CONCEPTUAL DESIGN REPORT

RURAL POWER SYSTEM UPGRADES PROJECT

PORT HEIDEN, ALASKA

Prepared for:
State of Alaska
Alaska Energy Authority /
Rural Energy Group

Prepared By:
CRW Engineering Group
3940 Arctic Boulevard, Suite 300
Anchorage, Alaska 99503
(907) 562-3252

February 13, 2006

FINAL

EXECUTIVE SUMMARY

This Conceptual Design Report (CDR) was prepared by CRW Engineering Group, LLC. (CRW) for the Alaska Energy Authority / Rural Energy Group (AEA). The purpose of this study is to provide a conceptual design and construction cost estimate for upgrading electrical power generation and distribution systems for the community of Port Heiden, Alaska. The City operates the local utility and will be the only participant in this project.

Existing Conditions

Representatives from AEA, CRW and Electric Power Systems Inc. (EPS) conducted site visits on June 19, 2003 and October 7, 2004. During the initial site visit AEA Project Manager Lenny Landis met with local leaders to discuss the Rural Power System Upgrade (RPSU) program policies and goals. CRW engineer Karl Hulse and EPS engineer Jim Hall documented the existing electrical distribution system and power plant facilities, evaluated the potential power plant site and exchanged ideas with local operators regarding operation and maintenance of the existing and proposed facilities. During the follow up site visit AEA and CRW representatives held a second meeting with local leaders to confirm project objectives, installed wind monitoring equipment on an existing community-owned wind turbine and performed a limited geotechnical investigation at the proposed power plant and wind turbine sites using the City's back-hoe.

Port Heiden's electrical distribution system consists of approximately 24,000 feet of three phase and 16,000 feet of single phase underground, direct bury primary voltage cable. The primary line operating voltage is 12,470/7200 grounded wye. The majority of distribution system components are approximately 20 years old, although some buried components might be significantly older. Outages are a common occurrence and are likely the result of damaged insulation and corrosion of the buried conductors. Over the years, long sections of buried primary voltage line have been "repaired" by laying new cable directly on the ground surface to bypass the failed section of buried line.

All existing transformers, including thirteen 25 kVA single phase and five 150 kVA three phase units, are severely corroded and are at the end of their useful design lives.

The Community's existing power plant, located approximately 500 feet west of the Meshik Subdivision (Figure 2), is a relatively new, metal-framed building that doubles as the City's fire station. The structure has a concrete slab-on-grade foundation, overhead garage doors and a separate room for the diesel generator cooling system; the plant's rated power generation capacity is 420 kilowatts (kW) from a combination of two generators (one 230 kW Cummins and one 190 kW John Deere unit). The 480 volt switchgear includes a breaker for each generator unit, and a breaker for the single feeder line to the three phase, wye-wye connected, 150 kVA pad-mounted step-up transformer located in front of the building. Currently, no heat is recovered from the generators.

The existing power plant facility is in fair overall condition. The Cummins gen set has high hours but continues to operate reliably. The John Deere genset, which was purchased by the City in 2005 via a loan from the Alaska Industrial Development and Export Authority (AIDEA), looks to be in excellent condition. However, a qualified diesel generator mechanic should inspect both generators prior to considering them for reuse. In particular, the generators should be checked for possible damage incurred due to the existing wye-wye step up transformer configuration; this configuration exposes the gen sets to potentially damaging shock loads whenever the distribution system experiences a fault (severed conductor, failed transformer, etc).

Recommendations

Power Plant

Due to the age and questionable condition of the power generation and switchgear components, and the inherent dangers associated with co-location of the power plant and fire hall, it is recommended that a new dedicated power generation facility be constructed at the site selected by the community during the initial field inspection. The site is located near the existing City shop, approximately 200 feet south of the school. The site is owned by the City; the site's close proximity to the shop and school provides opportunity for beneficial use of recovered engine heat.

The proposed diesel power plant consists of a 16-foot x 42-foot module which will be pre-fabricated in Anchorage and shipped with all motors, switchgear and other components already installed. The plant will house three diesel generators with a combined capacity of 460 kW (two 190 kW and one 80 kW genset) and include room for a fourth generator in the future. The planned switchgear will incorporate remote monitoring capabilities and allow for seamless integration with future wind turbines or other alternative energy technologies. A heat exchanger at the plant combined with buried, insulated hydronic lines will allow for recovered heat from the engine jacket water to be utilized at the school and/or city shop.

Fuel for the plant will be stored in an existing 12,000-gallon, double walled intermediate tank currently located adjacent to the existing power plant building. The intermediate tank will be relocated to the proposed site and filled periodically via a City-owned fuel truck.

Electrical Distribution System

Based upon observations made during the site visits, upgrades to the community's electrical distribution system should include:

- Replacement of all exposed primary voltage cable (approximately 3,000 feet total) and select repair of buried portions of primary voltage distribution system.
- Replacement of all exposed secondary voltage cable (approximately 1,000 feet total) and select repair of buried portions of secondary voltage distribution system.
- Replacement of all existing pad-mount transformers in the community (13 single phase and 5 three phase) with new marine grade units.
- Replacement of approximately 30 residential electric meters and boxes.
- Disconnection of electrical service west of the bulk fuel tank farm to reduce line losses and help balance system loads.

All exposed electrical cable will be replaced with new, code compliant buried cable. Existing buried cables will be located, tested for ground faults and repaired as necessary. All new conductors will be installed within NEC approved conduit.

Schedule and Cost

The proposed project schedule, subject to availability of funding, calls for design and permitting during the spring and summer of 2006 with construction beginning in the fall of 2006. It is anticipated that all construction will be complete by fall 2007.

The total cost of the proposed diesel power system including design, supervision, construction, inspection, permitting, and insurance is estimated to be $1,649,000.

TABLE OF CONTENTS

Section/Title **Page**

TABLES

FIGURES

PHOTOGRAPHS

APPENDICES

ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AEA	Alaska Energy Authority/Rural Energy Group
CDR	Conceptual Design Report
City	City of Port Heiden
COE	U. S. Army Corps of Engineers
CRW	CRW Engineering Group, LLC
DA	U.S. Department of the Army
DT	Electrical Demand versus Time
EA	Environmental Assessment
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
kVA	Kilovolt-Ampere
kW	Kilowatt
kWh	Kilowatt-Hour
O&M	operation and maintenance
PCE	Power Cost Equalization
RCA	Regulatory Commission of Alaska
SCHOOL	Lake and Peninsula School District

1.0 INTRODUCTION

1.1 PURPOSE

This Conceptual Design Report (CDR) was prepared by CRW Engineering Group, LLC. (CRW) for the Alaska Energy Authority / Rural Energy Group (AEA). The purpose of this study is to provide a conceptual design and construction cost estimate for upgrading electrical power generation and distribution systems for the City of Port Heiden (City), Alaska. The City operates the local utility and will be the only participant in this project.

1.2 COMMUNITY OVERVIEW

Port Heiden is located at the outlet of Meshik River on the north side of the Alaska Peninsula, approximately 424 air miles southwest of Anchorage (Figure 1). Local community organizations include the City of Port Heiden, and the Native Council of Port Heiden. Regional organizations include the Bristol Bay Native Corporation, SECAP (a regional alternative energy organization) and the Lake and Peninsula School District.

The current population of Port Heiden is approximately 90, (estimated by State Demographer). The majority of residents within the community are Alutiiq Alaska Natives.

Based upon the U.S. 2000 Census, there are 56 total housing units in the community, including 15 vacant structures. The majority of homes are heated with oil stoves.

All community and residential buildings receive electricity via a partially buried distribution system fed by a diesel generator power plant, which is owned and operated by the City.

2.0 SITE VISITS AND COMMUNITY INVOLVEMENT

2.1 SITE VISIT

Representatives from AEA, CRW and Electric Power Systems Inc. (EPS) conducted site visits on June 19, 2003 and October 7, 2004. During the initial site visit AEA Project Manager Lenny Landis met with local leaders to discuss the Rural Power System Upgrade (RPSU) program policies and goals. CRW engineer Karl Hulse and EPS engineer Jim Hall documented the existing electrical distribution system and power plant facilities, evaluated the potential power plant site and exchanged ideas with local operators regarding operation and maintenance of the existing and proposed facilities. During the follow up site visit AEA and CRW representatives held a second meeting with local leaders to confirm project objectives, installed wind monitoring equipment on an existing community-owned wind turbine and performed a limited geotechnical investigation at the proposed power plant and wind turbine sites using the City's back-hoe.

Copies of site visit reports are provided in Appendix A. A map of the community is shown on Figure 2.

2.2 CONTACTS AND COMMUNITY INVOLVEMENT

Project and background information were obtained from the entities listed in Table 1.

Table 1 – Contact Information

Entity	Contact	Address	Phone Number
City of Port Heiden	Marc Welbourne (Mayor)	P.O. Box 49050 Port Heiden, AK 99549	907-837-2209 (ph) 907-837-2248 (fx)
Native Council of Port Heiden	Henry Matson Jr. (President)	P.O. Box 49007 Port Heiden, AK 99549	907-837-2296 (ph) 907-837-2297 (fx)

3.0 APPLICABLE REGULATIONS AND CODES

The proposed improvements must be designed, constructed and operated in accordance with applicable sections of the following state and federal regulations:

- State of Alaska Fire and Life Safety Regulations, 13 AAC 50.
- 2003 International Fire Code, as adopted by 13 AAC 50.
- 2003 International Building Code, as adopted by 13 AAC 50.
- U.S. Environmental Protection Agency EPA Oil Pollution Prevention Regulations, 40 CFR Part 112.
- Alaska Department of Environmental Conservation Air Quality Regulations, 18 AAC 52.
- Regulatory Commission of Alaska (RCA) Certification, 3 AAC 42.05.221.
- National Electric Code, NFPA 72
- National Electric Safety Code, ANSI C2

4.0 EXISTING POWER GENERATION AND DISTRIBUTION FACILITIES

4.1 DESCRIPTION OF EXISTING FACILITIES

Visual inspections of Port Heiden's electrical distribution and power generation systems were conducted during the initial site visit. The following sections include descriptions of each system and pertinent field observations.

4.1.1 Power Plant

The Community's existing power plant, located approximately 500 feet west of the Meshik Subdivision (Figure 2), is a relatively new, metal-framed building that doubles as the City's fire station. The structure has a concrete slab-on-grade foundation, overhead garage doors and a separate room for the diesel generator cooling system (Photos 1 and 2); the plant's rated power generation capacity is 430 kilowatts (kW) from a combination of two generators (one 230 kW and one 200 kW unit). The 480-volt switchgear includes a breaker for each generator unit, and a breaker for the single feeder line to the three phase, wye-wye connected, 150 kVA pad mount step-up transformer located in front of the building. Currently, no heat is recovered from the generators.

4.1.2 Distribution System

The existing underground electrical distribution system was inspected during the initial site visit, and the conditions of all visible appurtenances were documented. Port Heiden's electrical distribution system consists of approximately 24,000 feet of three phase and 16,000 feet of single phase underground, direct bury primary voltage cable. The primary line operating voltage is 12,470/7200 grounded wye. At least three different types of #2 aluminum primary conductors are present in the distribution system, including two bare concentric neutral types (with 175 and 220 mils of XLPE insulation respectively) and a third, jacketed concentric neutral type, with 220 mils of insulation. Conductors of each type were observed at above grade connection points throughout the system; other types of conductors may also be present. Secondary voltage and service conductors are reportedly aluminum direct bury triplex and quadraplex types, for single and three phase lines respectively. Primary and secondary conductor sizes and configurations should be verified by the installer prior to procurement.

Other distribution components include thirteen 25 kVA single phase transformers, five 150 kVA three phase transformers, and approximately 60 socket-type residential electric meters. These components were reportedly installed with the original buried system.

4.1.3 Equipment Suitable for Reuse

Portions of the existing buried distribution system may be suitable for continued use. The actual extent of reusable conductor should be delineated by the electrical installer prior to beginning procurement. Many of the existing residential meters and meter bases also appear to be suitable for re-use if properly cleaned. The existing 12,000 gallon intermediate fuel storage tank at the power plant was installed as part of the AEA bulk fuel upgrades project and is suitable for reuse (Photo 3).

4.2 EXISTING POWER GENERATION CAPACITY AND DEMAND

There are two diesel generator sets within the existing power plant, with a combined potential capacity of approximately 420 kW. Individual generator capacities include:

- Unit 1- Cummins Generator and Engine

  230 kW, 480 volts, 1,800 RPM

- Unit 2- Magnaplus Gen / John Deere Engine

  190 kW, 480 volts

The historical peak demand reported by the community to the AEA was 175 kW recorded in the winter of 2000. Additional community power consumption information is provided in Section 5.1.1 Historical Electrical Demand.

4.3 EXISTING SYSTEM DEFICIENCIES

The existing power plant facility is in fair overall condition. The Cummins gen set has high hours but continues to operate reliably. The John Deere genset, which was purchased by the City in 2005 via a loan from the Alaska Industrial Development and Export Authority (AIDEA), looks to be in excellent condition. However, a qualified diesel generator mechanic should inspect both generators prior to considering them for reuse. In particular, the generators should be checked for possible damage incurred due to the existing wye-wye step up transformer configuration; this configuration exposes the gen sets to potentially damaging shock loads whenever the distribution system experiences a fault (severed conductor, failed transformer, etc).

The majority of distribution system components are reportedly more than 20 years old, although some buried components might be significantly older. Most visible components of the distribution system are in poor condition. All pad-mounted transformers exhibit severe external and interior corrosion and/or physical damage, and are at the end of their useful design lives (Photos 6 and 7). No transformer oil leaks were observed during the site visit, but several transformer tanks are seriously compromised and oil leakage is inevitable if measures are not taken to repair or replace the units.

Power outages are a common occurrence and are likely the result of damaged insulation and corrosion of the buried conductors. The City has replaced primary and secondary conductors as required over the past twenty years. However, the majority of this work was not done by qualified lineman and the quality of the repairs is suspect. In particular, several sections of primary conductor (totaling several thousand feet) were intentionally routed above grade and now rest directly on the ground surface. Several of these high voltage lines cross gravel roadways and are regularly crossed by vehicular traffic. It is suspected that typical burial depths for the existing system are less than 12 inches, providing minimal protection from environmental and/or vehicular traffic related stresses.

