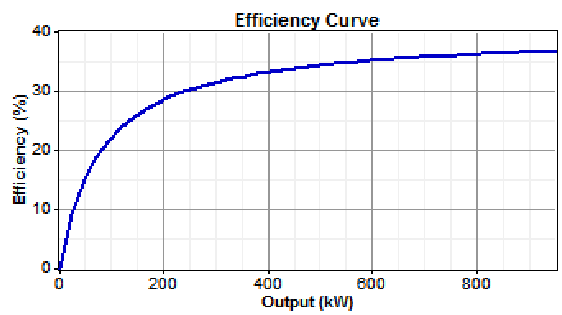
### Caterpillar Diesel Generators

The graphs below illustrate fuel usage and electrical efficiency curves of the Caterpillar 3508 diesel generator used in Homer modeling (Cat 3508 fuel usage information obtained from Alaska Energy Authority). Note that North Slope Borough did not report a seasonal or other specific scheduling plan, hence Homer software was programmed to select the most efficient diesel for any time period. This is somewhat of a moot point for modeling Point Lay in that all four diesel generators are identical and hence of equal fuel efficiency. Also note that Homer was programmed to allow parallel diesel generator operation, which is verfied on review of North Slope Borough's Point Lay power plant logs.

*Cat 3508 fuel curve*




*Cat 3508 electrical energy efficiency curve*




### Cat 3508 Recovered Heat Ratio

The 35 percent heat recovery potential of the Cat 3508 generator was assumed to be equivalent to that of the Cat 3512 generators in use in Point Hope. This information was derived from technical data supplied by NC Power Systems for the Cat 3512. Homer software defines the heat recovery ratio as the percentage of generator waste heat energy available to serve the thermal load. Generator waste heat is energy not used for work; work being the energy output of the generator. As the table below indicates, the recovered heat ratio of the Cat 3512 generator equipped with an after cooler (known also as an intercooler), is 41.8%. Assuming 15% system heat loss, actual heat recovery ratio is 35.5%, which was modeled at 35%.

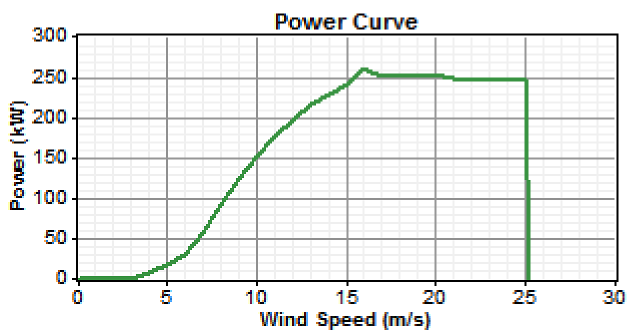
### *Cat 3512 heat recovery table (used as stand-in for Cat 3508)*

| gen pwr | % load | rej to JW (BTU/m) | rejected energy: rej to atmos (BTU/m) | rej to exhaust (BTU/m) | returned energy to JW: exh rcov to 350F (BTU/m) | from oil cooler (BTU/m) | from after cooler (BTU/m) | electricity work energy (BTU/m) | TOTAL (BTU/m) |
|---|---|---|---|---|---|---|---|---|---|
| 665 | 100 | 23,146 | 5,857 | 33,610 | 15,753 | 4,896 | 3,037 | 39,865 | 102,478 |
| % total energy | | 22.6% | 5.7% | 32.8% | 15.4% | 4.8% | 3.0% | 38.9% | 100.0% |
| % of remaining non-work energy | | 37.0% | 9.4% | 53.7% | 25.2% | 7.8% | 4.9% | | |
| JW and aftercooler | | 37.0% | | | | | 4.9% | | 41.8% |
| Recovered heat ratio, Homer, 15% heat loss assumed | | | | | | | | | 35.5% |

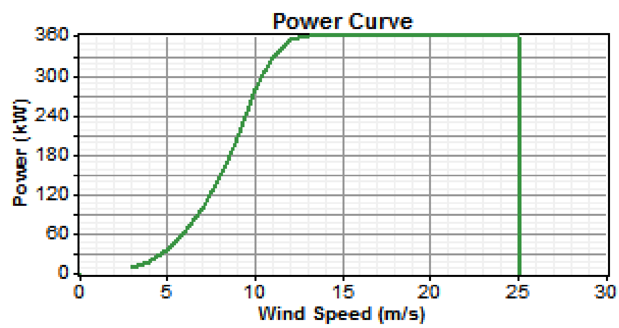
## Wind Turbines

Wind turbine options for Point Lay are discussed previously in this report. For Homer modeling, standard temperature and pressure (STP) power curves were used. This is quite conservative in that actual wind turbine power production in Point Lay will typically be higher than predicted by the STP power curves due to the cold temperature climate and consequent high air density of the area.

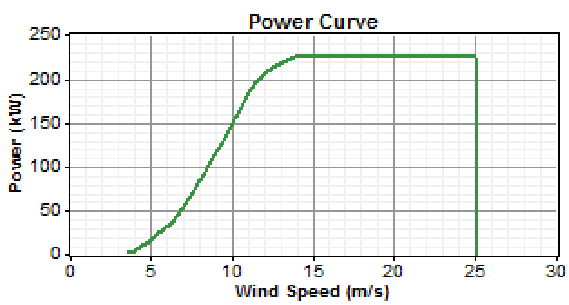
### *Aeronautica AW/Siva 250 power curve*




### *Northern NPS 360-39 power curve*




### *Vestas V27 power curve*

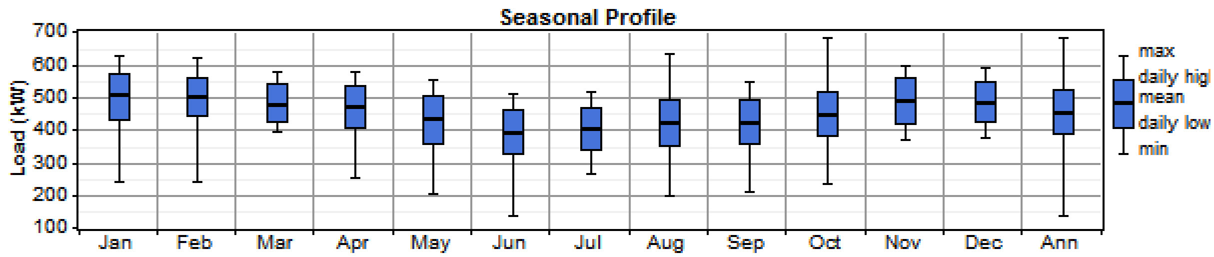


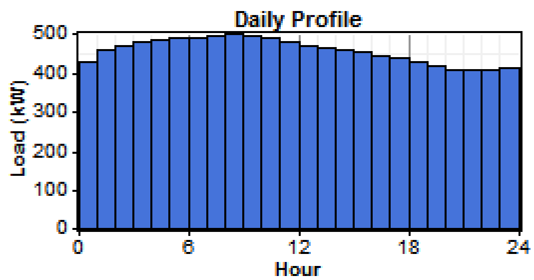

## Electric Load

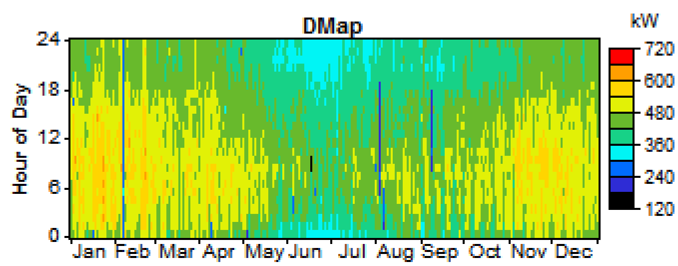
For modeling purposes with Homer software, the Point Lay electric load was derived from calendar year 2013 Point Lay and Point Hope powerplant data forwarded to V3 Energy, LLC by North Slope Borough in an Excel spreadsheet entitled *2013_Point_Lay_PPOR*. The spreadsheet tabulates average power per hour for each diesel engine on-line. If two diesel engines are operating in parallel, individual generator power output is summed to equal total hour (average) load. For each day, generator output is summed to yield kWh produced per generator and aggregate. Below are an example of daily generator output/load data and the monthly Point Lay load profile for 2013.

Completion of the Point Lay powerplant logs was spotty however and data is entirely missing for July through December. With these limitations in mind and with reference to the Statistical Report of the Power Cost Equalization Program, Fiscal Year 2013, the much more complete Point Hope data was scaled 59 percent to match Point Lay's energy usage for the Homer model. This is reasonable as seasonal and diurnal variation are likely to be similar between the villages with the primary difference being the magnitude of usage.

### *Point Lay electric load*




For Homer input, load data is organized into 8,760 lines, representing 24 hours per day, 365 days per year. In a number of instances diesel generator power (load) data was missing from the data set. In these cases, missing data interpolated with reference to data before and after the blank sections.

## Thermal Load

The new Point Lay powerplant is equipped with a heat recovery system to extract jacket water waste heat from the diesel generators and supply it thermal loads, but unfortunately system potential is significantly underutilized at present. RSA Engineering recently indicated to WHPacific that only the wastewater treatment plant is connected to the recovered heat loop and temperature drop between supply and return is well below system design potential. RSA Engineering noted that the recovered heat system was installed with flanges for the school and public works building, but at present they are not connected. It should be noted, however, that the school is located approximately 1,500 ft. from the powerplant, and supplying jacket water recovered heat this distance may be less efficient than installing a remote node electric boiler directly in the school's hydronic heat system. In any event, a medium-to-high penetration wind-diesel system requires substantial thermal load demand to make use of excess instantaneous wind energy, hence options to connect the school and public works building will be investigated during the design phase of this project.

## Wind Turbine Configuration Options

Discussions between WHPacific Solutions Group, V3 Energy, LLC and North Slope Borough to date have indicated that the borough's goals with a wind-diesel system in Point Lay is to offset a high percentage of fuel used in the powerplant, but not create a highly complex system with significant thermal offset and/or electrical storage capability. This philosophy dictates a medium penetration design approach (see previous section of this report) where wind power supplies approximately one-third of the electric load, but at least one diesel generator is always on-line to provide spinning reserve. Medium penetration design, though, means that instantaneous wind power will at times be well over 100 percent of the load. This can result in unstable grid frequency, which occurs when electrical power generated exceeds load demand. In a wind-diesel power system without electrical storage, there are three options to prevent this possibility:

1. Curtail one or more wind turbines to prevent instantaneous wind penetration from exceeding 100 percent (one must also account for minimum loading of the diesel generator).

2. Install a secondary load controller with a resistive heater. The secondary load controller is a fast-acting switch mechanism commanding heating elements to turn on and off to order to maintain stable frequency. The resistive heating elements can comprise a device as simple as a heater ejecting energy to the atmosphere or an interior air space, or more desirably, an electric boiler serving one or more thermal loads. The boiler can be installed in the powerplant heat recovery loop and operate in parallel with fuel oil boilers.

3. Equip the wind turbines with output controllers (some wind turbines, such as the NPS 360, are pre-equipped with these controllers) to enable reduction of turbine power to match load demand. This is a more efficient turbine control strategy than curtailment, but of course presents as additional cost to the project.

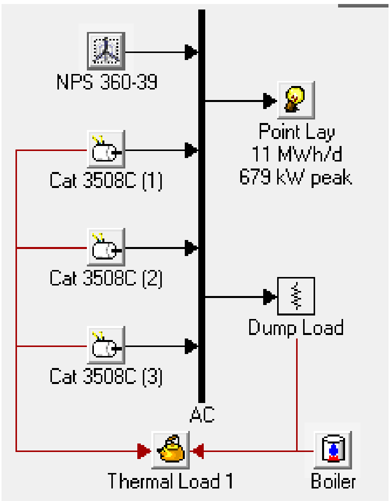
For medium penetration design, frequency control features as described above are necessary because, generally speaking, diesel generators paralleled with wind turbines during periods of high wind energy input may not have sufficient inertia to control frequency by themselves. This design philosophy is true of most wind-diesel systems presently operational in Alaska and provides a solid compromise between the minimal benefit of low penetration systems and the high cost and complexity of high penetration systems.