5.0 FACILITY DESIGN AND SITING RECOMMENDATIONS

5.1 ELECTRICAL CAPACITY CONSIDERATIONS

Electrical demands in rural Alaskan communities, while relatively small in overall magnitude, tend to be more variable than those for larger communities. This is due to dynamic fluctuations in seasonal populations, temperatures, local industrial activities, and other factors. Properly sizing power generation systems for these communities requires the integration of hard data, such as historical consumption records, with socio-economic trends, such as projected housing and population growth, planned infrastructure improvements, and the applicability of alternative energy sources and emerging energy system control technologies.

The following sections summarize the historical electrical usage in the community, and identify factors such as planned infrastructure improvements, alternative energy sources, and shifts in population that were considered in sizing the proposed system.

5.1.1 Historical Electrical Demand

Port Heiden participates in the State's Power Cost Equalization (PCE) Program and is required to submit monthly reports to the AEA itemizing a myriad of power system related parameters, most notably the quantity of electric power generated and sold, as well as peak monthly electrical demands. Historical PCE report data was analyzed to determine trends in the community's energy consumption. The historical trend appears to indicate that the community's power consumption has remained relatively consistent and averaged approximately 101 kW per year. Using the historic ratios between average and peak loads in the community, the current instantaneous peak is assumed to be approximately 160% of the average demand, or approximately 162 kW (Appendix B). Table 2 summarizes the historical power consumption data analysis.

Table 2 – Historical Demand Data

Year	Annual Consumption (kWh)	[Column A] Annual Average Load (kW)	[Column B] Annual Peak Load (Dec-Feb) (kW)	Peak Load Factor (B/A)
1998	959,000	110	N/A	--
1999	950,000*	108	162	1.5
2000	988,000	113	175	1.6
2001	993,000*	113	160	1.4
2002	990,000*	113	N/A	--
2003	857,000	98	N/A	--
2004	724,000	83	N/A	--
2005	630,000	72	N/A	--

* Value extrapolated from partial year data.
N/A – Information not available.

5.1.2 Planned Infrastructure and Capital Improvement Improvements

Infrastructure improvement projects tend to increase community electrical demands. The scope and anticipated impact of planned infrastructure improvements are discussed in the following sections.

5.1.2.1 Water System Improvements

The City recently completed a Sanitation Improvements Feasibility Study funded through a grant from the State of Alaska Village Safe Water Program. Further, the City has secured funding to construct several new individual residential wells, a new washeteria/water treatment plant and a community watering point. These improvements, along with possible future sewer and sanitary landfill upgrades, are anticipated to boost residential and commercial development within the community, causing populations and energy consumption rates to increase. For the purposes of this report it is assumed that an additional 15 kW average load (approximately 130,000 kWh per year) will be required to support these improvements.

5.1.2.2 Community Seafood Processing Facility

Port Heiden is actively pursuing design and construction funding for a new seafood processing and cold storage facility. As currently envisioned, the project would include a 2,000 square foot building complete with drying and flash freezing equipment. The proposed site for the facility is near the proposed power plant location, allowing for beneficial use of heat recovered from the plant's generators. It is estimated that a facility of this type would operate approximately 10 hours a day for 2 months per year. Assuming an average demand of 100 kW, the plant would require approximately 60,000 kWh per year.

5.1.3 Projected Community Growth

Historical census data shows that the population of Port Heiden steadily increased between 1960 and 1990 at an average rate of 1.6% per year, reaching a peak population in 2000 of 119. Over the past five years, the population has declined to approximately 90 residents. Local leaders attribute this downswing in population to the lack of a regional processor for local fishermen to deliver to, and capital improvement projects in adjacent communities drawing working age residents away.

Completion of the infrastructure improvements discussed in Section 5.1.2 is expected to increase the availability of jobs and draw residents back to the community; for the purposes of this report, an annual growth rate of 1.5% is assumed, resulting in a design population of 105 in 2015. The resulting increase in electrical demand, assuming 5 new houses are required to accommodate the added population, is 40,000 kWh per year.

5.1.4 Projected Electrical Demands

The energy consumption and average demand estimates for the design year are presented in Table 3. The annual baseline kWh consumption was calculated from an average of historical demand values (see Section 5.1.1). Future values were determined by combining the demands due to infrastructure improvements and community growth discussed above with the calculated present demand. The instantaneous peak demand in the design year was calculated by applying the peak load factor of 1.6.

Table 3 – Projected Electrical Demands

Baseline Consumption (2005 PCE Data)	630,000 kWh
Estimated Increase Due to Capital Improvement and Community Growth (Sections 5.1.2.1 - 5.1.3))	230,000 kWh
Estimated Consumption at Design	**860,000 kWh**
Average Demand at Design	**98 kW**
Instantaneous Peak Demand at Design (PF = 1.6)	**157 kW**

5.2 DESIGN CONSIDERATIONS

5.2.1 Climate

Port Heiden lies in the maritime climate zone. Average temperatures range from 50 ºF in July to 25 ºF in January. Precipitation averages 16 inches of water per year, including 51 inches of snow. There are frequent winds and severe storms in the winter and calm, often foggy weather in summer. Design snow loading for the community is 40 pounds per square foot. Design wind speed is 110 miles per hour, exposure D.

5.2.2 Natural Hazards

The potential natural hazards resulting from the community's physical location are numerous including, among others, earthquake, tsunami and volcanic eruption. The potential for flooding at the proposed new power plant site is low. According to the U.S. Army Corps of Engineers (COE) flood management database, no known flooding has occurred within the community.

5.2.3 Geotechnical Conditions

Geotechnical investigations completed to date include two test holes dug to a depth of 10 feet at the proposed power plant site using the City's backhoe. The soils at the proposed site consist of 6 inches of gravel topping followed by 6 to 12 inches of organics which are underlain by 8 to 9 feet of silty sand with 1 inch minus broken pumus stone to depth.

5.2.4 Borrow Sources, Ownership, Material Costs

There are two established local borrow pits - one is owned by the Bristol Bay Native Corporation (BBNC) and located in town; the second pit is controlled by the Alaska Department of Transportation (ADOT) and is located at the airport (Photo 8). Both pits consist of relatively clean gravels which have been successfully used on multiple road and foundation projects in the community.

Permits and the payment of royalties to the state or BBNC ($1 to $3 per cubic yard) will be required for all borrow extraction operations.

5.2.5 Site Control

During the site visit, a location for the power plant was identified by the community. The site lies within an un-subdivided, City-owned tract of land located just north of the City shop and approximately 300 feet south of the School lot. A copy of the City's deed for the property is included in Appendix C.

All distribution system improvements should be constructed in existing rights-of-way, or established permanent easements. If construction activities require crossing private land the appropriate easement documents should be prepared prior to construction.

5.2.6 Alternative Energy Sources

Diesel generators are typically considered the simplest and most reliable method of power production in rural communities. However, rising fuel costs and mounting regulatory concern over fuel spills and power plant emissions warrant a close evaluation of potential alternative energy sources. With proper planning, design and management, today's alternative energy technologies could reduce the region's dependence upon fossil fuels in the future. Brief discussions of some fuel-saving technologies are proved below.

5.2.6.1 Wind Turbine Power Generation

Wind Resource

The AEA conducted wind resource monitoring in Port Heiden in 2004/2005 and found low turbulence winds suitable for development. The average wind power density was found to be 490 W/m^2 at a height of 30 meters which translates to a Wind Power Class of 5-6 on a scale of 1-7. A copy of the full wind resource report is presented in Appendix D - a copy of the report can also be reviewed at http://www.akenergyauthority.org/programwind.html. AEA input this resource data into a wind analysis program and developed power production estimates for various wind and wind/diesel hybrid systems. Power production estimates for five production model wind turbines are presented in Table 4.

Table 4 – Wind Turbine Power Production Estimates

Turbine	Rated Energy Output (kW)	Annual Energy Production Per Turbine (kWh)	Gross Capacity Factor	Annual Fuel Displaced (at Diesel Efficiency of 14 kWh/gal)
Bergey 10 kW	10	23,300	27%	1660
Entegrity E15	15	171,800	30%	12273
Northwind 100	100	276,100	32%	19718
Furlander 100	100	337,800	39%	24125
Vestas V27	250	718,800	36%	51342

The added capital cost of purchasing wind turbines, coupled with Port Heiden's relatively low energy demand, reduces the long term economic viability of multiple wind turbine / diesel hybrid systems in the community. Further, based upon the limited selection of production model wind turbines less than a megawatt in size, the majority of single turbine wind / diesel configurations do not displace enough diesel fuel or reduce diesel engine run times sufficiently to compete with diesel-only or multiple turbine hybrid systems. Based upon AEA's computer model analysis (Appendix D) a high penetration wind / diesel hybrid system including a single, remanufactured, 250 kW wind turbine (Vestas V-27 or equal) has the best potential for long term economic viability in the community. The initial construction estimate for the wind portion of a single turbine design, if built in conjunction with the diesel power plant, is approximately $650,000. Modeled with medium to high future fuel costs, the initial investment for a single turbine would be recovered in approximately 15 years. Multiple wind turbine scenarios generally provide better power quality and allow for wind power production to continue when one turbine is down for maintenance or repairs. Integrating multiple wind turbines into the Port Heiden generation system would cost from $1 to $1.5 million.

These cost estimates are based upon limited computer modeling and field investigations. A detailed geotechnical investigation is necessary to prepare foundation designs and better quantify the costs prior to construction.

Port Heiden has a good wind resource. However, due to limited funding and the additional capital costs associated with adding wind are prohibitive at this time. If the City is able to secure additional funding for the wind system then AEA could more easily support design and construction activities. The $650,000 to $1,500,000 needed for a wind-diesel system could come from federal or state grant agencies or regional entities interested in community sustainability and economic development.

5.2.6.2 Heat Recovery

Heat recovery technology, sometimes referred to as co-generation, provides a means of reclaiming energy lost to heat during the burning of fossil fuels. Co-generation systems in rural Alaska typically consist of a heat exchanger connected to the liquid cooling system of power plant diesel generators. The exchanger draws heat from the engine cooling system to supplement heat-reliant processes in the power plant and adjacent buildings. Common implementations include pre-heating hydronic system return water to reduce boiler firing frequency, and heating raw well water to make treatment easier.

No heat is recovered from the generators at the existing power plant. As currently envisioned, the new diesel plant will incorporate a co-generation system to supplement the heating systems in the school and city shop, and provide beneficial heat to the future fish processing plant.

5.2.6.3 Geothermal

Although the potential for geothermal power production may exist in the region, no studies have been conducted to evaluate the feasibility of harnessing geothermal energy to date, and the City has no plans of pursuing such an investigation in the future.

5.2.6.4 Hydro-electric

Hydro-electric power generation would probably involve the installation of remote hydro turbines and dams, and require relatively long electrical transmission lines. No known studies have been conducted to evaluate the feasibility of hydro power generation in the area, and the City has no plans of pursuing such investigations in the future.

5.2.6.5 Solar Photovoltaic Power

The typical solar energy system consists of multiple arrays of photovoltaic panels situated on top of buildings, towers or other relatively high structures. The fact that sunlight intensity varies from minute to minute due to changes in cloud cover, smoke from fires, blowing dust etc., requires that most solar systems have substantial battery storage. Due to the dramatic solar radiation fluctuations in northern latitudes and the practical limitations of storing and disposing of battery banks, solar systems are rarely capable of providing more than a minor amount of the total power necessary for a community. However, residential scale solar installations may be capable of meeting essential household electrical demands during the summer months.

5.3 PROPOSED UPGRADES

5.3.1 Scope of work

The proposed scope of work is listed below. Detailed discussions of each proposed upgrade are provided in following sections. Conceptual design drawings for the proposed upgrades are provided in the appendices.

- New diesel power plant consisting of a 16-foot X 44-foot pre-fabricated module with a total rated capacity of 460 kW. The planned switchgear will incorporate remote monitoring capabilities and allow for seamless integration with future wind turbines or other alternative energy technologies.
- Approximately 500 feet of buried, insulated, circulating hydronic line and appropriate heat exchanging components to allow for recovered heat from the power plant's engine jacket water to be utilized by the school and/or City shop.
- Replacement of all exposed primary voltage cable and select repair of buried portions of primary voltage distribution system (approximately 3,000 feet total).
- Replacement of all exposed secondary voltage cable and select repair of buried portions of secondary voltage distribution system (approximately 1,000 feet total).
- Replacement of all existing pad-mount transformers in the community (13 single phase and five three phase) with new marine grade units.
- Replacement of approximately 30 residential electric meters and boxes.

- Disconnection of electrical service west of the bulk fuel tank farm to reduce line losses and help balance system loads.

5.3.2 Power Plant Upgrades

Due to the age and questionable condition of the power generation and switchgear components, and the inherent dangers associated with co-location of the power plant and fire hall, it is recommended that a new dedicated power generation facility be constructed at the site selected by the community during the initial field inspection. The site is located near the existing City shop, approximately 200 feet south of the school. The site is owned by the City; the site's close proximity to the shop and school provides opportunity for beneficial use of recovered engine heat.

The proposed diesel power plant consists of a 16-foot x 42-foot module which will be pre-fabricated in Anchorage and shipped with all motors, switchgear and other components already installed. The plant will house three diesel generators with a combined capacity of 460 kW (two 190 kW and one 80 kW genset) and include room for a fourth generator in the future. The planned switchgear will incorporate remote monitoring capabilities and allow for seamless integration with future wind turbines or other alternative energy technologies. A heat exchanger at the plant combined with buried, insulated hydronic lines will allow for recovered heat from the engine jacket water to be utilized at the school and/or city shop.

Fuel for the plant will be stored in an existing 12,000-gallon, double walled intermediate tank currently located adjacent to the existing power plant building. The intermediate tank will be relocated to the proposed site and filled periodically via a City-owned fuel truck.

5.3.3 Distribution System Upgrades

5.3.3.1 Tie In to Existing Distribution System

The proposed power plant will have a single 3-phase feeder which will tie into a new pad-mount, step-up transformer installed adjacent to the module. New buried conductors will connect the step-up transformer to the community's existing electrical grid.

5.3.3.2 Transformers

The community's current electrical distribution system includes thirteen single-phase (25 kVA) and five three-phase (150 kVA), pad-mounted transformers with load break primary bushings and a feed through bus on the single phase units. As previously mentioned, all transformers have surpassed their useful lives and should be replaced. Marine grade, pad-mount transformers with stainless steel tanks and fiberglass or stainless steel enclosures are recommended for all new units.