Many utilities prefer to install more than one wind turbine in a village wind power project to provide redundancy and continued renewable energy generation should one turbine be out-of-service for maintenance or other reasons. With this guideline in mind, and referencing the medium wind power penetration design philosophy discussed above, modeled wind turbine configuration options considered in this report are as follows:

- Aeronautica AW 250, three turbines (750 kW capacity)
- Northern Power NPS 360-39, two turbines (720 kW capacity)
- Vestas V27, three turbines (675 kW capacity)

Turbine types are not mixed, however, as it is assumed that North Slope Borough will select only one type of wind turbine. A typical configuration for this project is show below.

***Sample wind-diesel configuration for Point Lay***




## System Modeling and Technical Analysis

Installation of wind turbines in medium penetration mode is evaluated in this report to demonstrate the economic impact of these turbines with the following configuration philosophy: turbines are connected to the electrical distribution system to serve the electrical load and a secondary load controller and an electric heater or boiler to divert excess electrical power to offset thermal load(s) via a secondary load controller.

HOMER energy modeling software was used to analyze the Point Lay power generation system. HOMER was designed to analyze hybrid power systems that contain a mix of conventional and renewable energy sources, such as diesel generators, wind turbines, solar panels, batteries, etc. and is widely used to aid development of Alaska village wind power projects. The following wind-diesel system configurations were modeled for this conceptual design report. A one-line diagram of this proposed system is presented in Appendix F.

***Modeled wind-diesel configurations***

| Turbine | No. Turbines | Installed kW | Tower Type | Hub Height (meters) |
|---|---|---|---|---|
| AW/Siva 250 | 3 | 750 | Monopole | 40 |
| NPS 360-39 | 2 | 720 | Monopole | 30 |
| Vestas V27 | 3 | 675 | Monopole | 32 |

Modeling assumes that wind turbines constructed in Point Lay will operate in parallel with the diesel generators. Excess energy presumably will serve thermal loads via a secondary load controller and electric boiler that will augment the existing diesel generator jacket water heat recovery system and is modeled as such in the technical analysis of this report (although not in the economic analysis).

Although not considered in this report, deferrable electric and/or remote node thermal loads could be served with excess system energy. This possibility will be considered during the design phase of this project.

### *Technical modeling assumptions*

| | |
|---|---|
| Operating Reserves | |
| Load in current time step | 10% |
| Wind power output | 50% (diesels always on) |
| Fuel Properties (no. 2 diesel for powerplant) | |
| Heating value | 46.8 MJ/kg (140,000 BTU/gal) |
| Density | 830 kg/m$^3$ (6.93 lb./gal) |
| Fuel Properties (no. 1 diesel to serve thermal loads) | |
| Heating value | 44.8 MJ/kg (134,000 BTU/gal) |
| Density | 830 kg/m$^3$ (6.93 lb./gal) |
| Diesel Generators | |
| Efficiency | 14.0 kWh/gal (Homer output) |
| Minimum load | 15% |
| Schedule | Optimized |
| Wind Turbines | |
| Net capacity factor | 85% (adjusted by reducing mean wind speed in Homer software) |
| Turbine hub height | As noted |
| Wind speed | 6.63 m/s at 30 m level at met tower site; wind speed scaled to 6.14 m/s for 85% turbine net AEP |
| Density adjustment | Density not adjusted |
| Energy Loads | |
| Electric | 10,963 kWh/day mean annual electrical load |
| Thermal | Not documented |
| Fuel oil boiler efficiency | 85% |
| Electric boiler efficiency | 100% |

## Model Results

The wind resource at Sites B and C is presumed to be identical to that measured at the met tower site. Site A may have a wind resource slightly better than measured by the met tower due to its higher elevation and likely lower wind shear. Note that turbine energy production is 85 percent net.

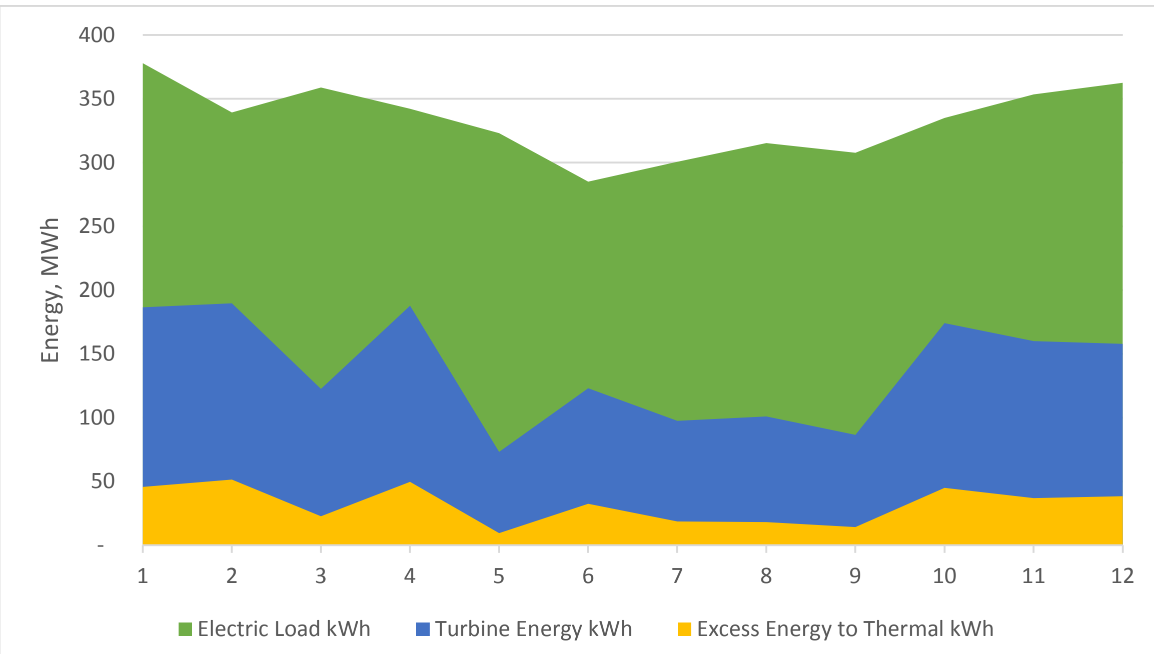
### AW/Siva 250, three (3) turbines, 40 m hub height

This configuration models three AW/Siva 250 kW wind turbines at Point Lay Site C at a 40 meter hub height and generating 85 percent of maximum annual energy production.

#### *Energy table, three AW/Siva 250's, 85% net AEP*

| Month | Electric Load kWh | Turbine Energy kWh | Energy Generated kWh | Turbine Energy to E. Load kWh | Wind Penetration % | Excess Energy to Thermal kWh | Excess Energy to Thermal % |
|---|---|---|---|---|---|---|---|
| 1 | 377,988 | 186,537 | 423,680 | 140,844 | 44.0% | 45,693 | 8.3% |
| 2 | 339,332 | 189,687 | 390,786 | 138,233 | 48.5% | 51,454 | 10.5% |
| 3 | 358,920 | 122,553 | 381,591 | 99,882 | 32.1% | 22,671 | 4.4% |
| 4 | 342,230 | 187,795 | 391,899 | 138,126 | 47.9% | 49,669 | 9.6% |
| 5 | 323,109 | 73,150 | 332,557 | 63,702 | 22.0% | 9,448 | 2.1% |
| 6 | 285,080 | 123,072 | 317,542 | 90,610 | 38.8% | 32,462 | 7.2% |
| 7 | 300,646 | 97,509 | 319,254 | 78,902 | 30.5% | 18,607 | 4.0% |
| 8 | 315,339 | 100,951 | 333,435 | 82,855 | 30.3% | 18,096 | 3.8% |
| 9 | 307,730 | 86,512 | 321,920 | 72,322 | 26.9% | 14,190 | 3.2% |
| 10 | 335,032 | 174,137 | 379,985 | 129,183 | 45.8% | 44,954 | 8.6% |
| 11 | 353,490 | 160,049 | 390,393 | 123,146 | 41.0% | 36,902 | 7.2% |
| 12 | 362,604 | 157,882 | 401,006 | 119,481 | 39.4% | 38,401 | 7.2% |
| Annual | 4,001,500 | 1,659,833 | 4,384,047 | 1,277,286 | 37.9% | 382,547 | 6.3% |

#### *Chart, four AW/Siva 250's*



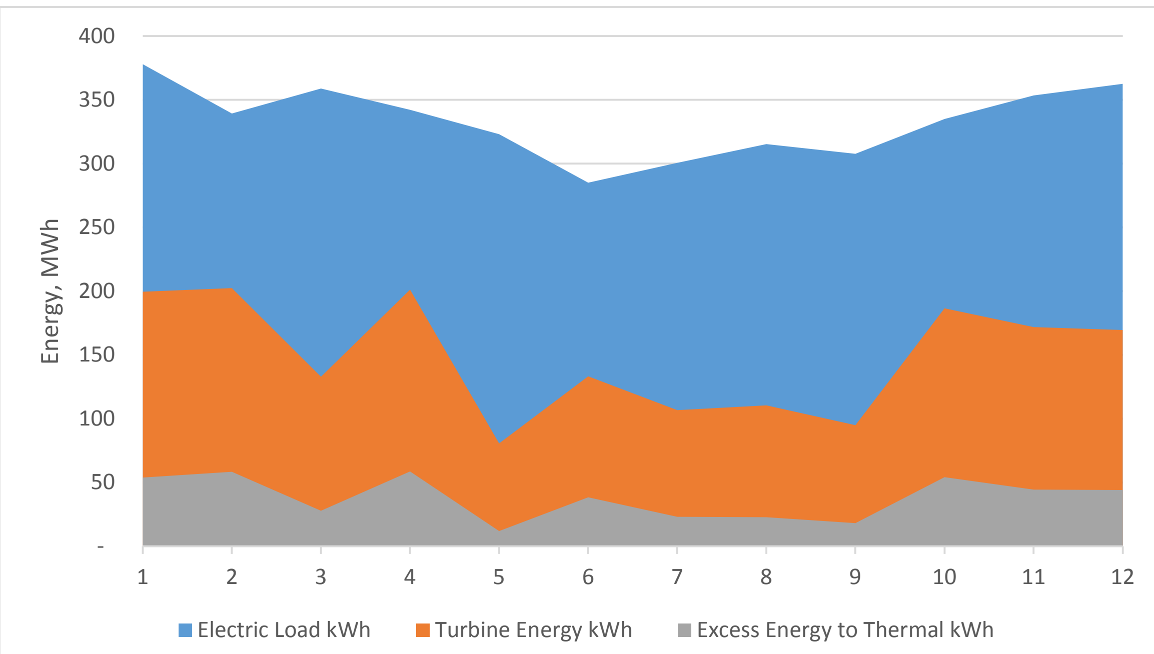
## Northern Power NPS 360-39, two (3) turbines, 30 m hub height

This configuration models two Northern Power Systems NPS 360-39 wind turbines at Point Lay Site C at a 30 meter hub height and generating 85 percent of maximum annual energy production.