5.3.3.3 Primary Voltage Distribution System Upgrades

All exposed direct-bury cable should be replaced with code-compliant conductors. All buried cables should be located and tested for current leakage. Lines that fail the continuity tests should be repaired. All new conductor will be installed within NEC approved conduit.

5.3.3.4 Secondary Voltage Distribution System Upgrades

All exposed secondary conductors should be replaced (approximately 1,000 feet); all buried secondary conductors should be located and integrity tested prior to final design and repaired as necessary. All new secondary conductor will be installed within NEC approved conduit.

5.3.3.5 Service Connections

All existing meters and sockets should be cleaned and tested. It is estimated that 50% of the meters and sockets will require replacement (approximately 30 new installations).

6.0 PERMITTING

6.1 GENERAL

This section describes, in broad terms, the permitting methodology successfully used for past RPSU projects in similar communities. Any future addition of wind energy components will likely require additional review by the U.S. Fish and Wildlife Service, the FAA, the Coastal Zone Management Program and, depending upon the selected sites and access road alignments, the Corps of Engineers.

6.2 COASTAL ZONE MANAGEMENT

Projects for communities in coastal regions, such as Port Heiden, must complete a Coastal Project Questionnaire in accordance with the Alaska Coastal Management Program. The questionnaire is submitted to the State of Alaska Department of Natural Resources, Office of Project Management and Permitting (ADNR). The ADNR reviews the questionnaire and assists in identifying required permits for the work. The ADNR review and public comment periods typically takes 60 days or more to complete.

6.2 FIRE MARSHALL REVIEW

Before construction of the new power plant begins, a set of stamped construction drawings must be submitted, along with the appropriate fee, to the State of Alaska, Department of Public Safety, Division of Fire Prevention (Fire Marshal) for plan review and approval. After review and approval, the Fire Marshal issues a Plan Review Permit to verify compliance with applicable building, fire, and life safety codes. Review times depend upon the agency's current work load; typically, a minimum of one month is required for review.

6.3 U.S. ARMY CORPS OF ENGINEERS WETLANDS FILL PERMIT

Projects that result in the placement of fill in wetlands require a Department of the Army (DA) permit. The proposed power plant site is located on an existing fill, and no DA Permit is anticipated.

6.4 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

In accordance with the National Environmental Policy Act an Environmental Assessment (EA) must be completed prior to construction of the project. The EA format should be based on the guidance documents provided in the AEA Reference Manual. The EA process should include the development and distribution of a project-scoping letter to all interested agencies. Responses from the agencies should be attached to the EA checklist as justification for a Finding of No Significant Impact (FONSI) for the project. AEA will act as the lead agency for FONSI determination.

6.5 ADEC REVIEW

ADEC regulates the operation of diesel power plants with the potential to emit more than 100 tons of dioxides per year (roughly equating to a diesel power plant with a generation capacity greater than 540 kW). The proposed power plant will be rated at 460 kW and, therefore, should not require an ADEC air permit.

6.6 RCA CERTIFICATION

Public utilities which meet certain criteria must obtain a Certificate of Public Convenience and Necessity (CPCN) from the Regulatory Commission of Alaska (RCA), which describes the authorized service area and scope of operations of the utility. The City of Port Heiden was issued a certificate by the RCA in 1988 (Certificate #399). The RCA requires that a utility update their CPNC after any major facility upgrade or operational change. To update the CPNC, the utility must complete and submit the RCA form entitled "Application for a New or Amended Certificate of Public Convenience and Necessity", which is available on the RCA website.

6.7 FAA REVIEW

Proposed projects within 5 miles of any airport runway must be reviewed by the FAA. The permitting process is initiated by completing and submitting the Federal Aviation Administration (FAA) Form 7460-1 "Notice of Proposed Construction or Operation" to the FAA Alaska Regional Office for review.

7.0 CONSTRUCTION PLAN

7.1 ADMINISTRATION

The AEA has a history of administering projects on a modified force-account basis. Under AEA's construction guidelines, a construction management firm is selected to act as the project employer and is encouraged to utilize primarily local labor. This method tends to achieve a higher percentage of local hire and is strongly supported by many communities and funding agencies.

The technical nature of the project will require a limited number of workers with specific experience and expertise to be brought in when not available locally. All work should be supervised and managed by a superintendent with extensive experience in the construction of rural power facilities. Skilled craftsmen, with appropriate certifications, must perform all specialty work, such as pipe welding and electrical panel installation. An experienced Construction Manager will be required to recruit the necessary skilled labor, coordinate the construction team, and oversee procurement and project logistics. The Design Engineer should provide quality control through communication with the Construction Manager, submittal reviews and periodic on-site inspections.

7.2 LOCAL LABOR SKILLS

A request was sent to the community for information regarding the availability of local labor to assist with construction. A summary of resources, per community response, is listed in Table 5.

Table 5 – Local Labor Pool

Name of Individual	Laborer	Operator	Truck Driver	Welder's Helper	Apprentice Electrician
Hank Matson		✓			✓
Jens Carlson		✓			✓
Andrew Lind		✓	✓		
Ryan Christensen		✓		✓	
Konan Lind		✓	✓		
Jamie Matson			✓		
Alvin Matson		✓			
Eli Nakita		✓	✓		
Travis Orloff	✓				
Jeffrey Orloff	✓				
John Christensen		✓		✓	
John Dundass		✓			
Teddy Matson	✓				
John Matson	✓				
Archie Reid			✓		
David Reid	✓				
Micheal Kalmakoff	✓				
Walter Nudlash	✓				
Dan Barker		✓			
Stephanie Anderson	✓				
Edward O'Domin	✓				

7.3 LOCAL EQUIPMENT

The Community owns several pieces of heavy equipment; the type and condition of each piece of equipment is listed in Table 6.

Table 6 – Locally Available Heavy Equipment

Equipment Type	Make	Model	Attachments	General Condition
Loader	Cat	950B	Bucket	Fair
Dozers	Cat	D3	Blade	Fair
	JD	850	Blade	Fair

7.4 ACCESS/ LOGISTICAL CHALLENGES

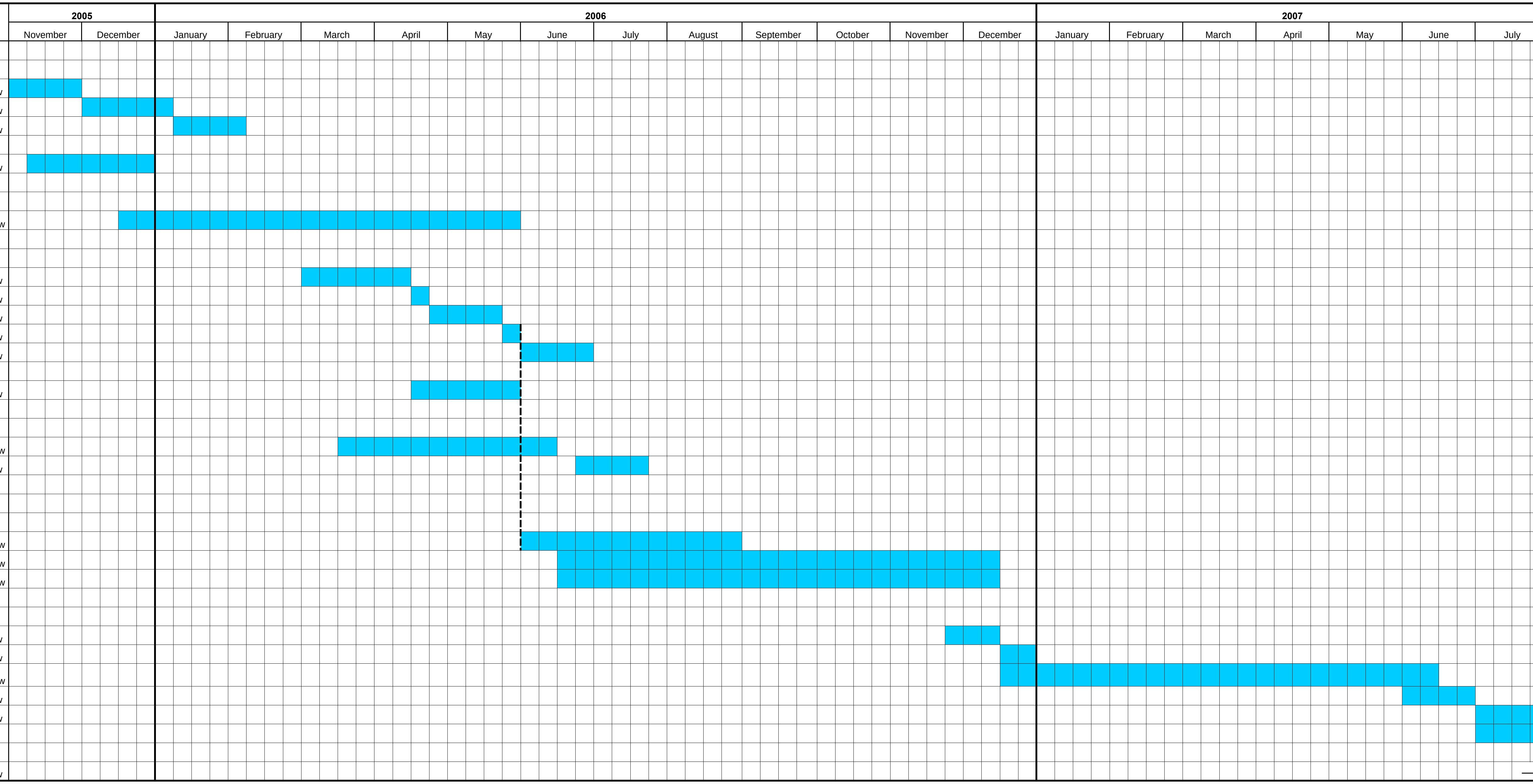
Port Heiden has a State-owned 5,000 foot long by 100 foot wide lighted, gravel runway and a 4,000 foot long, lighted cross-wind runway. Scheduled air services are available daily from King Salmon. There is a natural boat harbor, but no dock. Barges typically deliver cargo once or twice a year. Goods and passengers are lightered to the beach by landing craft. Lodging is generally available through the City Council or at the Carlson Lodge.

7.5 CONSTRUCTION SCHEDULE

The construction schedule presented in Table 7 is for conceptual planning purposes only. Once construction funding is secured, the Construction Manager should refine this schedule, taking into account freight options, subsistence activities, commercial fishing seasons, and other local factors that could affect construction costs or the availability of local labor. The proposed project schedule, subject to availability of funding, calls for design and permitting during the spring and summer of 2006 with construction beginning in the fall of 2006. It is anticipated that all construction will be complete by fall 2007.

TABLE 7
PROJECT SCHEDULE
PORT HEIDEN RURAL POWER SYSTEM UPGRADES

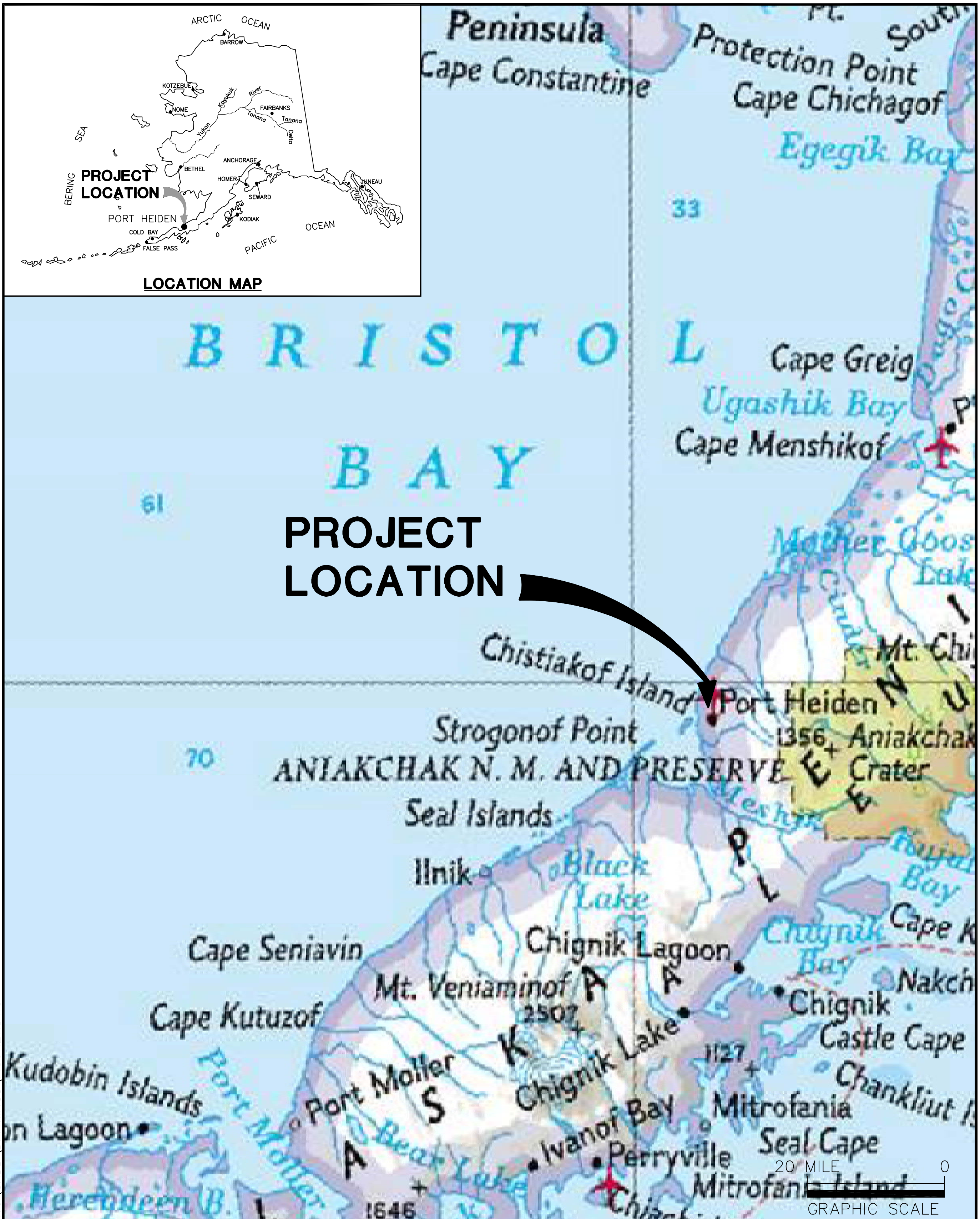
Task	Time
PHASE I TASKS	
Conceptual Design Report	
Complete Draft CDR and Site Visit	4w
AEA / Community Review	5w
Finalize CDR	4w
Business Plan (Draft)	7w
PHASE II TASKS	
Site Control / Utility Easements	22w
Design - Power Plant / Distribution System Upgrades	
65% Design	6w
AEA Review	1w
95% Design	4w
AEA Review	1w
Final Design	4w
Final Business Plan Preparation / Signing	6w
Permitting	
Environmental Assessment Preparation	12w
Fire Marshall Review	4w
PHASE III TASKS	
Pre-Construction Activities (Power Plant/Distribution System)	
Procure Generators / Switchgear	12w
Fabricate and Ship Module	24w
Procurement & shipment of Distribution Components	24w
Construction Activities (Power Plant/Distribution System)	
Mobilization	3w
Construct Power Plant Foundation	2w
Install Underground Primary and Secondary Conductors	16w
Power Plant Tie In and Startup	4w
Decommission Existing Systems	4w
Project Closeout	
Final Inspection and Punchlist Completion	6w



7.6 CONCEPTUAL CONSTRUCTION COST ESTIMATE

A conceptual cost estimate for the construction of proposed improvements is included in Appendix E. The estimate includes labor, materials, and shipping costs for all project components. The cost estimate was developed based upon the power plant module design and cost information provided by Alaska Energy and Engineering, and the assumption that a "modified" force-account approach, utilizing a combination of local labor, certified craftsmen, and specialty sub-contractors under the direction of an experienced Construction Manager would be used to construct the improvements. Labor rates are based on Title 36 equivalent wages for certified specialty labor and prevailing local force-account wage rates for general labor and equipment operation. The total cost of the proposed diesel power system including design, supervision, construction, inspection, permitting, and insurance is estimated to be $1,649,000.

FIGURES / PHOTOS



FILE NAME: 30401.10\CADD\DRAWINGS\FIGURE1.DWG

CRW ENGINEERING GROUP, LLC

Project:

State of Alaska
Department of Community and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503

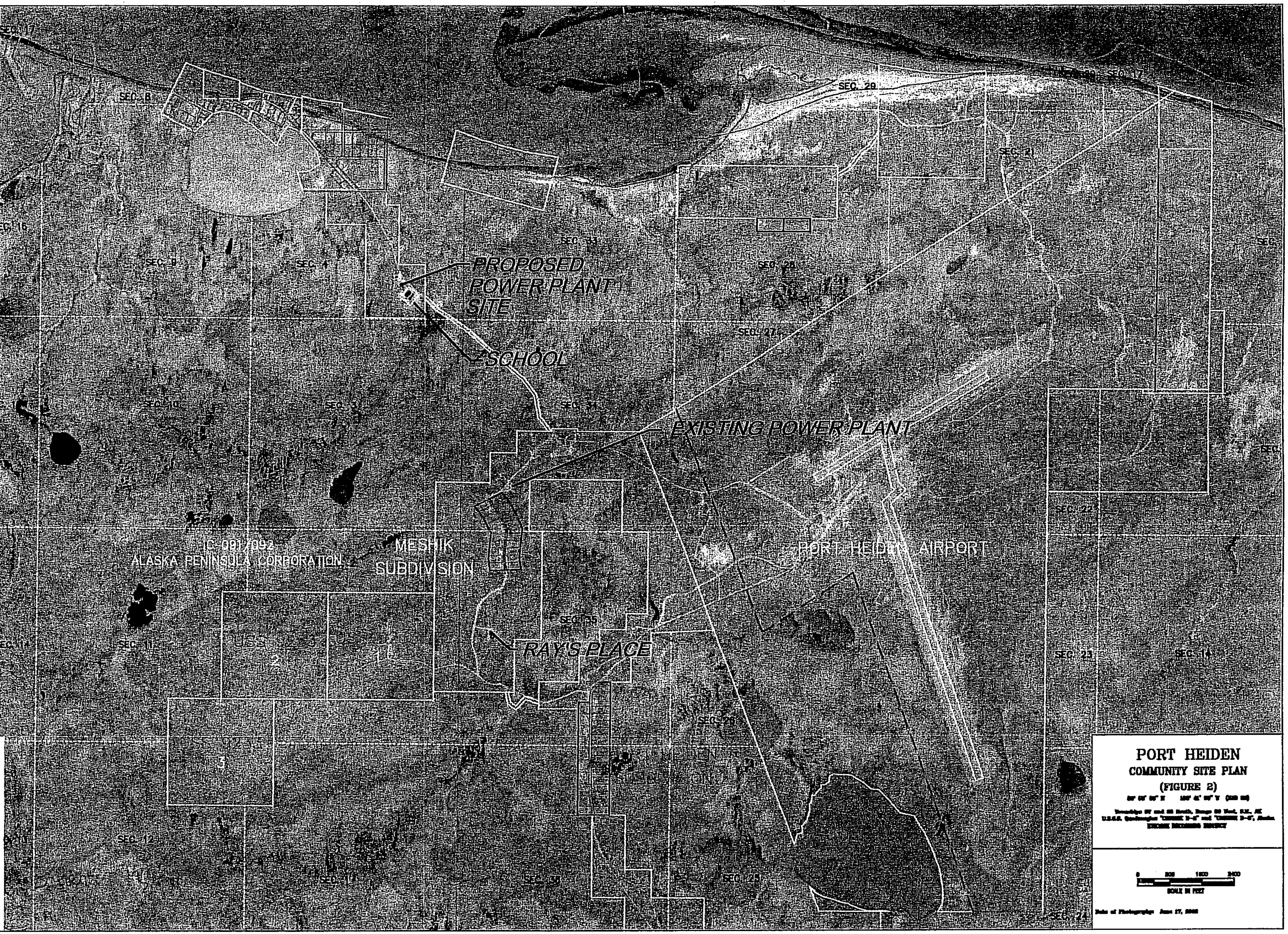
ALASKA ENERGY AUTHORITY

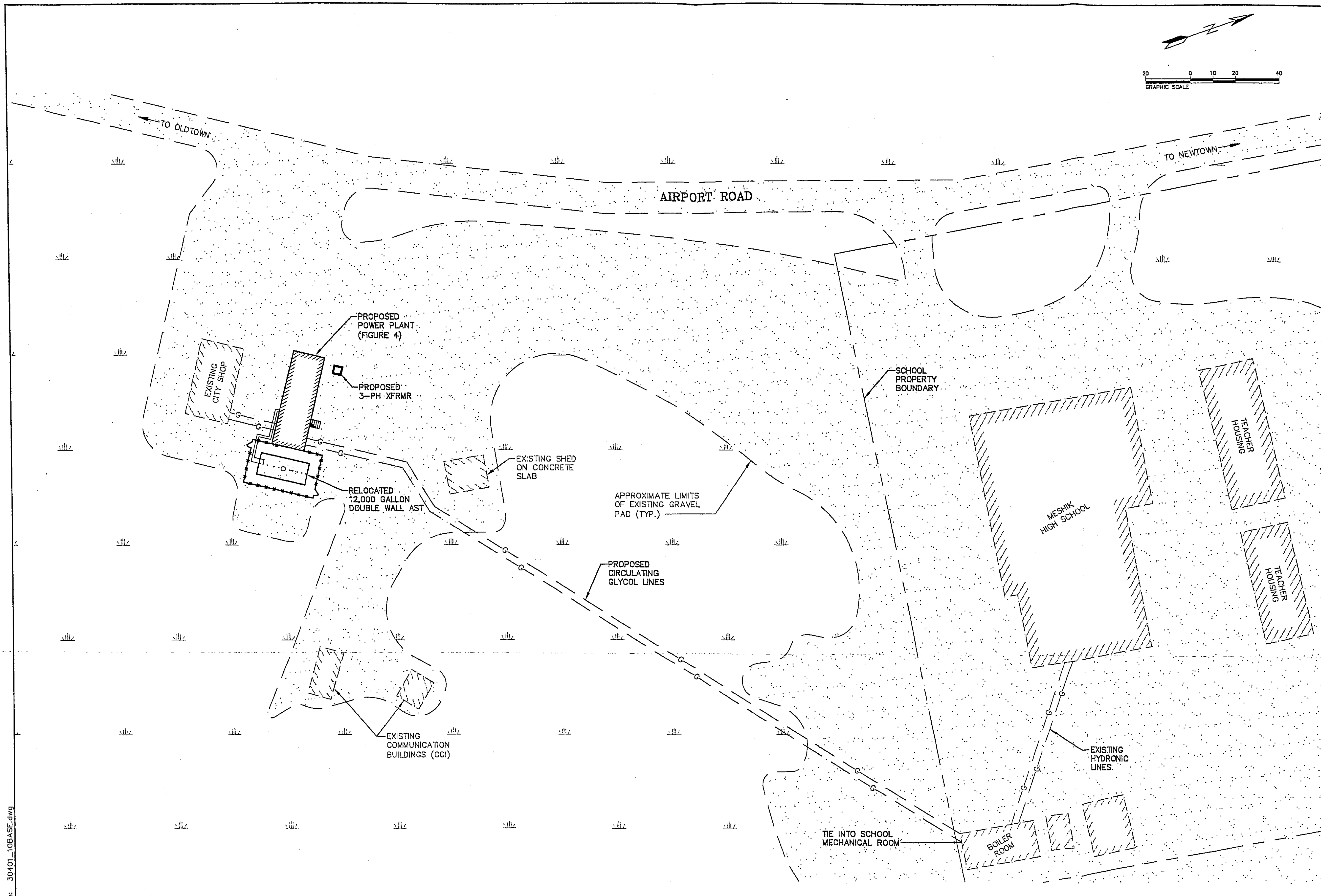
PORT HEIDEN

RURAL POWER SYSTEM UPGRADES

FIGURE 1
VICINITY MAP

Project No:	30401.10
Drawn By:	AJB
Scale:	AS SHOWN
Date:	8/04
Figure:	1


PROPOSED POWER PLANT SITE
SCHOOL
EXISTING POWER PLANT
PORT HEIDEN AIRPORT
MESHIK SUBDIVISION
IC-091/092
ALASKA PENINSULA CORPORATION
RAY'S PLACE
SEC. 8
SEC. 9
SEC. 4
SEC. 33
SEC. 28
SEC. 27
SEC. 21
SEC. 10
SEC. 11
SEC. 12
SEC. 22
SEC. 23
SEC. 14
SEC. 24
SEC. 25
SEC. 35
PORT HEIDEN
COMMUNITY SITE PLAN
(FIGURE 2)
SCALE IN FEET



State of Alaska
Department of Community and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503

ALASKA ENERGY AUTHORITY

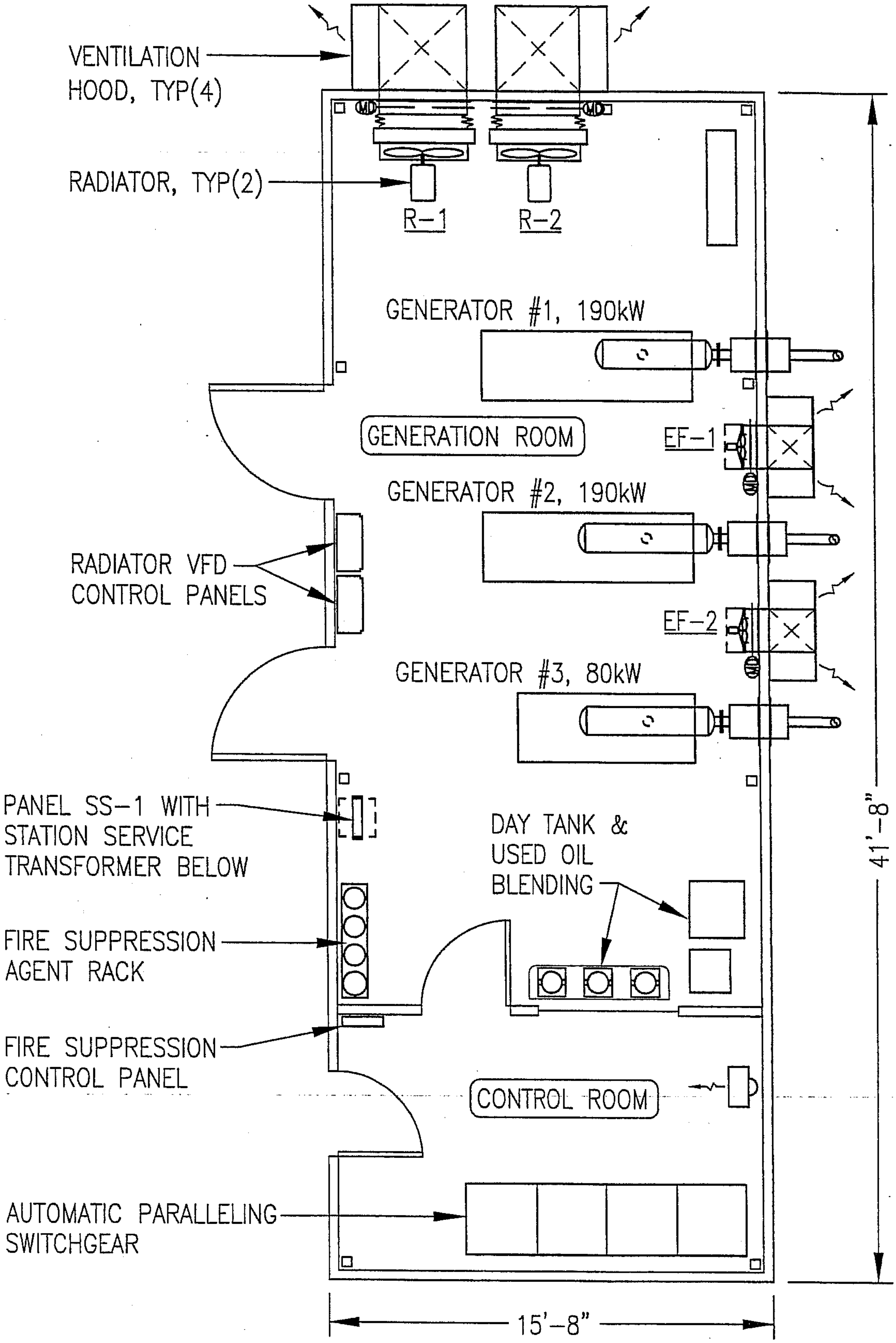
CRW ENGINEERING GROUP, LLC
3940 ARCTIC BLVD. SUITE 300
ANCHORAGE, ALASKA 99503
PHONE: (907) 562-3252
FAX: (907) 561-2273

CITY OF PORT HEIDEN
POWER PLANT SITE PLAN
FIGURE 3

REV	DESCRIPTION	BY	DATE
-	-	-	-

Project No. 30401.10
Date AUGUST 2004
Designed
Drawn JAM
Approved
Sheet No. FIG 3

File: 30401_10BASE.dwg



PROJECT: PORT HEIDEN RPSU	DRAWN BY: BCG	SCALE: 3/16"=1'	State of Alaska Department of Community and Economic Development AIDEA/AEA Rural Energy Group 813 West Northern Lights Blvd. Anchorage, Alaska 99503 ALASKA ENERGY AUTHORITY
	DESIGNED BY: BCG	DATE: 5/11/05	
TITLE: GENERATOR MODULE PLAN	FILE NAME PTHD-LAYOUT	SHEET M1 OF 1	

PORT HEIDEN EXISTING ELECTRICAL DISTRIBUTION SYSTEM SHEET INDEX

NOTE: THE LOCATIONS OF ELECTRICAL COMPONENTS AND PROPERTY LINES SHOWN HERE ARE APPROXIMATE. THE ELECTRICAL INSTALLER SHOULD FIELD VERIFY ALL COMPONENT LOCATIONS AND QUANTITIES PRIOR TO PROCUREMENT.