### *Energy table, two NPS 360-39's, 85% net AEP*

| Month | Electric Load | Turbine Energy | Energy Generated | Turbine Energy to E. Load | Wind Penetra-tion | Excess Energy to Thermal | Excess Energy to Thermal |
|---|---|---|---|---|---|---|---|
| | kWh | kWh | kWh | kWh | % | kWh | % |
| 1 | 377,988 | 199,573 | 431,844 | 145,716 | 46.2% | 53,857 | 9.5% |
| 2 | 339,332 | 202,416 | 397,703 | 144,045 | 50.9% | 58,371 | 11.6% |
| 3 | 358,920 | 132,893 | 386,734 | 105,079 | 34.4% | 27,814 | 5.2% |
| 4 | 342,230 | 201,198 | 400,870 | 142,558 | 50.2% | 58,640 | 10.9% |
| 5 | 323,109 | 80,630 | 335,000 | 68,739 | 24.1% | 11,891 | 2.4% |
| 6 | 285,080 | 133,229 | 323,438 | 94,871 | 41.2% | 38,358 | 7.9% |
| 7 | 300,646 | 106,705 | 323,717 | 83,634 | 33.0% | 23,070 | 4.6% |
| 8 | 315,339 | 110,454 | 338,083 | 87,709 | 32.7% | 22,744 | 4.5% |
| 9 | 307,730 | 94,928 | 325,833 | 76,824 | 29.1% | 18,104 | 3.8% |
| 10 | 335,032 | 186,558 | 389,179 | 132,411 | 47.9% | 54,147 | 9.9% |
| 11 | 353,490 | 171,841 | 397,881 | 127,450 | 43.2% | 44,391 | 8.2% |
| 12 | 362,604 | 169,538 | 406,682 | 125,460 | 41.7% | 44,078 | 7.9% |
| Annual | 4,001,500 | 1,789,961 | 4,456,964 | 1,334,497 | 40.2% | 455,464 | 7.1% |

### *Chart, two NPS 360-39's*



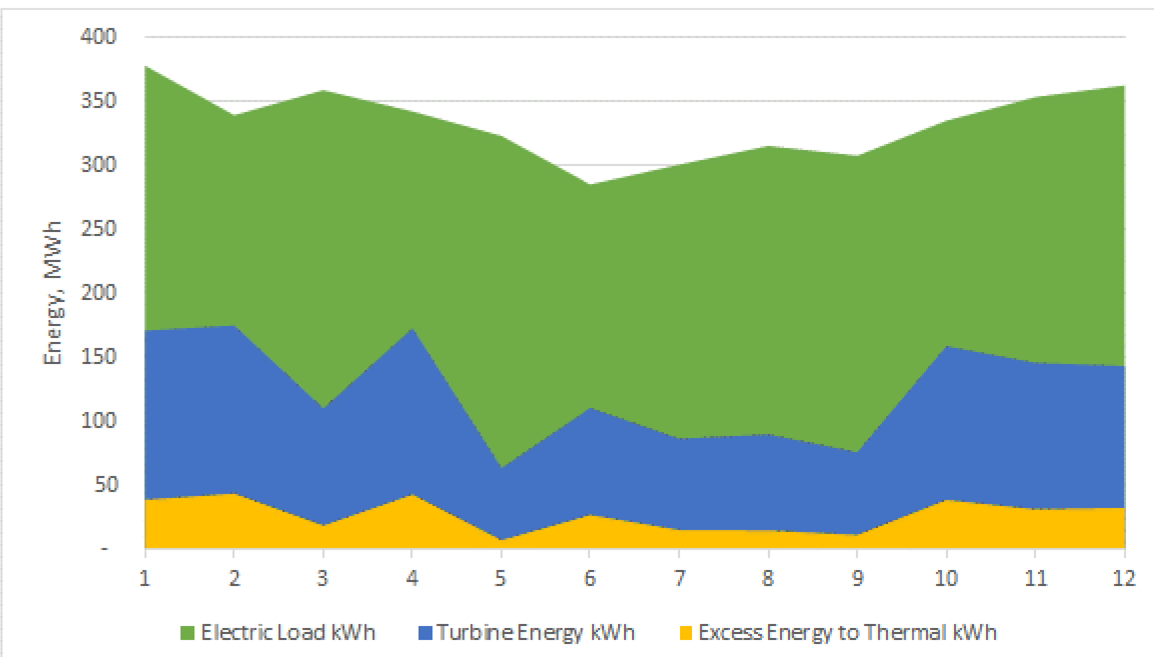
### Vestas V27, three (3) turbines, 32 m hub height

This configuration models three Vestas V27 wind turbines at Point Lay Site A or Site B at a 32 meter hub height and generating 85 percent of maximum annual energy production.

#### *Energy table, three V27's, 85% net AEP*

| Month | Electric Load | Turbine Energy | Energy Generated | Turbine Energy to E. Load | Wind Penetra-tion | Excess Energy to Thermal | Excess Energy to Thermal |
|---|---|---|---|---|---|---|---|
| | kWh | kWh | kWh | kWh | % | kWh | % |
| 1 | 377,988 | 171,029 | 416,781 | 132,236 | 41.0% | 38,794 | 7.3% |
| 2 | 339,332 | 174,977 | 383,084 | 131,225 | 45.7% | 43,753 | 9.2% |
| 3 | 358,920 | 110,015 | 377,626 | 91,308 | 29.1% | 18,706 | 3.6% |
| 4 | 342,230 | 172,843 | 385,182 | 129,891 | 44.9% | 42,952 | 8.5% |
| 5 | 323,109 | 63,526 | 330,411 | 56,224 | 19.2% | 7,302 | 1.6% |
| 6 | 285,080 | 110,679 | 312,059 | 83,700 | 35.5% | 26,979 | 6.0% |
| 7 | 300,646 | 86,519 | 315,986 | 71,179 | 27.4% | 15,340 | 3.3% |
| 8 | 315,339 | 89,799 | 330,235 | 74,902 | 27.2% | 14,897 | 3.2% |
| 9 | 307,730 | 75,981 | 319,098 | 64,613 | 23.8% | 11,368 | 2.6% |
| 10 | 335,032 | 158,762 | 373,779 | 120,015 | 42.5% | 38,747 | 7.6% |
| 11 | 353,490 | 145,812 | 384,935 | 114,367 | 37.9% | 31,445 | 6.2% |
| 12 | 362,604 | 143,341 | 395,167 | 110,779 | 36.3% | 32,562 | 6.2% |
| Annual | 4,001,500 | 1,503,283 | 4,324,344 | 1,180,439 | 34.8% | 322,844 | 5.4% |

#### *Chart, three V27's*



# Economic Analysis

Modeling assumptions are detailed in the table below. Many assumptions, such as project life, discount rate, operations and maintenance (O&M) costs, etc. are AEA default values. Other assumptions, such as diesel overhaul cost and time between overhaul are based on general rural Alaska power generation experience. The base or comparison scenario is the Point Lay powerplant with its present configuration of diesel generators and the existing thermal loads connected to the heat recovery loop.

## Fuel Cost

A fuel price of $6.13/gallon ($1.62/Liter) was chosen for the initial HOMER analysis by reference to *Alaska Fuel Price Projections 2013-2035*, prepared for Alaska Energy Authority by the Institute for Social and Economic Research (ISER), dated June 30, 2013 and the *2013_06_R7Prototype_final_07012013* Excel spreadsheet, also written by ISER. The $6.13/gallon price reflects the average value of all fuel prices between the 2015 (the assumed project start year) fuel price of $5.17/gallon and the 2034 (20 year project end year) fuel price of $7.28/gallon using the medium price projection analysis with an average $CO_2$-equivalent allowance cost of $0.58/gallon included.

By comparison, the fuel price for Point Lay reported to Regulatory Commission of Alaska for the 2013 PCE report is $3.96/gallon ($1.05/Liter), without inclusion of the $CO_2$-equivalent allowance cost. Assuming a $CO_2$-equivalent allowance cost of $0.40/gallon (ISER *Prototype* spreadsheet, 2013 value), the 2013 Point Lay fuel price was $4.36/gallon ($1.15/Liter).

Heating fuel displacement by excess energy diverted to thermal loads is valued at $7.18/gallon ($1.90/Liter) as an average price for the 20 year project period. This price was determined by reference to the *2013_06_R7Prototype_final_07012013* Excel spreadsheet where heating oil is valued at the cost of diesel fuel (with $CO_2$-equivalent allowance cost) plus $1.05/gallon, assuming heating oil displacement between 1,000 and 25,000 gallons per year.

### *Fuel cost table, $CO_2$-equivalent allowance cost included*

| ISER med. projection | 2015 (/gal) | 2034 (/gal) | Average (/gallon) | Average (/Liter) |
|---|---|---|---|---|
| Diesel Fuel | $5.17 | $7.28 | $6.13 | $1.62 |
| Heating Oil | $6.22 | $8.33 | $7.18 | $1.90 |

## Wind Turbine Project Costs

Construction cost for wind turbine installation and integration with the diesel power plant will be accurately estimated during the design phase of the project. Project costs are estimated in this conceptual design report in order to provide comparative valuation. The client is strongly encouraged not to select the wind turbine configuration option based on cost alone, especially the tentative costs presented in this conceptual design report, as other factors may be more important from an operational, maintenance, integration, and support point of view.

### *Economic modeling assumptions*

| Economic Assumptions | |
|---|---|
| Project life | 20 years (2014 to 2033) |
| Discount rate for NPV | 3% (ISER spreadsheet assumption) |
| System fixed capital cost (plant upgrades required to accommodate wind turbines) | Included in turbine project cost |
| Fuel Properties (no. 2 diesel for powerplant) | |
| Price (20 year average; ISER 2013, medium projection plus social cost of carbon) | \$6.13/gal (\$1.62/Liter) |
| Fuel Properties (no. 1 diesel to serve thermal loads) | |
| Price (20 year average; ISER 2013, medium projection plus social cost of carbon) | \$7.18/gal (\$1.90/Liter) |
| Diesel Generators | |
| Generator capital cost | \$0 (already installed) |
| O&M cost | \$0.02/kWh (ISER spreadsheet assumption) |
| Efficiency | 14.0 kWh/gal (Homer calculation) |
| Wind Turbines | |
| Net capacity factor | 85% (adjusted by reducing mean wind speed in Homer software) |
| O&M cost | \$0.049/kWh (ISER spreadsheet assumption) |

### *Wind Turbine Costs*

| Config-uration | No. Turbs | Wind Capacity (kW) | Estimated Cost (in \$ millions) Turbine | Freight | Install | Civil | Distribu-tion | Power-plant | Project Cost | Cost/kW |
|---|---|---|---|---|---|---|---|---|---|---|
| AW 250 | 3 | 750 | 1.90 | 0.70 | 2.00 | 1.40 | 0.75 | 0.30 | 7.05 | \$ 9,400 |
| NPS 360 | 2 | 720 | 1.50 | 0.70 | 1.80 | 1.30 | 0.75 | 0.30 | 6.35 | \$ 8,800 |
| V27 | 3 | 675 | 0.90 | 0.50 | 2.00 | 1.40 | 0.75 | 0.30 | 5.85 | \$ 8,700 |

## Modeling Results

Economic benefit-to-cost is shown by the ISER method which does not account for heat loss from the diesel engines due to reduced loading and subsequent impact on heating fuel usage to serve the thermal loads.  ISER cost modeling assumptions are noted above or are discussed in the 2013_06_R7Prototype_final_07012013 Excel spreadsheet.  Net annual energy production of the wind turbines was assumed at 85 percent to reflect production losses due to operations and maintenance down time, icing loss, wake loss, hysteresis, etc.

***Economic comparison table of Point Lay wind turbine options***

| Configuration | Wind Turbine Capacity (kW) | Project Cost (in $ millions) | NPV Benefits (in $ millions) | NPV Costs (in $ millions) | B/C ratio | Diesel Fuel Saved (gal/yr) | Heat Oil Saved (gal/yr) | Petroleum Fuel Saved (gal/yr) |
|---|---|---|---|---|---|---|---|---|
| AW 250 | 750 | 7.05 | 7.91 | 6.26 | 1.26 | 95,100 | 9,800 | 101,000 |
| NPS 360 | 720 | 6.35 | 8.39 | 5.64 | 1.49 | 95,100 | 11,600 | 106,700 |
| V27 | 675 | 5.85 | 7.24 | 5.20 | 1.39 | 84,300 | 8,300 | 92,600 |

## Data Analysis Uncertainty

There are a number of concern and potential problems with data used for modeling in this report. Chief among them is that the Point Lay powerplant data are manually-collected log readings, *not* computer-calculated average power per hour as one might conclude by reviewing North Slope Borough's *2013_Point_Lay_PPOR* file. Further, one half year of the 2013 powerplant logs were missing. While manually collected logs are desirable from an operational perspective, manual logs are not suitable for modeling as they are only a brief "snapshot" once per hour of the load and are generally unrepresentative, sometimes dramatically so, of actual average load demand during the time period of the log entry.

Note that the manually-collected logs in Point Hope (used as a reference load for Point Lay) likely account for the odd occurrences of very low electrical loads for a particular hour that are bracketed by much higher loads on either side. In reality this load variation most likely did not occur, but identifying and correcting every questionable occurrence in an 8,760 line data set is extremely tedious and not necessary for this analysis.

The thermal load in Point Lay is not documented and is not quantified in this report. Thermal loads in other North Slope Borough communities are reasonably well documented and can be used as reference for Point Lay, but that data is four years old. Additionally, the RSA Engineering report, the source document of thermal loads for other Borough villages, was structured such that actual load demand is not readily apparent. This might be a consideration during design should North Slope Borough wish to consider much higher wind penetrations where thermal offset would be considerably larger than modeled.

Project costs are estimated in this conceptual design report and will be determined with greater accuracy during the design phase of the project.