State of Alaska
Department of Community and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503

ALASKA ENERGY AUTHORITY

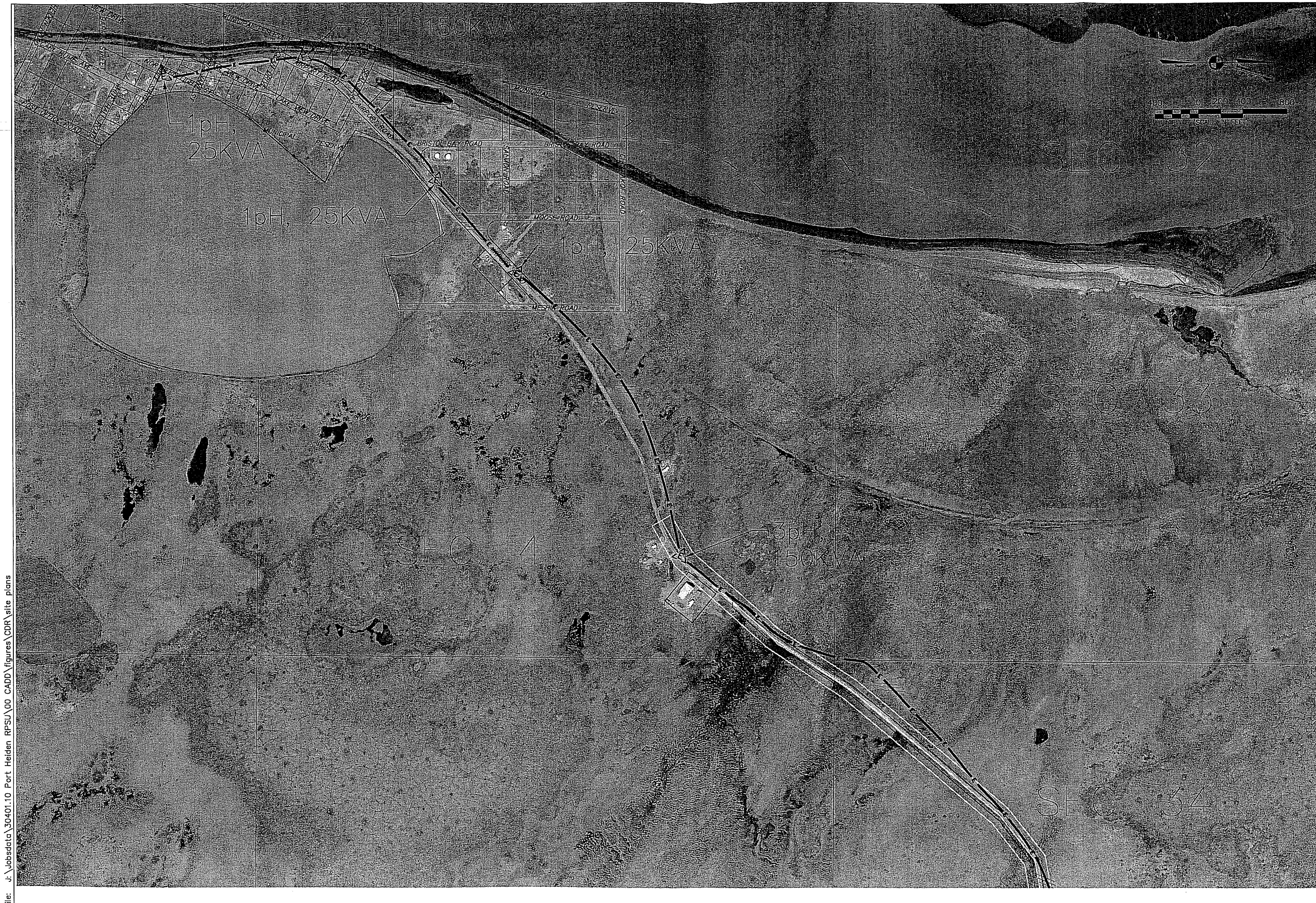
CRW ENGINEERING GROUP LLC
3900 ARCTIC BLVD., SUITE 203
ANCHORAGE, ALASKA 99503
PHONE: (907) 562-3252
FAX: (907) 561-2273

PORT HEIDEN
RURAL POWER SYSTEM
UPGRADES PROJECT
EXISTING ELECTRICAL SYSTEM
SHEET INDEX

Project No.
Date
Designed
Drawn
Approved

Sheet No. FIG 5-1

File: J:\Jobsdata\30401.10 Port Heiden RPSU\00 CADD\figures\CDR\site plans



State of Alaska
Department of Community and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503

ALASKA ENERGY AUTHORITY

CRW ENGINEERING GROUP, LLC
3900 ARCTIC BLVD. SUITE 203
ANCHORAGE, ALASKA 99503
PHONE: (907) 562-3252
FAX: (907) 561-2273

PORT HEIDEN ,RPSU
RURAL POWER SYSTEM UPGRADES

EXISTING ELECTRICAL
DISTRIBUTION SYSTEM

Project No.
Date
Designed
Drawn
Approved

Sheet No. FIG 5-2
SHEET OF

File: J:\Jobsdata\30401.10 Port Heiden RPSU\00 CADD\figures\CDR\site plans

File: J:\Jobsdata\30401.10 Port Heiden RPSU\00 CADD\figures\CDR\site plans

State of Alaska
Department of Community and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503
ALASKA ENERGY AUTHORITY

CRW ENGINEERING GROUP, LLC
3900 ARCTIC BLVD. SUITE 203
ANCHORAGE, ALASKA 99503
PHONE: (907) 562-3252
FAX: (907) 561-2273

PORT HEIDEN RPSU
RURAL POWER SYSTEM UPGRADES

EXISTING ELECTRICAL DISTRIBUTION SYSTEM

Project No.
Date
Designed
Drawn
Approved

Sheet No. FIG 5-3
SHEET OF

File: J:\Jobsdata\30401.10 Port Heiden RPSU\00 CADD\figures\CDR\site plans

Sheet No. FIG 5-4	Project No.		
SHEET OF	Date		
	Designed		
	Drawn		
	Approved		

PORT HEIDEN,RPSU
RURAL POWER SYSTEM UPGRADES

EXISTING ELECTRICAL
DISTRIBUTION SYSTEM

CRW ENGINEERING GROUP, LLC
3900 ARCTIC BLVD. SUITE 203
ANCHORAGE, ALASKA 99503
PHONE: (907) 562-3252
FAX: (907) 561-2273

State of Alaska
Department of Community
and Economic Development
AIDEA/AEA
Rural Energy Group
813 West Northern Lights Blvd.
Anchorage, Alaska 99503
ALASKA ENERGY AUTHORITY

Photo 1- Existing Power Plant Building and 12,000 Gallon Intermediate Tank

Photo 2- Power Plant Interior (JD Genset)

Photo 3- Existing 12,000 Gallon Tank To Be Relocated

Photo 4- Proposed Power plant Site (Pad Beyond Dozer)

Photo 5- Exposed Primary Cable Strung Along Ground

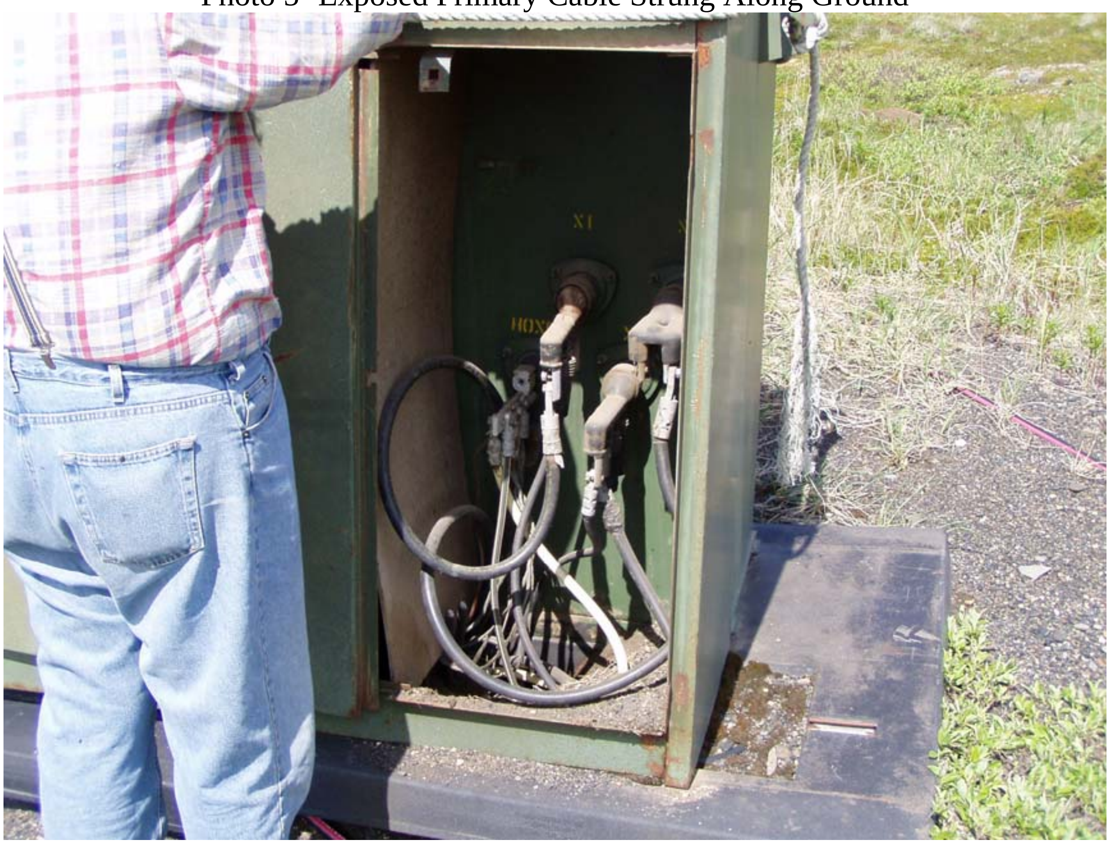


Photo 6- Typical Existing Transformer, Door No Longer Attached

Photo 7- Typical Secondary Voltage Pedestal

Photo 8- Local Borrow Source

APPENDIX A

SITE VISIT REPORT AND
ELECTRICAL SYSTEM INSPECTION REPORT

TRIP REPORT

CRW Engineering Group
3900 Arctic Blvd. Suite 203
Anchorage, AK 99503
(907) 562-3252 FAX 561-2273

TRAVEL DATES: 6/19/03 to 5/20/03

PROJECT: Port Heiden Rural Power System Upgrade Project

LOCATION: Port Heiden, Alaska

PARTICIPANTS: Karl Hulse, CRW
Jim Hall, EPS
Lenny Landis, AEA

REPORTER: Karl Hulse

PURPOSE: Initial Site Reconnaissance

LOCAL CONTACTS: Lynn Carlson, Mayor
John Christensen Sr., Village Council President
Jens Carlson, Power Plant Operator

ACTIVITIES:

6/19/03

Karl Hulse arrived at the Anchorage Airport at 7:00 a.m. and met Lenny Landis of AEA and Jim Hall of EPS for the 7:45 flight to King Salmon. The site visit crew arrived at King Salmon at 9:00, and proceeded to the Pen Air gate to catch the 10:30 flight to Port Heiden. Poor weather prevented further travel that day and the site visit crew spent the night in Dutch Harbor. The crew arrived in Port Heiden at 12:00 pm. Mayor Lynn Carlson met the crew at the airport and accompanied them to the City Office (Ray's Place). After dropping off luggage at the Carlson Lodge, the crew proceeded to inspect the community's power generation and electrical distribution systems.

Major observations noted during the inspection are listed below.

Existing Power Plant-

1. The power plant currently houses two generators, one 230 kw and one 200 KW. The only fully functioning generator in the community is the 230 KW unit.
2. The generation step up transformer has a wye-wye connection which results which results in severe fault duty on the generator windings and could

damage the diesel generator windings in the event of a fault or short in the distribution system.

3. Due to the wye-wye wiring, the condition of the only operating generator is questionable.
4. The generators receive fuel via a 100 gallon day tank and pump located within the building. The daytank pump pulls fuel from a 12,000 gallon double wall tank located within a fenced area adjacent to the building. The intermediate tank and day tank were installed as part of the recent bulk fuel upgrades project funded by AEA.

<u>Proposed Power Plant Site-</u>

1. The general consensus is to construct the new power plant on a parcel of land southwest of the existing school lot. This location is relatively close to the bulk fuel tank farm, reducing the fuel haul distance, and would provide the option of using recovered heat to help heat the school and a proposed future fish processing plant planned for the area.
2. The proposed site is located on an existing gravel pad more than 10 years old.
3. Locally available fill material consists of angular rock obtained from an established borrow pit in town or from the ADOT pit located near the airport. Material from the pit has been used successfully on many road and foundation projects in the community.
4. The preferred area is not subject to flooding.