## Discussion

For this conceptual design report, only proven and robust wind turbines were considered for evaluation, hence any of the configurations considered can be designed and operated to meet expectations of high performance and reliability. Integration requirements will vary depending on the type of electrical generator in the turbine (synchronous vs. asynchronous), inverter-conditioning, soft-start or other similar grid stability control features, VAR support if necessary, minimum loading levels of the diesel generators as a percentage of the electric load, secondary load controller resolution and response time, among others. These design elements are beyond the scope of this conceptual design project, but the technology has matured such that one may be assured that wind turbines are controllable when operating in Point Lay in a medium penetration/non-storage mode.

With these issues in mind, the primary deciding factors for selection of wind turbine(s) for Point Lay will be cost, aesthetics, redundancy, support, and commonality.

## Cost

Note that the cost estimates in this report were not produced with the same level of precision and accuracy as will occur during the design phase and so should be treated with a substantial level of caution. Also note that many cost parameters such as operations and maintenance costs over the life of the project are estimated using Alaska Energy Authority default values and may not be realistic for any particular turbine configuration option. For this reason the benefit-to-cost ratios indicated in the preceding table should not be ranked nor compared. The point of including the table is to indicate that per the parameters of this analysis, all three turbine options exhibit beneficial economic potential for North Slope Borough and the community of Point Lay.

## Reliability

Turbine reliability can be obtained from manufacturer data, third party reviews, and utility experience. Even with a great warranty and promises of strong manufacturer support, robust and reliable wind turbines are highly desirable. Point Lay is an isolated community and expensive to visit, so it is desirable to install equipment where the likelihood of nagging maintenance issues are minimal. All warranty and maintenance support periods eventually end, and North Slope Borough will want to be assured that the turbines they purchase will serve them well in the future.

## Aesthetics

This is a highly subjective consideration that undoubtedly will elicit a number of strong and conflicting opinions. Ultimately, Point Lay residents must collectively agree on the project site and on the aesthetic impact of wind turbines in their community. Simply put, wind turbines will have a visual impact in Point Lay and will easily be the highest and most dominating structure(s) for miles around. Which is preferable: one or two larger turbines or an array of several smaller turbines? This is a difficult question for most people to answer in the abstract because one must mentally imagine wind turbines at Site C (or the other sites) where at present the landscape is flat, bare and nearly featureless. Software modeling that superimposes virtual wind turbine(s) onto the Google Earth image of Point Hope may prove beneficial for the discussion.

## Redundancy

A single wind turbine would be redundant in the sense that diesel generation will continue to function to meet electrical load demand should the turbine be off-line for maintenance or a fault condition. On the other hand, a single wind turbine is not redundant with respect to wind generation itself. Should a single installation wind turbine be out of service for an extended period of time, no wind energy would be generated during the outage.

## Support

Manufacturer warranty and support will be a primary consideration of North Slope Borough given its responsibility as electrical utility for Point Lay. The Borough must have confidence that the turbine manufacturer and/or its representatives will be available throughout the life of the project. This is a matter of trust and ultimately a value that North Slope Borough must determine for itself.

## Commonality

This is a practical consideration for North Slope Borough. There are four Borough village wind projects presently entering the design phase: Point Hope, Point Lay, Wainwright, and Kaktovik. In the related Kaktovik project, North Slope Borough arranged a manufacturer site visit report in March 2014 to Halus Power Systems in California (remanufacturer of Vestas turbines), Aeronautica Windpower in Massachusetts, and Northern Power Systems in Vermont. Objectives of this trip were to meet company representatives, establish relationships, and assess the desirability and potential of each as the "fleet turbine" provider for the Borough.

There are many desirable aspects of a fleet turbine – whether a single turbine model or a family of models – that would be attractive to North Slope Borough. These include a single supplier and point of contact, a common control system for all turbines in the fleet, common parts, and utility and village technicians that learn to service only one type of turbine, not two or more.

On the other hand, given the variability in electrical load profile, site dimensions, and height constraints, no one turbine manufacturer addressed in this conceptual design report provides the perfect solution for all four North Slope Borough villages. It may be more optimal cost-wise to install a turbine(s) from one manufacturer in one village or more villages and turbine(s) from a different manufacturer in the other villages.

# Turbine Recommendation

A number of factors presented in the discussion section above are the province of North Slope Borough and/or the community of Point Lay to decide, such as aesthetic considerations and confidence in manufacturer guarantees and proffered support. These factors and others will influence the turbine configuration decision for the design phase of the project. Nevertheless, and with these issues in mind, WHPacific Solutions Group and V3 Energy, LLC recommends the configuration of two Northern Power Systems NPS 360-39 wind turbines (with the possibility of additional turbines in the future) as the preferred option for wind power development in Point Lay.

WHPacific Solutions Group and V3 Energy recommend a configuration of three Vestas V27 wind turbines as an alternate option, and a configuration of three AW/Siva 250 wind turbines as a second alternate option, but less is known about the Siva turbine compared to Vestas, hence some hesitancy about this option at the present time.

These recommendations are based on the following considerations:

- Cost – Preliminary cost modeling indicates that the NPS 360-39 and V27 options are relatively equal with respect to life-cycle economic benefit. The AW/Siva 250 option appears to have a lower life-cycle economic benefit, but still positive.

- Reliability – All turbine options presented in this report are considered to be reliable machines with proper maintenance and support.

- Aesthetics – The NPS 360-39 is offered only on a relatively low 28.5 meter tower (for a 30 meter hub height), minimizing the visual impact of this turbine compared to the others. The alternate turbines, however, are available on approx. 35 meter towers on the low end, so their visual impact is not much greater.

- Redundancy – With respect to redundancy, WHPacific Solutions Group and V3 Energy recommend two or more wind turbines for Point Lay. As a general rule, wind turbine availability has been lower in Alaska village wind-diesel systems than in grid-connected applications. There are many reasons for this, principally related to integration and operational factors. Some of these issues can be mitigated with careful design and planning, but an expectation of utility-experience wind turbine availability is unrealistic in rural Alaska. With this reality in mind, installing at least two wind turbines enables continuity of wind power production should one turbine be out of service for an extended period of time.

- Support – The turbine manufacturers evaluated in this conceptual design report are highly regarded companies with extensive depth and capability to provide warranty and continuing support over time with both factory personnel and Alaska-based representatives. In addition, all three companies will train North Slope Borough personnel to operate and maintain the turbines.

- Commonality – Considering the electric load demand and wind turbine site constraints in Point Lay, Point Hope, Wainwright and Kaktovik (North Slope Borough's companion wind power project villages), only the Aeronautica, Northern Power Systems, and Vestas family of turbines can be used in all four communities.

  It is the opinion of WHPacific Solutions Group and V3 Energy LLC that North Slope Borough will find it less demanding to manage one type of wind turbine among several village projects than two or more turbine types, other factors aside.

## Single Turbine Option

This conceptual design report focused on medium penetration options to provide approximately one-third of Point Lay's electrical load demand with wind power. Should higher wind penetration be contemplated and should NSB be amenable to a single turbine configuration, the EWT DW 900 wind turbine is an excellent option.

The EWT DW 52/54-900 is a direct-drive, pitch-regulated wind turbine with a synchronous generator and inverter-conditioned power output. More information regarding the EWT DW 52/54-900 wind turbine can be found on EWT's website: http://www.ewtdirectwind.com/. The turbine boasts a track record of over 400 operating turbines in many different wind climates. At present, six DW 900 turbines have been installed in Alaska: two each in Delta Junction, Kotzebue and Nome. For Point Lay, the 54 meter rotor version likely would be most optimal and should Site C be developed, a higher hub height of 50 or 75 meters can be considered.

It should be noted that as with the NPS 360-39, the EWT DW 54-900 can be setpoint controlled to limit maximum power output; for the EWT to as low as 250 kW. This is accomplished by pitching the rotor blades to achieve less than optimal power production.

Recommending a EWT 900 for Point Lay, however, even if operated in a permanent setpoint-controlled manner to reduce wind penetration, would counter the values of redundancy and commonality expressed above. WHPacific Solutions Group and V3 Energy believe that North Slope Borough would be better served with redundant wind turbine capacity in their project communities, but this is not strictly necessary for a successful wind project. It should be noted that EWT offers performance guarantees for their turbines that mitigates the risk of a single turbine application, which North Slope Borough may wish to consider.

WHPacific Solutions Group and V3 Energy considers commonality of wind turbines for all four planned wind power projects (Point Hope, Point Lay, Wainwright, and Kaktovik) to be in the Borough's best interests and hence the recommendation of a wind turbine that will be suitable for all four communities. Should North Slope Borough be willing to consider two turbine types for their fleet, the EWT DW 900 may be an excellent choice for Point Lay.

## Wind Turbine Layout

Site C boundaries indicate ownership by both the U.S. military, presumably the Air Force, and Arctic Slope Regional Corporation. It is presumed that the Air Force would consider transfer of land ownership to corporate or borough control to support a wind project, but lacking that, Arctic Slope Regional Corp. land boundaries appear sufficient to support wind development at the site. The image below shows two Northern Power Systems NPS 360-39 wind turbines in a northwest-to-southeast alignment with five rotor diameter (approximately 200 meters) separation. This is within the three to five rotor diameter separation generally recommended for turbine array design. Precise turbine locations with attendant wake loss (array efficiency) calculations will be modeled during the design phase of this project after site and turbine selections.

Refer to Appendix G for drawings of the existing electrical distribution system and necessary expansion to connect wind turbines located at Site C. As indicated, approximately 3.5 km (2.2 miles) of new 4,160 V distribution is required. Should wind turbines be located at Sites A or B, much shorter new distribution would be required.

*Proposed NPS 360-39 turbine layout, Site C*


## Data Collection Recommendation

Prior to or at least during the design phase of the Point Lay wind power project, North Slope Borough is strongly encouraged to implement an enhanced power plant monitoring and data collection effort to obtain average and transient load and other data not presently available. To capture transient behavior, highly granular data (one second or less averaging time) is most desirable. Data of this nature is extremely valuable for the design process and significantly reduces the risk of design errors and/or omissions resulting from unknown or unrecognized behavior of existing system components.

## Project Design Penetration Consideration

This conceptual design report focused on four wind turbine configuration options that achieved approximately 35 percent wind power penetration. During design, presuming that the turbine type has been selected, North Slope Borough is encouraged to consider the benefits and cost implications of additional wind turbine capacity; for instance, 50 percent and higher average wind power penetration. This evaluation can be achieved with Homer software and other modeling tools and may reveal a more optimal and beneficial wind-diesel power system for the community of Point Lay than the configurations presented in this report. Higher wind penetration though requires greater system complexity and control; these factors are inter-mutual and cannot be de-linked. But, high penetration yields the greatest benefit of wind power and North Slope Borough may want to examine and consider this option carefully before committing to a design objective.

## Appendix A – FAA's Notice Criteria Tool, Site A

Federal Aviation Administration

The OE/AAA site will be temporarily unavailable Wednesday, 17 December from 7:00PM to 10:00PM eastern due to scheduled maintenance.

« OE/AAA

# Notice Criteria Tool

Notice Criteria Tool - Desk Reference Guide V_2014.2.0

The requirements for filing with the Federal Aviation Administration for proposed structures vary based on a number of factors: height, proximity to an airport, location, and frequencies emitted from the structure, etc. For more details, please reference CFR Title 14 Part 77.9.

You must file with the FAA at least 45 days prior to construction if:

- your structure will exceed 200ft above ground level
- your structure will be in proximity to an airport and will exceed the slope ratio
- your structure involves construction of a traverseway (i.e. highway, railroad, waterway etc...) and once adjusted upward with the appropriate vertical distance would exceed a standard of 77.9(a) or (b)
- your structure will emit frequencies, and does not meet the conditions of the FAA Co-location Policy
- your structure will be in an instrument approach area and might exceed part 77 Subpart C
- your proposed structure will be in proximity to a navigation facility and may impact the assurance of navigation signal reception
- your structure will be on an airport or heliport
- filing has been requested by the FAA

If you require additional information regarding the filing requirements for your structure, please identify and contact the appropriate FAA representative using the Air Traffic Areas of Responsibility map for Off Airport construction, or contact the FAA Airports Region / District Office for On Airport construction.