<u>Existing Distribution System-</u>

1. The existing distribution system consists of approximately 40,000 feet of direct buried conduit. The system is approximately 20 years old.
2. The community's current electrical distribution system includes thirteen single-phase (25 kVA) and five three-phase (150 kVA), pad mounted transformers with load break primary bushings and a feed through bus on the single phase units. All transformers have surpassed their useful lives and should be replaced.
3. No as-builts were available for the buried system- Jim Hall drove the entire community and sketched the existing distribution system.
4. No major problems have occurred with the buried power cables to date. However, the age of the system increases the potential for problems in the near future.

<u>Potential Wind Generator Sites-</u>

1. The most probable site for installing a wind turbines appeared to be the ridge just south of Ray's Place. A portion of the ridge is reportedly owned by the City, and the topography and orientation of the ridge appear suitable.

Village of Port Heiden
Electrical Power System Inspection

July 2003

Prepared by:

James D. Hall, P.E.
David Burlingame, P.E.

PHONE (907) 522-1953 • 3305 ARCTIC BLVD., SUITE 201, ANCHORAGE, ALASKA 99503 • FAX (907) 522-1182 • WWW.EPSINC.COM
PHONE (907) 789-2474 • 2213 JORDAN AVE, JUNEAU, ALASKA 99803 • FAX (907) 789-4939
PHONE (425) 883-2833 • 3938 150 AVE. N.E., REDMOND, WASHINGTON 98052 • FAX (425) 883-8492

Table of Contents

1. Scope of Work

Electric Power Systems, Inc. (EPS) was contracted to perform an on-site inspection of the electrical distribution system at Port Heiden, Alaska and develop a list of required improvements and deficiencies. This report will document what was found during the on-site inspection of the electrical distribution system and recommend improvements required for continued service of reliable electrical power.

2. Existing Power Generation and Distribution Facilities

2.1. Description of Existing Facilities

A visual inspection of the electrical system in Port Heiden was conducted on June 19, 2003. The underground electrical distribution system was toured on foot and by truck to allow good access and close examination. The power plant was also toured.

2.1.1. Power Plant

The existing generation plant was possibly installed in 2000. Generator nameplates did not list year of manufacture.

The building appears to be slab on grade. The generation units share the building with the village fire truck.

The 480-volt switchgear includes a breaker for each generating unit, and a breaker for the outgoing feeder line to the system.

The plant is connected to the distribution system by underground conductors via a three-phase 150 KVA padmount stepup transformer. This transformer has a WYE–WYE connection.

2.1.2. Distribution System

The distribution system in was perhaps installed in the 1980s.

The system consists of about 24,000 feet of three phase underground primary line, and about 16,000 feet of single-phase primary line. The system operating voltage is 12470/7200 grounded wye. The entire system is underground direct buried construction.

Primary conductor is of at least three different types. All primary conductors examined were #2 Aluminum, and all insulation examined was XLPE. The first type of conductor inspected had 175 mil insulation and a bare concentric neutral; the second type had 220 mil insulation and a bare concentric neutral; and the third type had 220 mil insulation and a jacketed concentric neutral. These conductors were observed where they were exposed above grade. Other conductors may exist.

Transformers are pad mount with a load break primary bushings, and a feed through bus on the single-phase units. There are 13 single-phase padmount transformers and 5 three-phase padmount transformers on the system. The single-phase transformers are all reported to be 25 KVA units; the three-phase units (where size could be determined) were 150 KVA units.

Secondary conductor and service conductor is probably aluminum underground triplex for single phase, and aluminum underground quadraplex for three phase. Soil conditions are reasonably good for direct burial of electrical conductor.

Meters in the community are socket type and were probably installed with the distribution system.

2.1.3. Equipment Suitable for Reuse

The primary and secondary conductors appear to be in good condition however, the use of direct buried conductor in this location may render the cables not suitable for future use in new projects.

2.2. Existing Power Generation Capacity

There are two engine generator sets. They are rated:

1. 230 kW
   480 Volts
   1800 RPM
   Cummins Generator
   Cummins Engine

2. 200 kW
   480 Volts
   1800 RPM
   Stamford Generator
   Cummins Engine

The most recent complete year of power consumption records is for fiscal year 2000, at which time the peak load was 175 kW and the average peak was 152 kW.

2.3. Existing Power Generation and Distribution System Deficiencies

The generation plant building is in good condition. Due to the heat, fuel, and electricity that are necessary in a generator building, and the inherent risk of fire, it seems a poor arrangement to house the fire truck in the same building. There is no waste heat recovery system from the generation units. One of the engine generator units appears to be in good condition. The other unit appears to be in fair condition but is not presently operated except for maintenance or emergency due to apparent problems with engine bearings. The switchgear appears to be in good condition.

The generation stepup transformer has a WYE–WYE connection which results in severe fault duty on the generator windings for faults on the primary distribution system.

The distribution system is in generally fair condition. Single-phase transformers are in fair condition. All of the three-phase padmount transformers are in very poor condition. The access doors on these transformers are rusted to such an extent that the doors do not operate properly, and many of the doors are no longer attached to the transformer. No three-phase transformer was properly locked and secured. The doors on these three-phase units can no longer be properly closed and secured; this presents a serious safety hazard, and should be addressed immediately. Though these units have a considerable amount of rust, there is no noticeable oil leakage, but the transformer tanks are seriously compromised, and oil leakage is inevitable if measures are not taken soon to repair or replace these units. These transformers are beyond repair, and should be replaced.

The primary conductors appeared to be in reasonably good condition. The different types of cable will require a number of different splice kits, and different types of spare cable for maintenance and repair purposes. Though the primary conductor that was observed in enclosures appeared to be in good condition, the conductor in the ground may be corroded. Primary cable is exposed above grade at several locations. Some of these appear to be the result of beach erosion, and others appear to be emergency repairs that have not been reburied.

Meters appear to be in fair condition. Sockets are generally in fair to poor condition, due to rust.

3. Recommended Improvements

3.1. Distribution System Improvements

3.1.1. Transformers

Due to immediate safety concerns, the transformers that are not properly locked and sealed should be repaired. A temporary solution would be to bolt new hinges and padlock hasps to the existing doors such that they can be secured. These units are rusted beyond acceptable limits and should be replaced. Stainless steel, or galvanized steel transformer tanks should be seriously considered since conditions here result in very rapid corrosion, and replacement costs will be very high.

3.1.2. Buried Distribution System

The long runs of underground primary cable on the system, and the relatively light system load could result in difficulty in voltage control. Consideration should be given to having an analysis of the system performed, to determine if voltage control problems are likely to be present, and what actions can be taken to solve any such problems.

If at a future time there is any section of a primary conductor replaced, it is recommended that a sample portion of the old conductor be sent to a qualified test lab for analysis. To follow are two recommendations:

Georgia Technology Research Corp / Neetracc
Attn: Angelo Lawton, Research Coordinator
PO Box 100117, Atlanta GA 30384 (billing)
62 Lake Muir Building, Forest Park GA 30297-1613 (lab)
(404) 675-1893

Cable Technology Laboratories, Inc.
Attn: Carlos Katz, Chief Research Engineer
690 Jersey Ave, New Brunswick NJ 08903
(732) 846-3133

A minimum of six splice kits, two elbow kits, and basic cable preparation tools should be provided for each of the three types of primary cable in use. The correct dies and tools for installing the splices and elbows should also be provided.

3.1.3. Service Connections

Though the meters appear to be in fair condition, meters should be cleaned and tested due to extended exposure to harsh weather conditions. Sockets are generally in fair condition due to rust, and should be monitored and replaced as needed with aluminum or stainless steel units.

3.2. Diesel Power Generation Facility Improvements

3.2.1. Planned Infrastructure Improvements

The planned future improvements that would impact the power plant design are as follows: a new Septic Tank Effluent Pumping System, a new Washeteria, new Health Clinic Lighting, new Multi-purpose Building lighting, and Airport Improvements.

3.2.2. Recommended Electrical Generation Capacity

According to the only available data (monthly PCE reports) to compute current average demand and peak loading, fiscal year 2000 was the most recent complete year of recorded history for the previous five years. Thus, calculations show the current average demand to be 112 kW. Factoring in the planned infrastructure improvements, community growth, and an estimated fuel efficiency of 12 kWh/gal, the five year peak would be 218 kW, the 10 year energy would be 1,250,000 kWh, and the 10 year consumption would be 105,000 gallons per year.

3.2.2.1. Diesel Generator Sizes and Switchgear Considerations

Based on the proposed future average demand and peak loads, the recommended generator sizes are two 120 kW generators and one 225 kW generator. The generators will feed switchgear containing PLC controls for demand control.

A preliminary cost estimate for a new plant that includes a waste heat recovery system, switchgear with synchronization capabilities, a new building to house up to four generators, and the new generators would be around $450,000.

The generators are sized to provide the community with “firm capacity” over the planning horizon of this project. Additional load monitoring is recommended to properly size the generators, as PCE data is adequate for preliminary sizing only.

3.2.3. Tie in / Synchronization to Existing Distribution System

The generation stepup transformer has a WYE–WYE connection which results in severe fault duty on the generator windings for faults on the primary distribution system. Consideration should be given to the use of a

DELTA-WYE transformer to step up to the distribution voltage as well as to provide zero sequence isolation.

The new plant switchgear will provide synchronization functions between the new diesel generators and the distribution system. Consideration should be given to load control components should a wind or hydro generation system be introduced.

4. Distribution System Improvement Cost Estimate

The table in Appendix A outlines the recommended distribution system improvements. To follow is a summary of these costs as well as an estimate for the design engineering of these improvements.

System Improvements	$100,671
Design Engineering	$2,680
Construction Staking	$2,800
Survey As-built (if required)	$7,300
Total	**$113,451**

5. Appendix A

07/07/03	PORT HEIDEN, ALASKA	Page 1 of 1
Project: Cost Estimate	3 Phase UG Distribution	

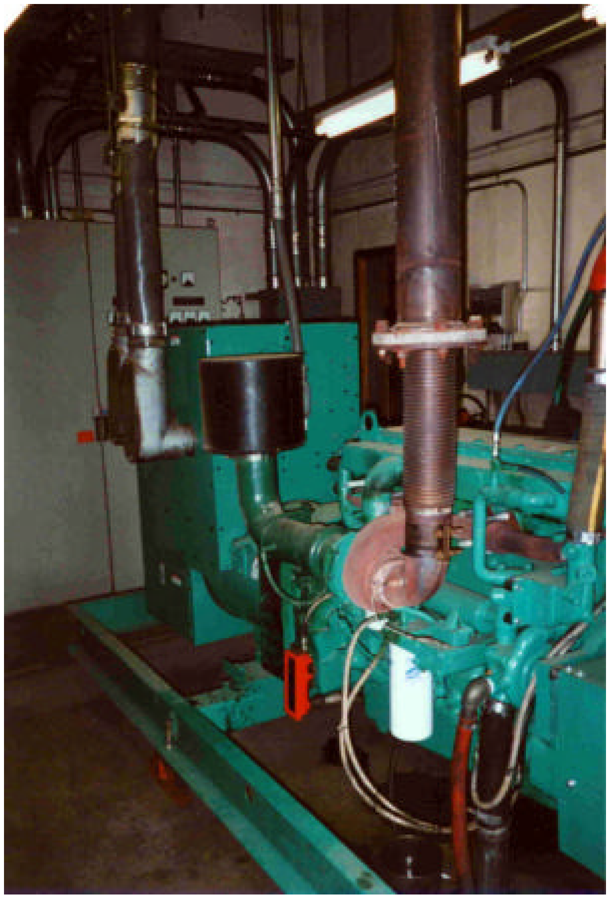
Structure(s)	Task	Qty	Material	Labor	Material + Labor	Extended Total
150 KVA XFMR	replace single phase transformer with stainless steel/galvanized unit	5	$8,700	$2,880	$11,580	$57,900
STEP UP XFMR	replace generation step-up transformers with padmount step-up transformer	1	$13,500	$5,760	$19,260	$19,260
RES METERS	clean & test residential meters; replace as needed	40		$180	$180	$7,200
COMM METERS	clean & test service meters; replace as needed	3		$540	$540	$1,620
SPLICE KIT	spare splice kits	12	$75		$75	$900
ELBOW KIT	spare high voltage elbow kit	4	$40		$40	$160
TOOLS	basic cable preparation tools	1	$500		$500	$500
					Subtotal	$87,540
					15 % contingency	$13,131
					Total	$100,671

Electric Power Systems inc.
Consulting Engineers

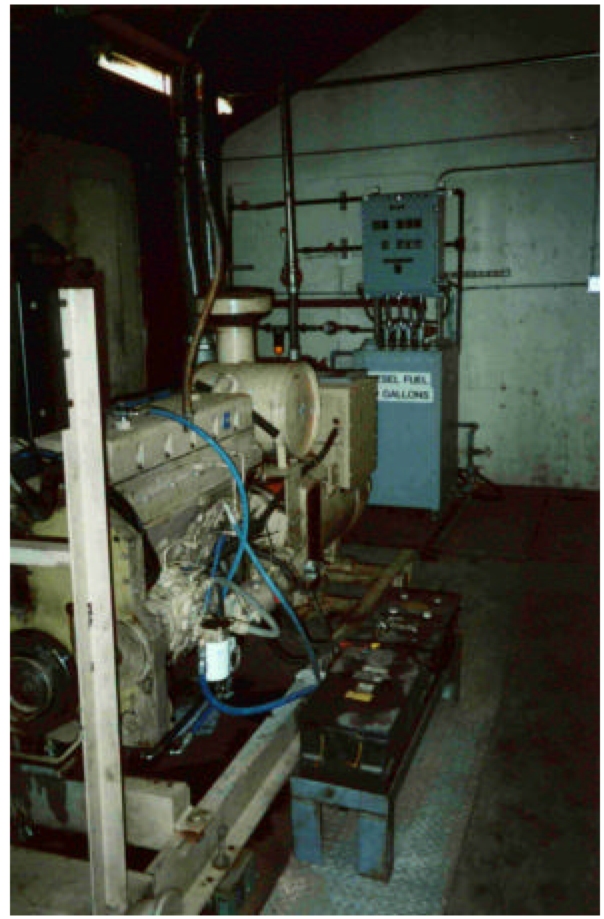
6. Appendix B

6.1. Pictures

6.1.1. Generators



Generator #1



Generator #2

6.1.2. Single Phase Transformer

Rusty Transformer & Sectionalizing Cabinet

Doors held closed with ropes

6.1.3. Secondary Pedestal & Conductors

APPENDIX B

COMMUNITY ELECTRICAL DEMAND ANALYSIS

PORT HEIDEN HISTORICAL ELECTRICAL LOAD DATA

Fiscal Year	Calendar Month	Generated (kWh)	Avg Demand (kW)	Peak Demand (kW)
1998	July	61,680	83	112
1998	August	71,160	96	130
1998	September	76,320	106	130
1998	October	76,320	103	-
1998	November	89,560	124	-
1998	December	87,840	118	-
1998	January	91,920	124	-
1998	February	94,680	141	-
1998	March	83,040	112	-
1998	April	82,233	114	-
1998	May	64,172	86	130
1998	June	80,331	112	130

1998 Summary	
Avg Demand	110
Peak Demand	130
Peak % of Avg	118.7%

1999	July	76,320	103	-
1999	August	76,320	103	-
1999	September	-	-	-
1999	October	-	-	-
1999	November	-	-	-
1999	December	-	-	-
1999	January	-	-	162
1999	February	99,720	148	-
1999	March	10,500	14	-
1999	April	76,800	107	-
1999	May	81,480	110	-
1999	June	72,000	100	-

1999 Summary	
Avg Demand	97
Peak Demand	162
Peak % of Avg	167.9%

2000	July	68,760	92	96
2000	August	71,160	96	125
2000	September	84,840	118	155
2000	October	74,280	100	160
2000	November	100,560	140	175
2000	December	126,840	170	175
2000	January	34,800	47	175
2000	February	99,960	149	165
2000	March	77,400	104	165
2000	April	89,400	124	155
2000	May	80,880	109	135
2000	June	79,200	110	140

2000 Summary	
Avg Demand	113
Peak Demand	175
Peak % of Avg	155.1%

2001	July	63600	85	130
2001	August	78840	106	-
2001	September	86040	120	145
2001	October	75390	101	160
2001	November	-	-	-
2001	December	-	-	-
2001	January	-	-	-
2001	February	-	-	-
2001	March	74760	100	145
2001	April	74160	103	140
2001	May	74160	100	140
2001	June	-	-	-

2001 Summary	
Avg Demand	103
Peak Demand	160
Peak % of Avg	155.2%

2002	July	58800	79	-
2002	August	-	-	-
2002	September	-	-	-
2002	October	-	-	-
2002	November	-	-	-
2002	December	-	-	-
2002	January	100080	135	-
2002	February	75880	113	-
2002	March	79200	106	-
2002	April	73560	102	-
2002	May	72240	97	-
2002	June	63360	88	-

2002 Summary	
Avg Demand	102
Peak Demand	0
Peak % of Avg	0.0%

APPENDIX C

SITE CONTROL DOCUMENTS

CITY OF PORT HEIDEN

(907) 837-2209
FAX (907) 837-2248

FACSIMILE TRANSMITTAL SHEET

TO: KARL HULSE, P.E.	FROM: BETTYANN WELBOURNE
COMPANY: CRW ENGINEERING	DATE: JULY 22
FAX NUMBER: 907-561-2273	TOTAL NO. OF PAGES INCLUDING COVER: 6
PHONE NUMBER: 907-646-5621	SENDER'S REFERENCE NUMBER:
RE: PTH POWER PLANT UPGRADE	YOUR REFERENCE NUMBER:

☐ URGENT x FOR REVIEW ☐ PLEASE COMMENT ☐ PLEASE REPLY ☐ PLEASE RECYCLE

NOTES/COMMENTS:

MR. HULSE:

PLEASE FIND THE ACCOMPANYING PAGES. I HOPE THIS IS THE INFORMATION YOU ARE REQUESTING.

IF YOU HAVE ANY QUESTIONS I AM IN THE OFFICE MONDAY-FRIDAY FROM 8:00-1:00.

THANK YOU

BETTYANN WELBOURNE
CITY CLERK

RECEIVED

JUL 22 2003

CRW Engineering Group, LLC
Project # [redacted] PORT HEIDEN BFU
File in Folder [redacted]
CC to Folder CORRS. IN

CORRECTIVE AND SUPPLEMENTAL
STATUTORY QUITCLAIM DEED
[AS 34.15.140]

WHEREAS, ALASKA PENINSULA CORPORATION, an Alaska Corporation (hereinafter "Corporation" or "Grantee"), and the CITY OF PORT HEIDEN (hereinafter "City" or "Grantor"), a municipal corporation, entered into an Agreement to Convey Real Property and Grant of Right of Entry (hereinafter "Agreement"), on January 28, 1985, which Agreement was recorded on the 29th day of January, 1986 in Book 0017, Pages 775-793; and

WHEREAS, said Agreement contemplated a quitclaim deed be granted by the Corporation and within 30 days and following survey, such corrective deed as may be necessary; and

WHEREAS, the Corporation did convey by statutory quitclaim deed dated February 15, 1985 and recorded on January 29, 1986, in Book 0017, Pages 784-789, all its rights, title and interest which it had, if any, in and to the surface estate of the tracts of land more particularly described therein; and

WHEREAS, said quitclaim deed contained an error in the description of parcels conveyed, to-wit: "Sections 15, 21, 22, 25, 26, 34, 35 and 36 of T39S, R59W, Seward Meridian"; and

WHEREAS, the Bureau of Land Management filed a surveyed plat pursuant to § 14(c)(3) of ANCSA, 43 U.S.C. § 1613(c)(3) which correctly identifies the Parcels 1 thru 9, which plat is recorded as Plat #92-02, on February 24, 1992 in the Kvichak Recording District, Third Judicial District, State of Alaska.

WHEREAS, only parcels 1 thru 8 are to be conveyed to the City of Port Heiden. Title to Section 5, T38S, R58W, Seward Meridian has not been received from the BLM. Parcel 9 is a 14(c)(1) subsistence hunting cabin site to be conveyed to the Village Council after Alaska Peninsula Corporation receives title from the BLM.

NOW, THEREFORE, THE CITY OF PORT HEIDEN, whose address is Port Heiden, Alaska 99549, for and in consideration of TEN DOLLARS ($10.00) in hand paid and other good and valuable consideration, hereby quitclaims and conveys all of its right, title and interest which it has, if any, in and to the surface estate of Sections 15, 21, 22, 25, 26, 34, 35 and 36 of T39S, R59W, Seward Meridian, Kvichak Recording District, Third Judicial District, State of Alaska, unto ALASKA PENINSULA CORPORATION, Grantee, and its assigns without warranty.

IN WITNESS WHEREOF, the authorized officers have hereunto set his/her hand on behalf of the Grantor this 24 day of August 1994.

CITY OF PORT HEIDEN

By: ______________________
Its: Mayor

(Corporate Seal)

By : ______________________
Its: Clerk

CERTIFICATE OF SATISFACTION

WHEREAS, Alaska Peninsula Corporation, successor in interest to Meshik, Inc., is required to transfer title to certain lands as specified in § 14(c)(3) of the Alaska Native Claims Settlement Act (ANCSA), as amended, to the Second Class City of Port Heiden, Alaska; and

WHEREAS, the Corporation has conveyed the surface estate of the land within those portions of the parcels described as:

> Lots 1 thru 8, Plat No. 92-02, recorded on February 24, 1992 in the Kvichak Recording District, Third Judicial District, State of Alaska, containing 1, 280 acres.

WHEREAS, it has been determined that the land transfer satisfies the requirements of § 14(c)(3) of ANCSA as amended;

NOW, THEREFORE, it is hereby certified that the Alaska Peninsula Corporation has completely discharged its obligation to the City of Port Heiden, Alaska, under the provisions of § 14(c)(3) of ANCSA, as amended.

CITY OF PORT HEIDEN

By: [signature]
Its: Mayor

STATE OF ALASKA)
) ss:
THIRD JUDICIAL DISTRICT)

THIS IS TO CERTIFY that on the 24th day of August, 1994, before me, the undersigned Notary Public for the State of Alaska, or U.S. Postmaster, duly commissioned and sworn as such, personally came Henry Matson Jr., ______________, to me known to be and said officers, respectively, of said City, and acknowledged that said instrument as signed and sealed on behalf of said City by the authority of its mayor, and ______________ OF THE CITY OF PORT HEIDEN, ALASKA, acknowledged said instrument to be the free act and deed of the City of Port Heiden.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

(SEAL) PORT HEIDEN, AK 99549 AUG 24 1994 U.S.P.S.

[signature]
Notary Public for Alaska
My Commission Expires: ______________

COPY

JLH:ckm\APC\5-94\CERT2:060594:mcv

ACCEPTANCE

This grant is hereby accepted by the Second Class City of Port Heiden, Alaska.

GRANTEE

CITY OF PORT HEIDEN

By: [signature]
Mayor of Port Heiden

ACKNOWLEDGEMENT

STATE OF ALASKA)
) ss:
THIRD JUDICIAL DISTRICT)

THIS IS TO CERTIFY that on the 24th day of August, 1994, before me, the undersigned Notary Public for the State of Alaska, duly commissioned and sworn as such, personally came Henry Matson Jr., Mayor of the City of Port Heiden, Alaska, and acknowledged that said instrument was signed and sealed on behalf of the City of Port Heiden by proper authority delegated and vested in himself, and acknowledged further said instrument to be the free act and deed of said City of Port Heiden.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

(SEAL)

PORT HEIDEN, AK 99549
AUG 24 1994
U.S.P.S.

[signature]
Notary Public for Alaska
My Commission Expires: ____________

COPY

ACKNOWLEDGEMENT

STATE OF ALASKA)
) ss:
THIRD JUDICIAL DISTRICT)

THIS IS TO CERTIFY that on the 24th day of August 1994, before me, the undersigned Notary Public for the State of Alaska, or U.S. Postmaster, duly commissioned and sworn as such, personally came Henry Matson Jr, ______________, to me known to be and said officers, respectively, of said City, and acknowledged that said instrument was signed and sealed on behalf of said City by the authority of its Mayor and ______________ of the CITY OF PORT HEIDEN, acknowledged said instrument to be the free act and deed of Port Heiden.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

PORT HEIDEN AK 99549 U.S.P.S. AUG 24 1994

[signature]
NOTARY PUBLIC IN AND FOR ALASKA or
U.S. POSTMASTER
My Commission Expires: ______________

COPY

APPENDIX D

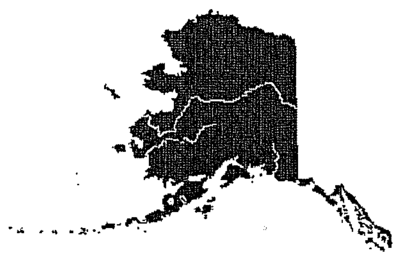
WIND DATA REPORT AND ECONOMIC ANALYSIS

ALASKA ENERGY AUTHORITY

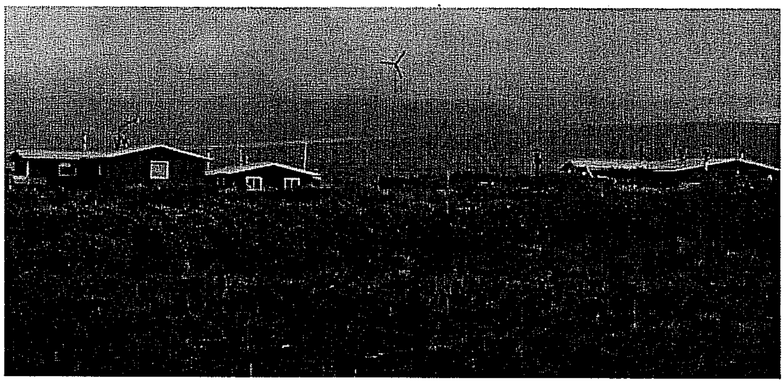
813 W. Northern Lights Blvd.
Anchorage, AK 99503
Phone: 907-269-3000
Fax: 907-269-3044
www.aidea.org/wind.htm

Wind Resource Assessment for PORT HEIDEN, ALASKA
Site # 2548

Date last modified: 11/04/2005
Prepared by: Mia Devine



Port Heiden



Latitude: (NAD27)	56° 55' 52" N 56° 55.867'
Longitude: (NAD27)	158° 37' 11.6" W 158° 37.193'

Elevation:	68 ft
Tower Type:	100-foot guyed lattice tower
Monitor Start: Monitor End:	8/06/2004 In operation

INTRODUCTION

On September 23, 2003, one anemometer and one wind vane were mounted on a 10-kW Bergey wind turbine tower at a height of 85 feet. The 100-foot tower is a 3-legged guyed lattice tower located next to the city building. A temperature sensor was mounted at a height of 14 feet. This system recorded data intermittently until the logger failed. On August 6, 2004, a new NRG Symphonie data logger was installed. On October 7, 2004, an additional anemometer and wind vane were installed at a height of 85 feet and at a 90 degree offset from the first set of equipment to reduce the effects of the tower on readings from certain directions. For consistency in the data sample, this report focuses on data collected by the Symphonie logger, beginning August 6, 2004.

The purpose of this monitoring effort, jointly funded by the Bristol Bay Native Corporation, the Sustainable Energy Council of the Alaska Peninsula (SECAP), and AEA, is to evaluate the feasibility of utilizing utility-scale wind energy in the community. This report summarizes the wind resource data collected and the long-term energy production potential of the site.

SITE DESCRIPTION

Port Heiden is located about 400 miles southwest of Anchorage on the north side of the Alaska Peninsula. It lies at the mouth of the Meshik River near the Aniakchak National Preserve and Monument. The climate is maritime with cool summers and relatively warm winters. Figure 1 shows the location of the wind monitoring tower relative to the surrounding terrain.