The tool below will assist in applying Part 77 Notice Criteria.

| | |
|---|---|
| **Latitude:** | 69 Deg 45 M 9.87 S N |
| **Longitude:** | 163 Deg 0 M 22.43 S W |
| **Horizontal Datum:** | NAD83 |
| **Site Elevation (SE):** | 25 (nearest foot) |
| **Structure Height (AGL):** | 200 (nearest foot) |
| **Traverseway:** | No Traverseway (Additional height is added to certain structures under 77.9(c)) |
| **Is structure on airport:** | (●) No ( ) Yes |

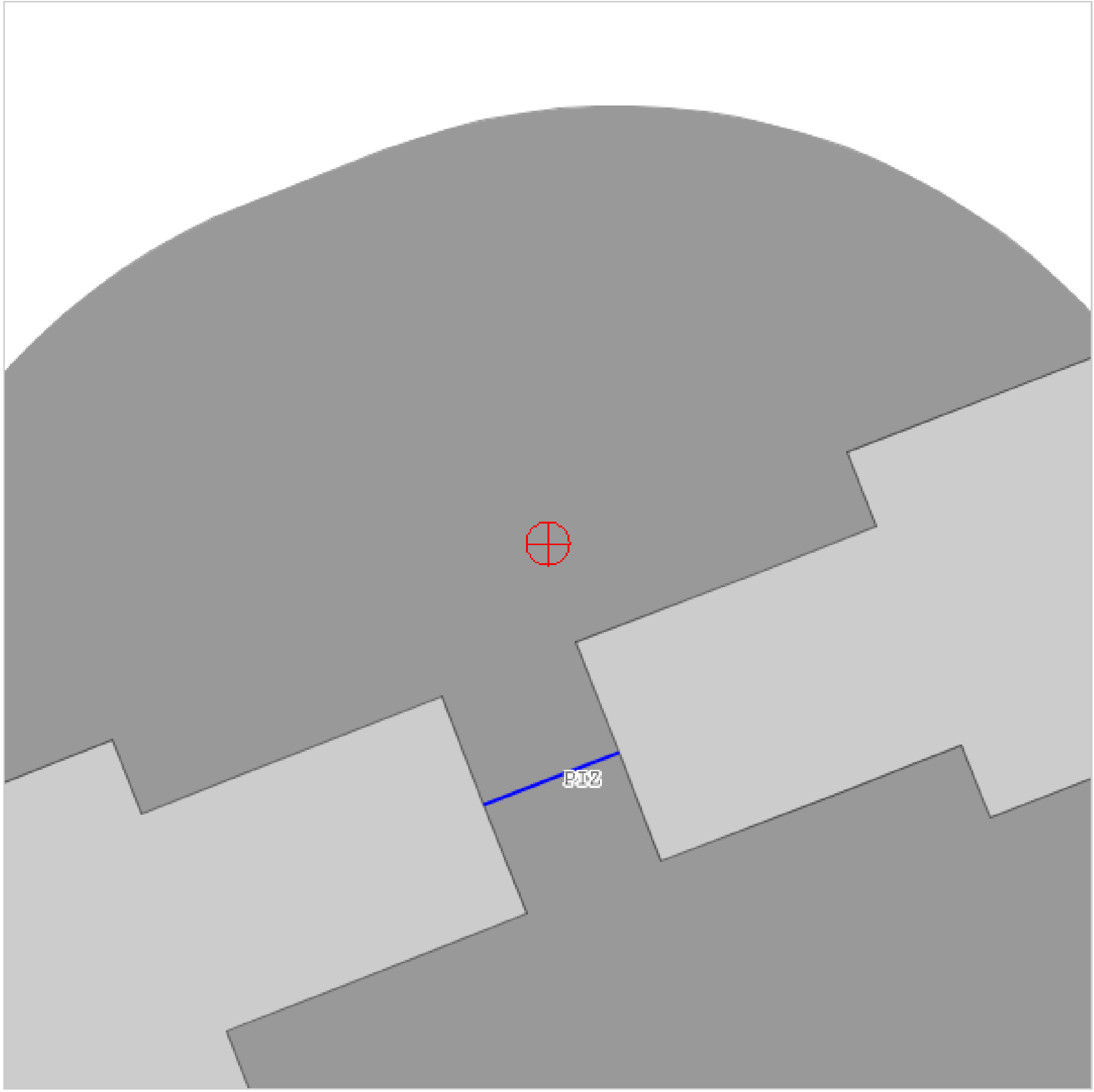
## Results

You exceed the following Notice Criteria:

Your proposed structure is in proximity to a navigation facility and may impact the assurance of navigation signal reception. The FAA, in accordance with 77.9, requests that you file.

77.9(b) by 140 ft. The nearest airport is PIZ, and the nearest runway is 05/23.

The FAA requests that you file



## Appendix B – FAA's Notice Criteria Tool, Site B

Federal Aviation Administration

The OE/AAA site will be temporarily unavailable Wednesday, 17 December from 7:00PM to 10:00PM eastern due to scheduled maintenance.

« OE/AAA

# Notice Criteria Tool

Notice Criteria Tool - Desk Reference Guide V_2014.2.0

The requirements for filing with the Federal Aviation Administration for proposed structures vary based on a number of factors: height, proximity to an airport, location, and frequencies emitted from the structure, etc. For more details, please reference CFR Title 14 Part 77.9.

You must file with the FAA at least 45 days prior to construction if:

- your structure will exceed 200ft above ground level
- your structure will be in proximity to an airport and will exceed the slope ratio
- your structure involves construction of a traverseway (i.e. highway, railroad, waterway etc...) and once adjusted upward with the appropriate vertical distance would exceed a standard of 77.9(a) or (b)
- your structure will emit frequencies, and does not meet the conditions of the FAA Co-location Policy
- your structure will be in an instrument approach area and might exceed part 77 Subpart C
- your proposed structure will be in proximity to a navigation facility and may impact the assurance of navigation signal reception
- your structure will be on an airport or heliport
- filing has been requested by the FAA

If you require additional information regarding the filing requirements for your structure, please identify and contact the appropriate FAA representative using the Air Traffic Areas of Responsibility map for Off Airport construction, or contact the FAA Airports Region / District Office for On Airport construction.

The tool below will assist in applying Part 77 Notice Criteria.

| | |
|---|---|
| **Latitude:** | 69 Deg 44 M 14.58 S N |
| **Longitude:** | 163 Deg 1 M 5.75 S W |
| **Horizontal Datum:** | NAD83 |
| **Site Elevation (SE):** | 6 (nearest foot) |
| **Structure Height (AGL):** | 200 (nearest foot) |
| **Traverseway:** | No Traverseway (Additional height is added to certain structures under 77.9(c)) |
| **Is structure on airport:** | (●) No ( ) Yes |

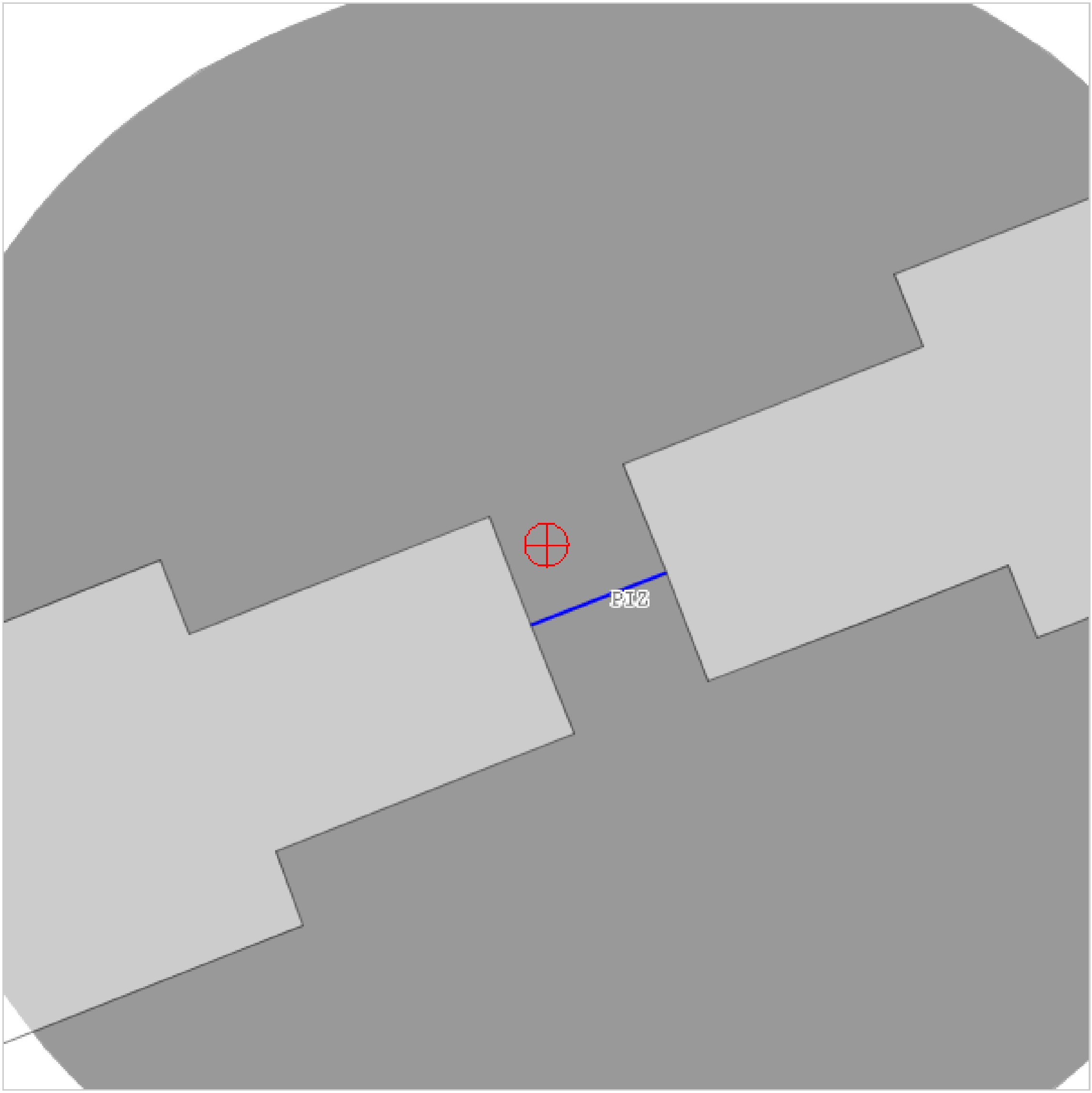
## Results

You exceed the following Notice Criteria:

Your proposed structure is in proximity to a navigation facility and may impact the assurance of navigation signal reception. The FAA, in accordance with 77.9, requests that you file.

77.9(b) by 160 ft. The nearest airport is PIZ, and the nearest runway is 05/23.

The FAA requests that you file


P12

## Appendix C – FAA's Notice Criteria Tool, Site C

Federal Aviation Administration

The OE/AAA site will be temporarily unavailable Wednesday, 17 December from 7:00PM to 10:00PM eastern due to scheduled maintenance.

« OE/AAA

# Notice Criteria Tool

Notice Criteria Tool - Desk Reference Guide V_2014.2.0

The requirements for filing with the Federal Aviation Administration for proposed structures vary based on a number of factors: height, proximity to an airport, location, and frequencies emitted from the structure, etc. For more details, please reference CFR Title 14 Part 77.9.

You must file with the FAA at least 45 days prior to construction if:

- your structure will exceed 200ft above ground level
- your structure will be in proximity to an airport and will exceed the slope ratio
- your structure involves construction of a traverseway (i.e. highway, railroad, waterway etc...) and once adjusted upward with the appropriate vertical distance would exceed a standard of 77.9(a) or (b)
- your structure will emit frequencies, and does not meet the conditions of the FAA Co-location Policy
- your structure will be in an instrument approach area and might exceed part 77 Subpart C
- your proposed structure will be in proximity to a navigation facility and may impact the assurance of navigation signal reception
- your structure will be on an airport or heliport
- filing has been requested by the FAA

If you require additional information regarding the filing requirements for your structure, please identify and contact the appropriate FAA representative using the Air Traffic Areas of Responsibility map for Off Airport construction, or contact the FAA Airports Region / District Office for On Airport construction.

The tool below will assist in applying Part 77 Notice Criteria.

| | |
|---|---|
| **Latitude:** | 69 Deg 43 M 14.79 S N |
| **Longitude:** | 162 Deg 55 M 49.41 S W |
| **Horizontal Datum:** | NAD83 |
| **Site Elevation (SE):** | 50 (nearest foot) |
| **Structure Height (AGL):** | 200 (nearest foot) |
| **Traverseway:** | No Traverseway<br>(Additional height is added to certain structures under 77.9(c)) |
| **Is structure on airport:** | (●) No<br>( ) Yes |

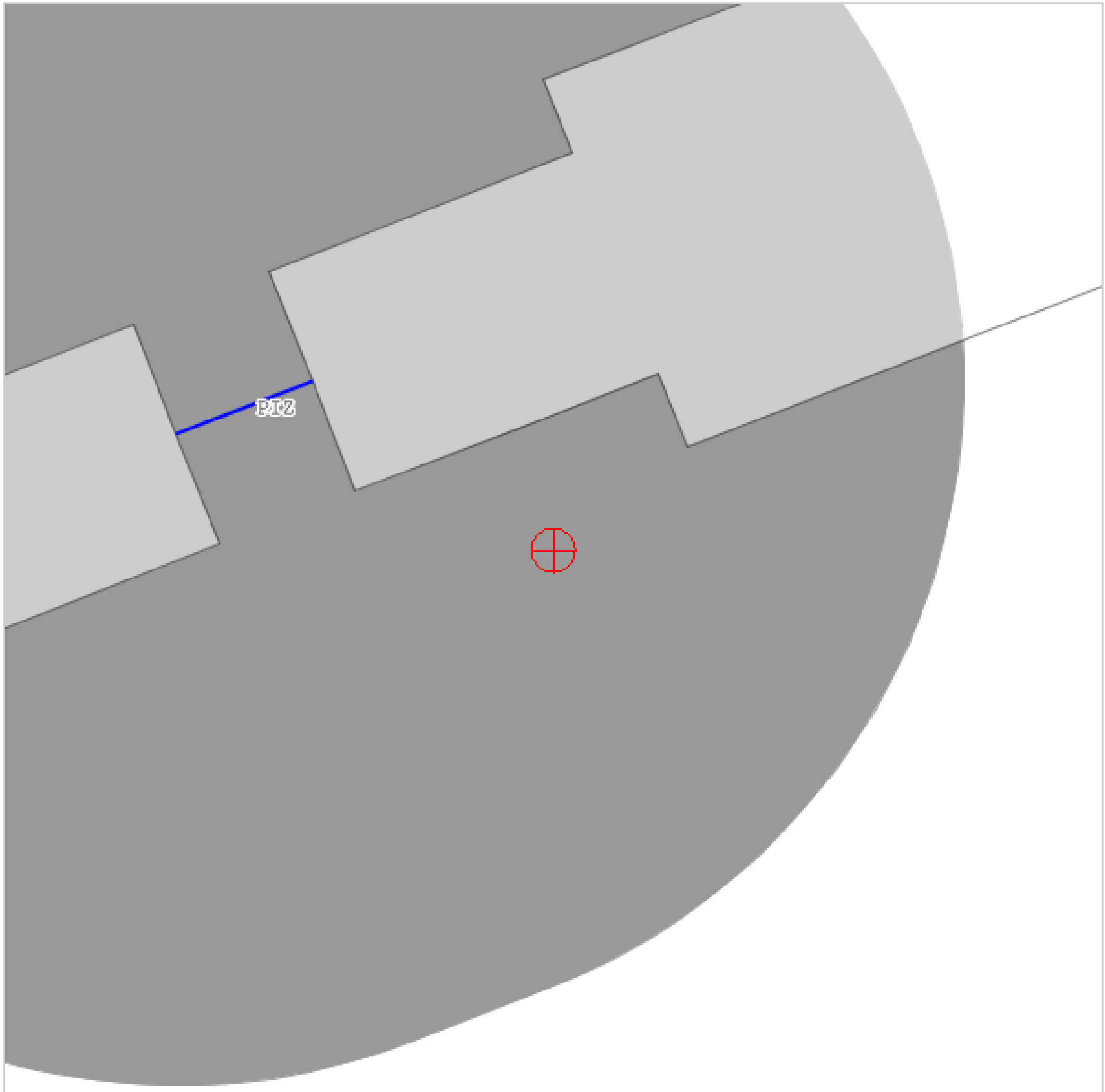
## Results

You exceed the following Notice Criteria:

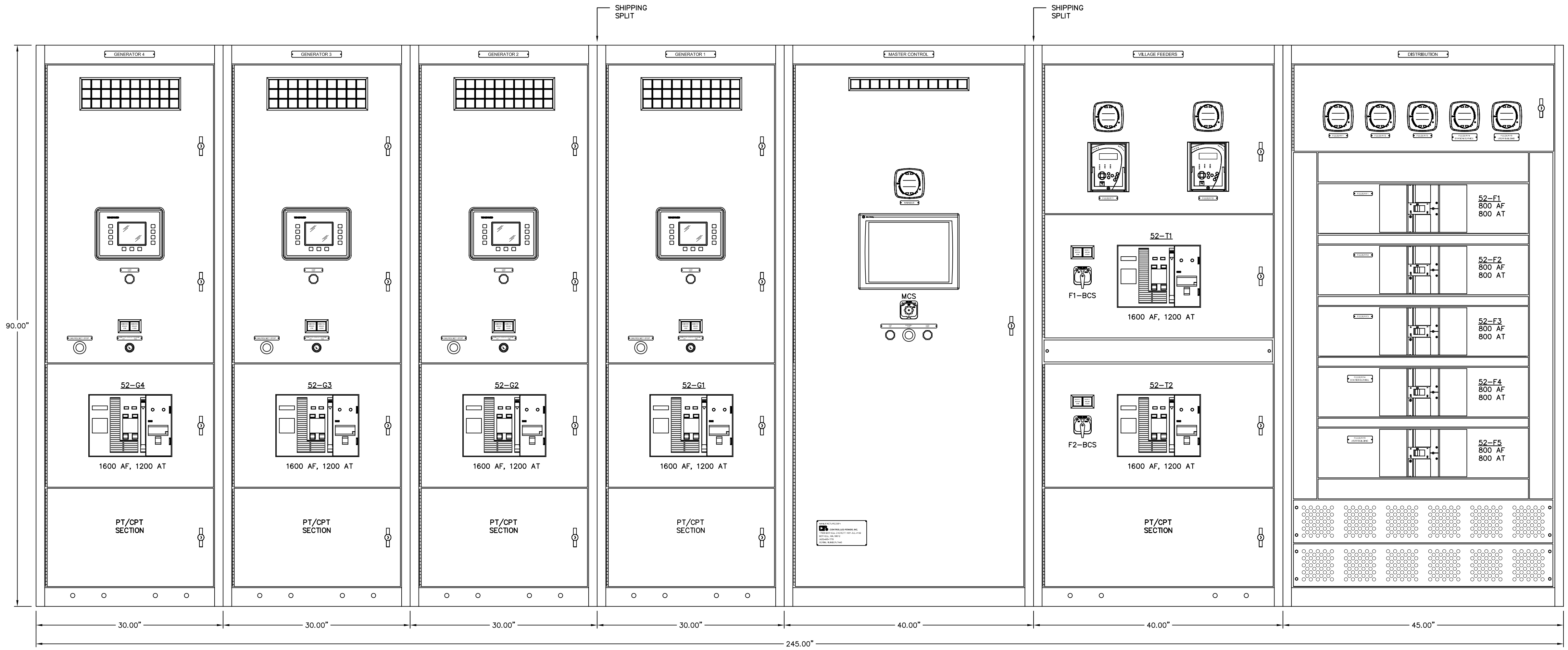
Your proposed structure is in proximity to a navigation facility and may impact the assurance of navigation signal reception. The FAA, in accordance with 77.9, requests that you file.

77.9(b) by 142 ft. The nearest airport is PIZ, and the nearest runway is 05/23.

The FAA requests that you file


PTZ

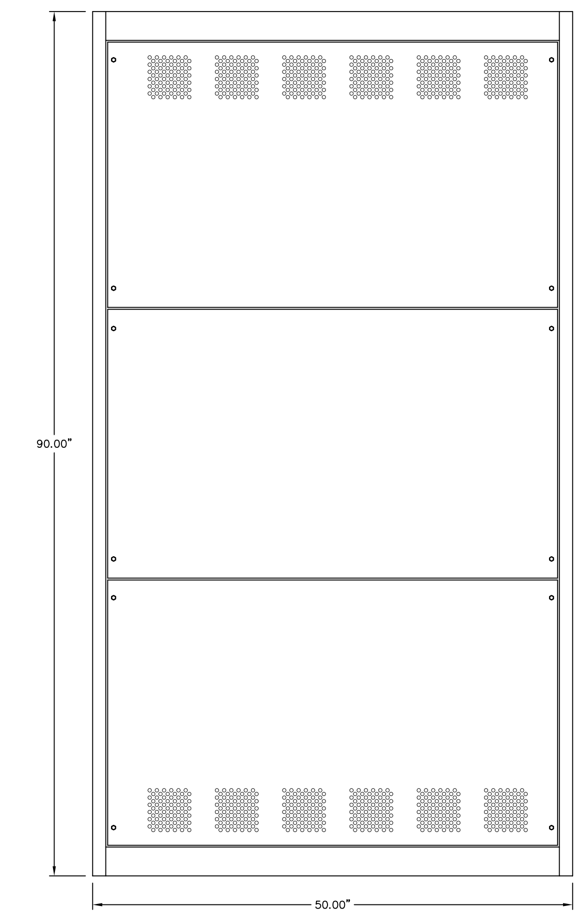
# Appendix D – Generator Switchgear Schematics




3545 lbs
96"H x 94"W x 56"D CRATE

2685 lbs
96"H x 74"W x 56"D CRATE

2270 lbs
96"H x 89"W x 56"D CRATE




SIDE VIEW

GENERATOR SWITCHGEAR – ELEVATION VIEW
NEMA I, 3ø, 4W 4,000A COPPER BUS, 65 KAIC
SEISMIC ZONE 3/4 RATED

| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| B | 01-02-12 | 52-F5 REVISED TO 800AF, 800AT PER SUBMITTAL REVIEW | TRT |
| A | 12-15-11 | SUBMITTAL | GPN |

N C PURCHASE ORDER No. 110875A001 CONTROLLED POWER JOB No. 7445

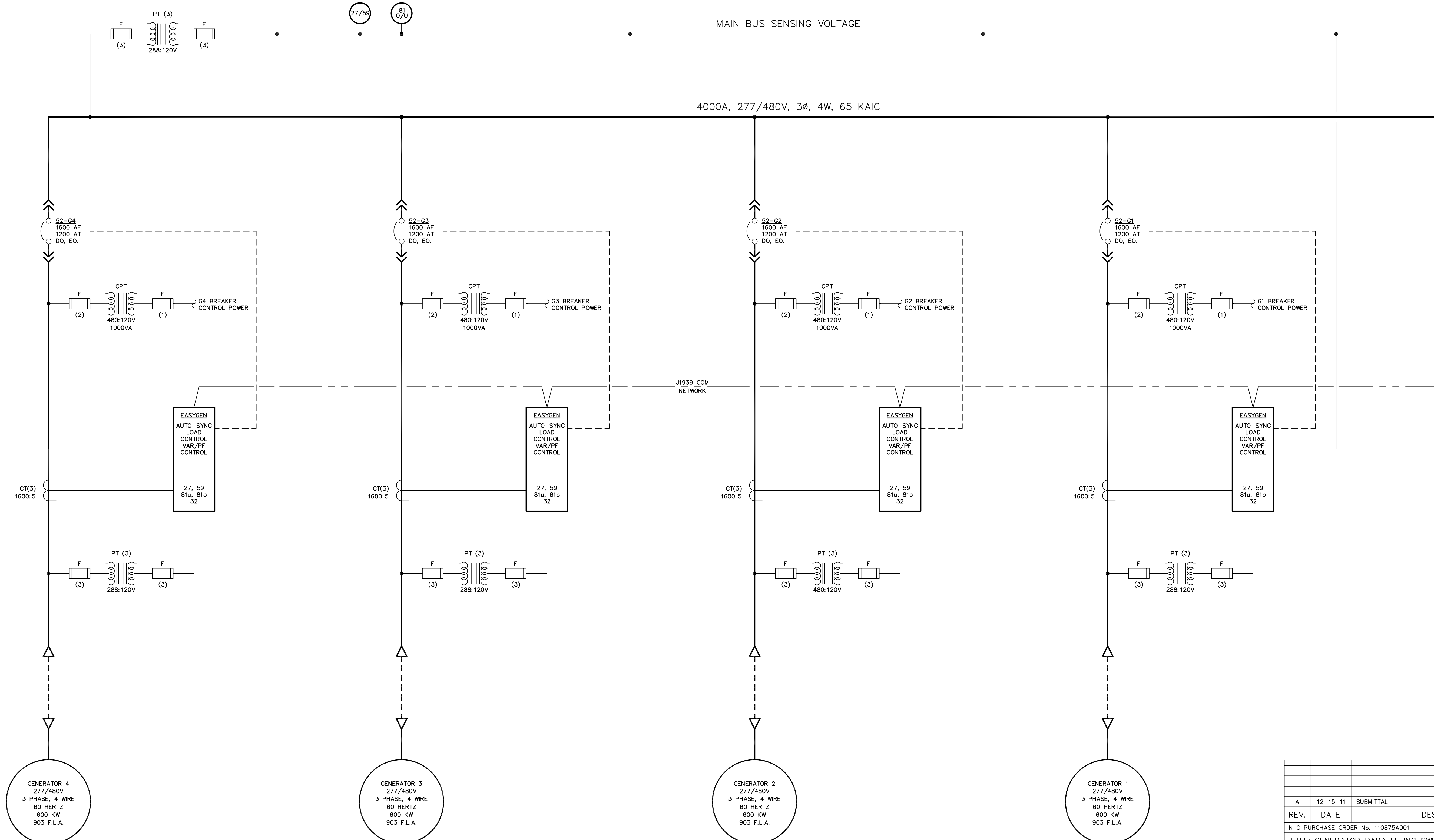
TITLE: GENERATOR PARALLELING SWITCHGEAR ELEVATION VIEW, OUTLINE DIAGRAM

| | | |
|---|---|---|
| SCALE: NONE | DATE: 12-15-11 | DWN. BY: GPN |
| DWG. No: 7445-4101-D | SHEET: 1 OF 1 | CKD. BY: TRT |

JOB: POINT LAY NEW POWERPLANT FACILITY, POINT LAY, ALASKA



N C POWER SYSTEMS CO.




| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| A | 12-15-11 | SUBMITTAL | GPN |

N C PURCHASE ORDER No. 110875A001 CONTROLLED POWER JOB No. 7445

TITLE: GENERATOR PARALLELING SWITCHGEAR SINGLE LINE, SCHEMATIC DIAGRAM

| | | |
|---|---|---|
| SCALE: NONE | DATE: 12-15-11 | DWN. BY: GPN |
| DWG. No: 7445-5101-D | SHEET: 1 OF 1 | CKD. BY: TRT |

JOB: POINT LAY NEW POWERPLANT FACILITY, POINT LAY, ALASKA



N C POWER SYSTEMS CO.

Plot date: 2013/7/12 - 7:59

# Appendix E – Power Grid, Point Lay

| REV # | DRAWN BY | APRVD BY | DATE | DESCRIPTION |
|---|---|---|---|---|
| 1 | RCK | RCK | 2/12/2012 | CORRECTIONS PER FIELD NOTES AND CONFORMANCE TO NSB STANDARDS |
| 2 | RCK | RCK | 3/28/2012 | FUSE COORDINATION, REPLACEMENT OF GANG SWITCHES. |

TRANSFORMER PROTECTION
AND FUSE COORDINATION

| Transformer 4.2Y/2.4kV | | Protecting SF Fuse | First Protected Fuse | Second Protected Fuse |
|---|---|---|---|---|
| 1Ø | 3Ø | | | |
| 10 | 30 | 3.1 | 25T | 40T |
| 15 | 45 | 5.2 | 40T | 65T |
| 25 | 75 | 7.0 | 40T | 65T |
| 37.5 | 112.5 | 7.8 | 65T | 100T |
| 50 | 150 | 14 | 65T | 100T |
| 75 | 225 | 21 | 65T [1] | 100T |
| 100 | 300 | 46 | 100T [2] | 140T |

**SPECIFIC NOTES:**

1 Coordinates at fault currents above 4200 amps.

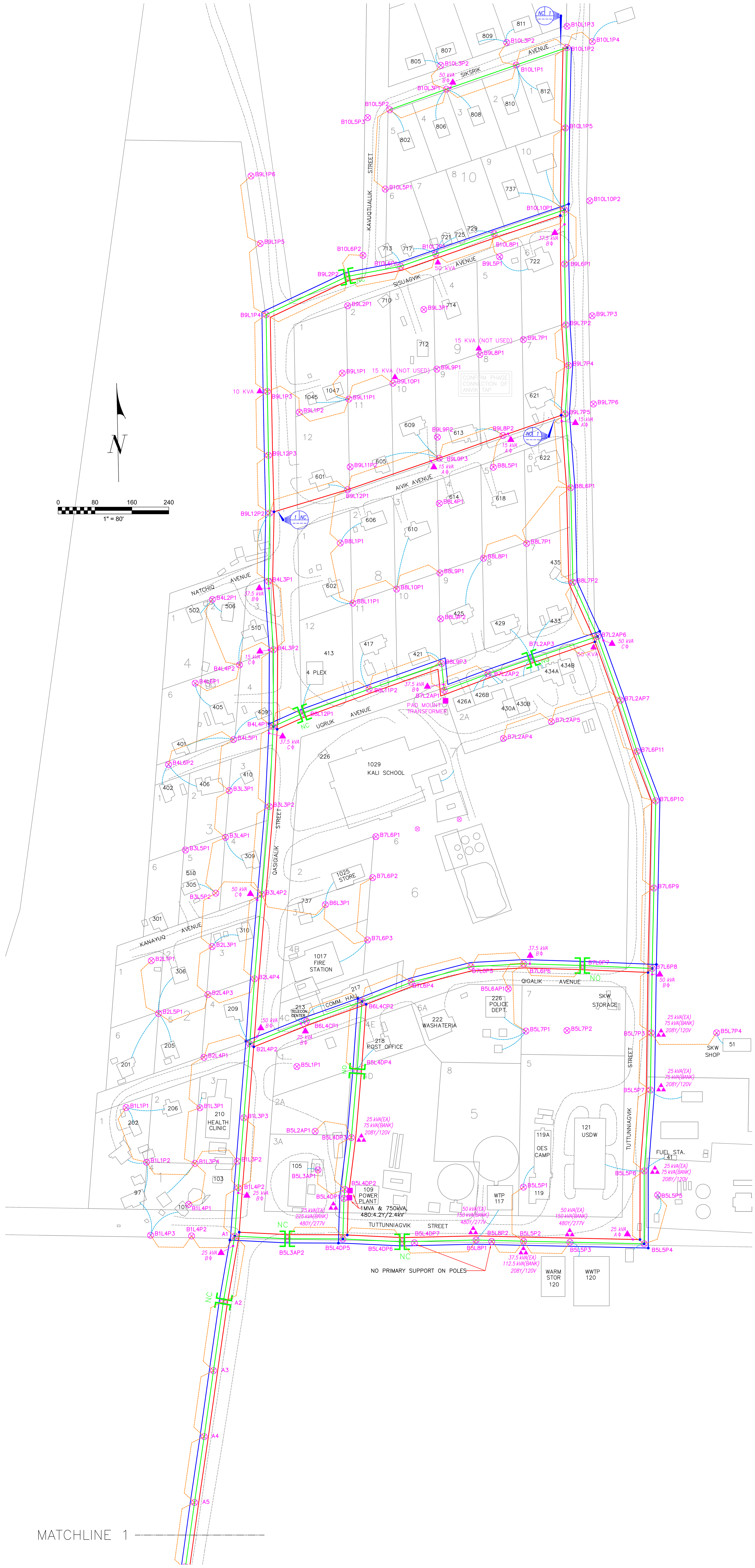
2 Coordinates at fault currents above 4400 amps.

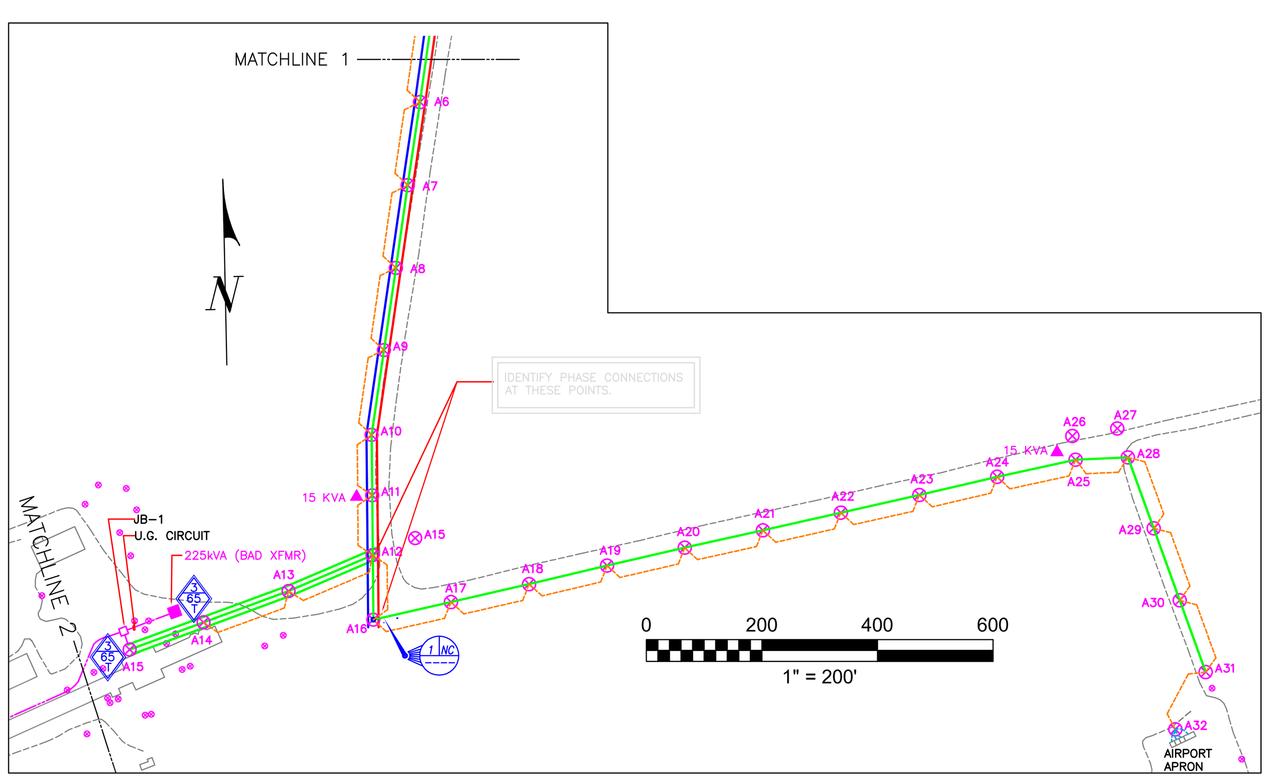
LEGEND

- B23L6P1 POLE AND NUMBER
- Aϕ CONDUCTOR
- Bϕ CONDUCTOR
- Cϕ CONDUCTOR
- SECONDARY MAIN
- SERVICE DROP
- PAD MOUNT TRANSFORMER
- 25 kVA Bϕ — TRANSFORMER, POLE-MTD, SINGLE-PHASE, kVA SIZE & CONNECTED PHASE
- 25 kVA(EA) 75 kVA(BANK) 208Y/120V — TRANSFORMER, 3-PHASE, POLE-MTD, kVA EA., kVA BANK, VOLTAGE
- NC — GANG SWITCH
- NO. OF CUTOUTS; FUSE, RATING AND TYPE; NC = NORMALLY CLOSED, NO = NORMALLY OPEN — CUT-OUT SWITCH - EXISTING
- CUT-OUT SWITCH - PROPOSED
- PHASE, 1 OR 3; FUSE AMPACITY; FUSE TYPE — PRIMARY RISER - 3 PHASE
- CONNECTED PHASE — PRIMARY RISER - 1 PHASE

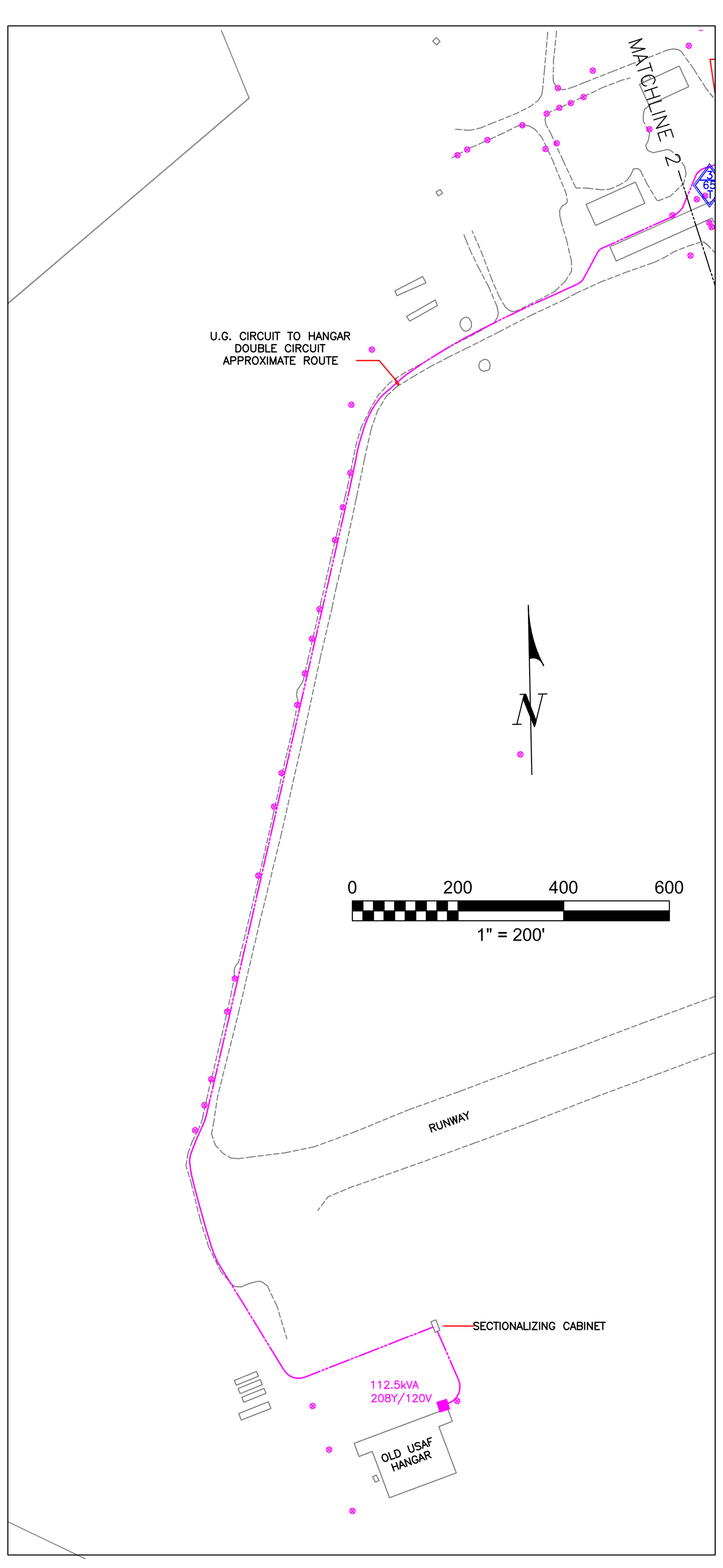
LEGEND FOR POLE NUMBERING SYSTEM:

- B3L1P1: BLOCK NO., LOT NO., POLE NO.
- T1P2: TRACT NO., POLE NO.




INSET MAP 1



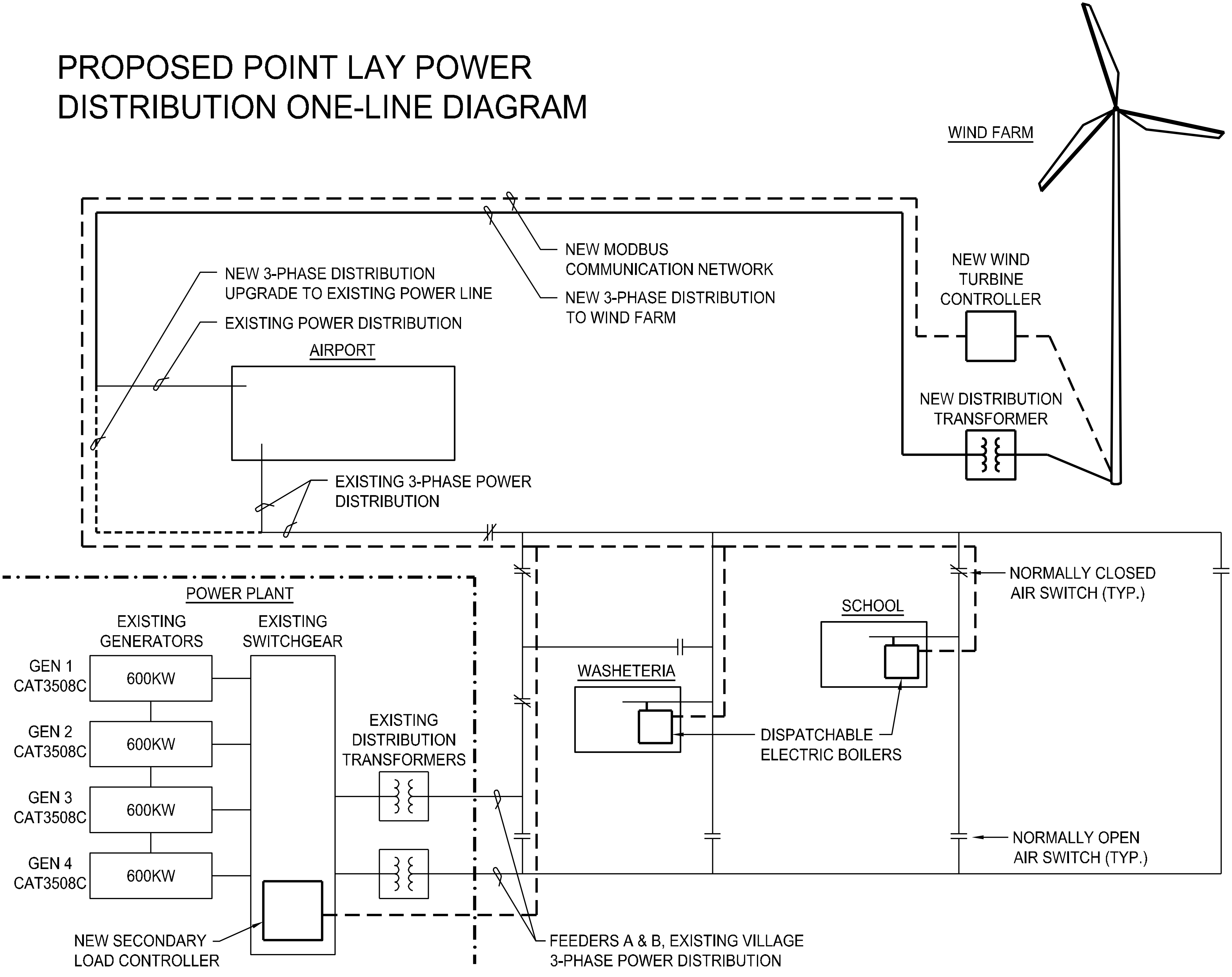

INSET MAP 2

NSB Power Grid
Point Lay

WHPacific

# Appendix F – Proposed Power Distribution One-Line Diagram

# PROPOSED POINT LAY POWER DISTRIBUTION ONE-LINE DIAGRAM



# Appendix G – Power Distribution System Expansion for Sites A, B, or C


| LEGEND | |
|---|---|
| red line | PHASE A |
| green line | PHASE B |
| blue line | PHASE C |

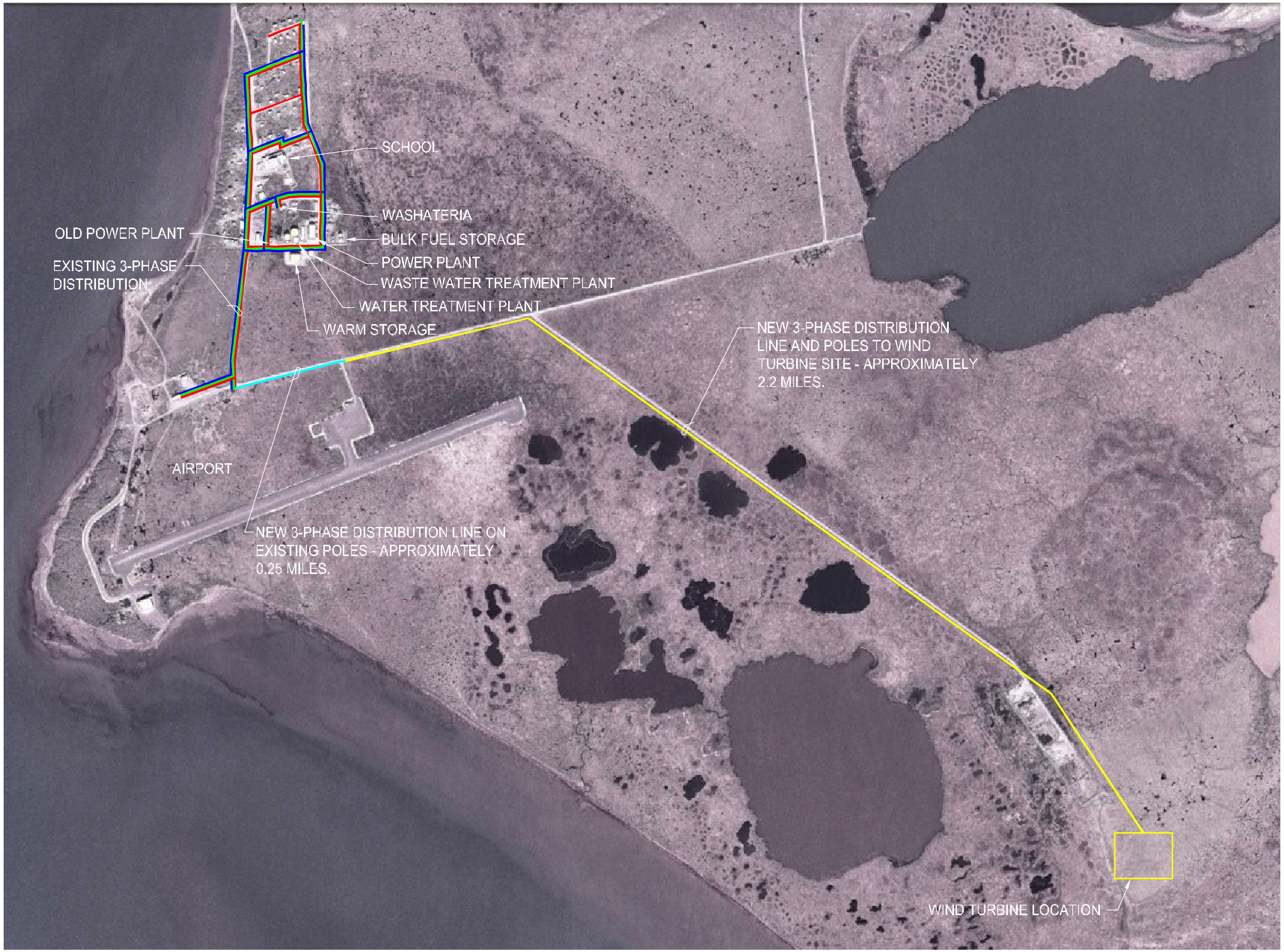
300' 150' 0 300'

APPROXIMATE SCALE: 1"=300'

WHPacific
300 West 31st Avenue
Anchorage, AK 99503
907-339-6500 Fax 907-339-5327
www.whpacific.com

# POINT LAY

SHEET 1 of 2
DATE: 12/23/2014
SHEET NO.:
E1




| LEGEND |
|---|
| PHASE A |
| PHASE B |
| PHASE C |
| NEW 3-PHASE |
| UPGRADE TO 3-PHASE |

SCALE: NONE


WHPacific
300 West 31st Avenue
Anchorage, AK 99503
907-339-6500 Fax 907-339-5327
www.whpacific.com


# POINT LAY

SHEET 2 of 2

DATE: 12/23/2014

SHEET NO.:

E2