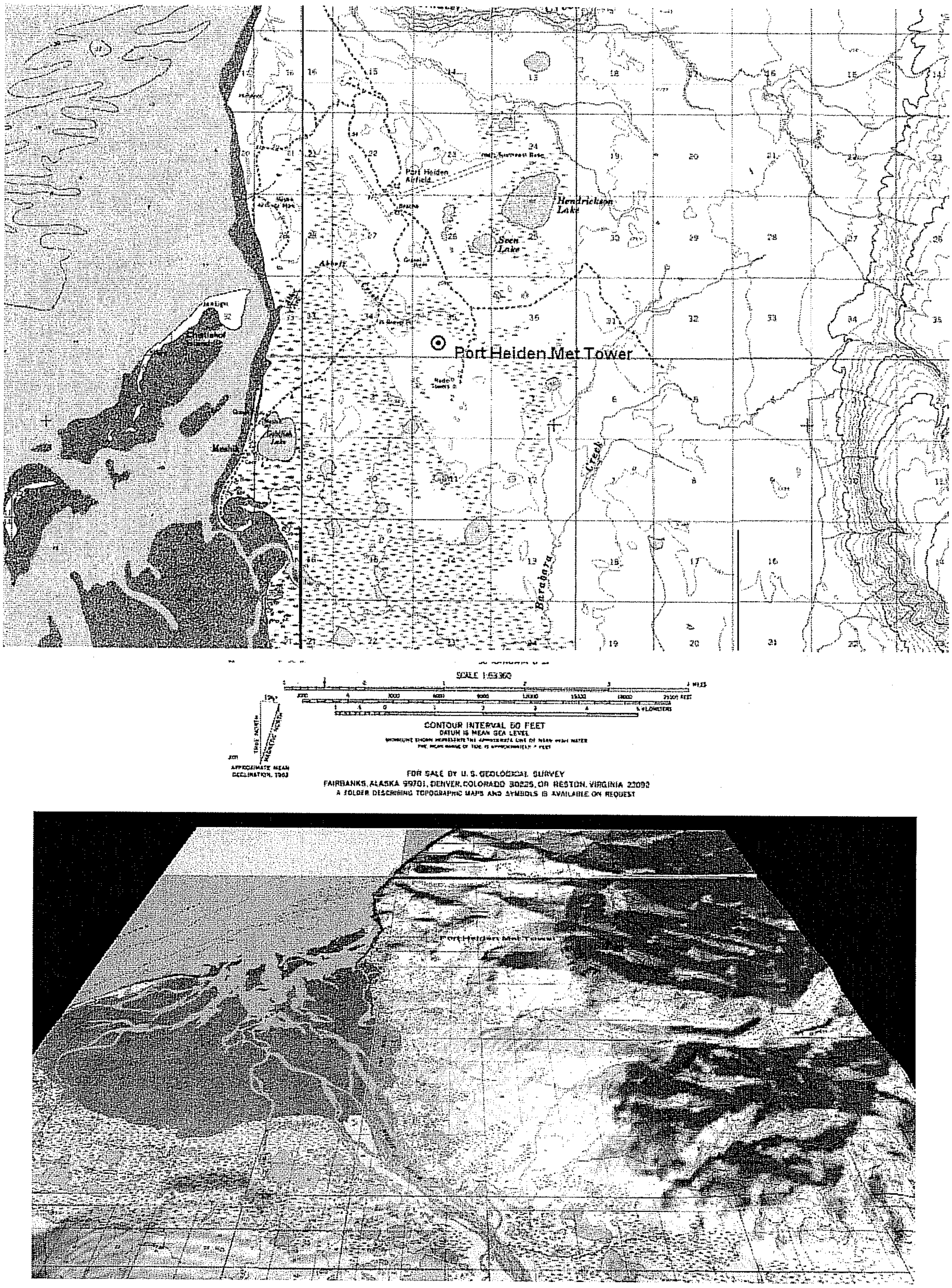
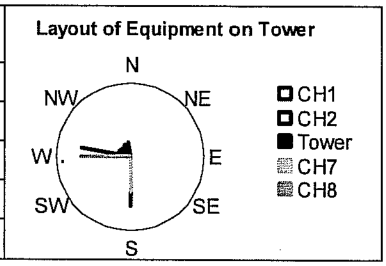


Figure 1. Topographic Map of Wind Tower Site and Surrounding Area

Table 1 lists the types of sensors that were mounted on the tower, the channel of the data logger that each sensor was wired into, and where each sensor was mounted on the tower.

Table 1. Summary of Sensors Installed on the Met Tower

Ch #	Sensor Type	Height	Offset	Boom Orientation
1	#40 Anemometer	85 ft	NRG Standard	180° True
2	#40 Anemometer	85 ft	NRG Standard	280° True
7	#200P Wind Vane	85 ft	180° True	180° True
8	#200P Wind Vane	80 ft	90° True	270° True
9	#110S Temperature	4 m	NRG Standard	-



In order to install the sensors, the wind tower was tilted down, as shown in the photos below.

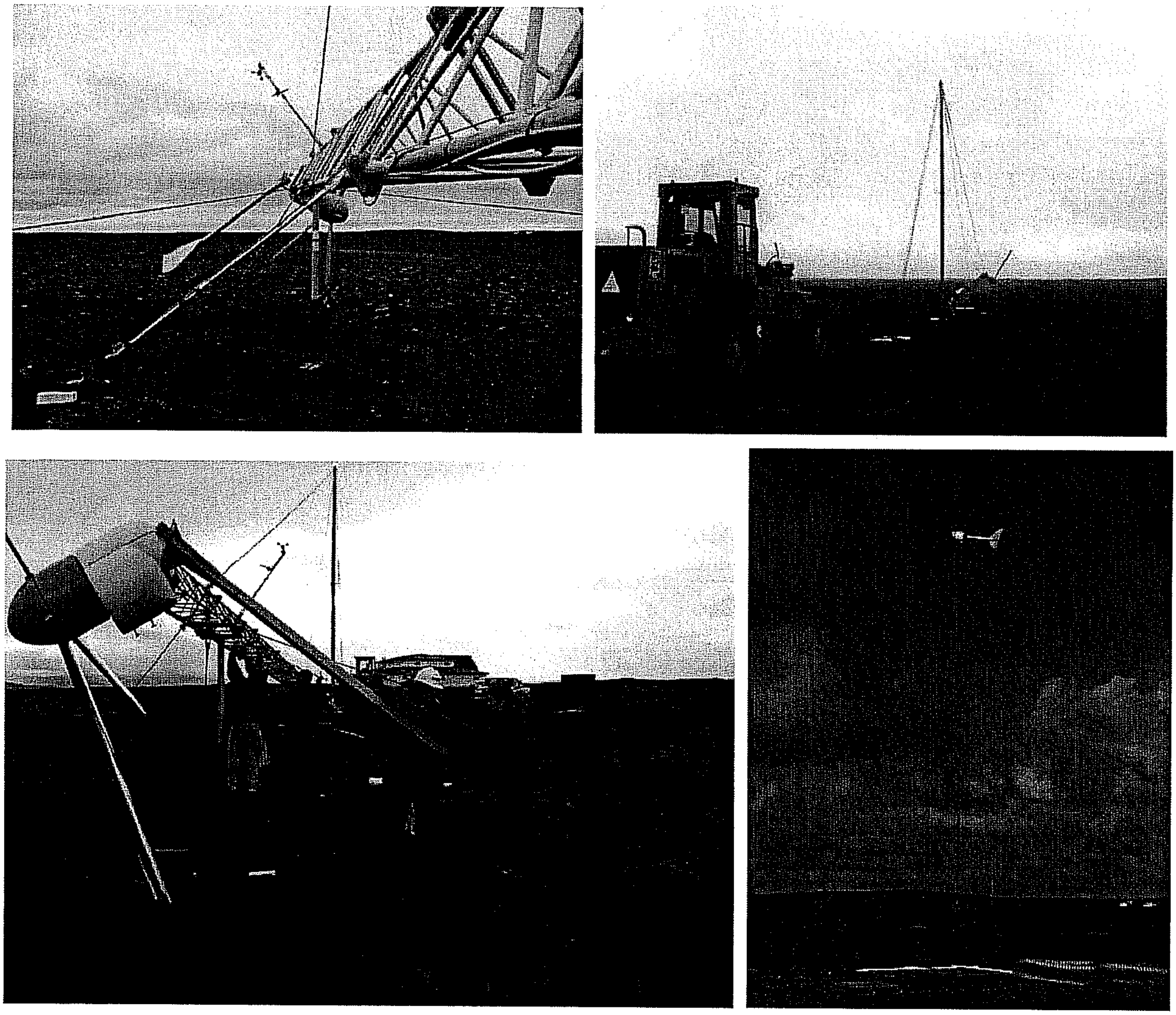


Figure 2. Installation of Sensors on Wind Tower in Port Heiden

DATA PROCESSING PROCEDURES AND DEFINITIONS

The following information summarizes the data processing procedures that were performed on the raw measured data in order to create an annual dataset of "typical" wind speeds, which could then be used to calculate potential power production from wind turbines. There are various methods and reasons for adjusting the raw data, so the purpose of these notes is to document what was done in this situation. The raw data set is available on the Alaska Energy Authority website (www.akenergyauthority.org) so one could perform their own data processing procedures.

Units – Since most wind turbine manufacturer data is provided in metric units, those units are used here.

1 meter/second = 2.24 mph = 1.95 knots
1 meter = 3.28 feet
1 °C = 5/9 (°F – 32)

Max/Min Test – All of the 10-minute data values were evaluated to ensure that none of them fell outside of the normal range for which the equipment is rated.

Tower Shadow – The tower itself can affect readings from the anemometer at times when the anemometer is located downwind of the tower. To minimize this effect, one data set is compiled from the 2 anemometers depending on the direction of the wind at any given time.

Icing – Anomalies in the data can suggest when the sensors were not recording accurately due to icing events. Since wind vanes tend to freeze before the anemometers, icing events are typically identified whenever the 10-minute standard deviation of the wind vane is zero (the wind vane is not moving) and the temperature is at or below freezing. Some additional time before and after the icing event are filtered out to account for the slow build up and shedding of ice.

Filling Gaps – Whenever measured met tower data is available, it is used. Two different methods are used to fill in the remaining portion of the year. First, nearby airport data is used if available. A linear correlation equation is defined between the airport and met tower site, which is used to adjust the hourly airport data recorded at the time of the gap. If neither met tower nor airport data is available for a given timestep, the software program Windographer (www.mistaya.ca) is used. Windographer uses statistical methods based on patterns in the data surrounding the gap, and is good for filling short gaps in data.

Long-term Estimates – The year of data collected at the met tower site can be adjusted to account for inter-annual fluctuations in the wind resource. To do this, a nearby weather station with a consistent historical record of wind data and with a strong correlation to the met tower location is needed.

Turbulence Intensity – Turbulence intensity is the most basic measure of the turbulence of the wind. Turbulence intensity is calculated at each 10-minute timestep by dividing the standard deviation of the wind speed during that timestep by the average wind speed over that timestep. It is calculated only when the mean wind speed is at least 4 m/s. Typically, a turbulence intensity of 0.10 or less is desired for minimal wear on wind turbine components.

Wind Shear – Typically, wind speeds increase with height above ground level. This vertical variation in wind speed is called wind shear and is influenced by surface roughness, surrounding terrain, and atmospheric stability. If the met tower is equipped with anemometers at different heights the wind shear exponent, α, can be calculated according to the power law formula:

$$\left(\frac{H_1}{H_2}\right)^{\alpha} = \left(\frac{v_1}{v_2}\right)$$ where H_1 and H_2 are the measurement heights and v_1 and v_2 are the measured wind speeds.

Wind shear is calculated only with wind speed data above 4 m/s. Values can range from 0.05 to 0.25. Since wind speeds were not measured at different heights at this location, a typical value of 0.14 is assumed.

Scaling to Hub Height – If the wind turbine hub height is different from the height at which the wind resource is measured, the wind resource can be adjusted using the power law formula described above and using the wind shear data calculated at the site.

Air Density Adjustment – The power that can be extracted from the wind is directly related to the density of the air. Air density, ρ, is a function of temperature and pressure and is calculated for each 10-minute timestep according to the following equation (units for air density are kg/m^3):

$\rho = \frac{P}{R \times T}$, where P is pressure (kPa), R is the gas constant for air (287.1 J/kgK), and T is temperature in Kelvin.

Since air pressure is not measured at the met tower site, the site elevation is used to calculate an annual average air pressure value according to the following equation:

P = 1.225 – (1.194 x 10^{-4}) x elevation

Since wind turbine power curves are based on a standard air density of 1.225 kg/m3, the wind speeds measured at the met tower site are adjusted to create standard wind speed values that can be compared to the standard power curves. The adjustment is made according to the following formula:

$$V_{s\tan dard} = V_{measured} \times \left(\frac{\rho_{measured}}{\rho_{s\tan dard}} \right)^{\frac{1}{3}}$$

Wind Power Density – Wind power density provides a more accurate representation of a site's wind energy potential than the annual average wind speed because it includes how wind speeds are distributed around the average as well as the local air density. The units of wind power density are watts per square meter and represent the power produced per square meter of area that the blades sweep as they rotate around the rotor.

Wind Power Class – A seven level classification system based on wind power density is used to simplify the comparison of potential wind sites. Areas of Class 4 and higher are considered suitable for utility-scale wind power development.

Weibull Distribution – The Weibull distribution is commonly used to approximate the wind speed frequency distribution in many areas when measured data is not available. In this case, the Weibull distribution is used to compare with our measured data. The Weibull is defined as follows:

$$P(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} \exp\left(\frac{-v}{c}\right)^{k}$$

Where P(v) is the probability of wind speed v occurring, c is the scale factor which is related to the average wind speed, and k is the shape factor which describes the distribution of the wind speeds. Typical k values range from 1.5 to 3.0, with lower k values resulting in higher average wind power densities.

LONG-TERM REFERENCE STATION

Wind data from the Port Heiden Airport weather station, located about 2 miles north of the met tower site, serves as a long-term reference for the wind resource in the area. This data is measured at a height of 7 meters above ground level and at an elevation of 29 meters. Since the airport is close to the met tower site and the surrounding terrain is relatively flat, the patterns in wind resource data between the sites are expected to be similar.

Nearly 30 years of wind speeds are shown in Table 2 and Figure 3. The average wind speed over the 30-year period is 5.7 m/s at a height of 7 meters above ground level. The annual wind speed rarely deviates more than 8% above or below this average.

Table 2. Average Wind Speeds at 7-m Height at Port Heiden Airport (m/s)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG	% of 30-yr Average
1976	5.4	5.86	5.83	4.7	5.44	4.45	4.34	3.94	4.66	5.5	5.22	5.55	5.1	89%
1977	7.11	6.49	6.61	5.74	4.44	4.78	5.43	5.2	5.55	6.33	6.36	6.14	5.8	102%
1978	5.46	6.52	5.62	5.58	4.65	5.06	5.17	5.57	5.99	5.9	7.8	8.9	5.7	99%
1979	7.55	5.79	5.92	6.13	5.93	4.91	3.95	5.43	5.66	6.06	7.14	7.33	6.0	105%
1980	6.66	5.41	6.92	5.28	6.05	6.64	5.18	4.76	5.47	4.81	4.64	6.61	5.7	100%
1981	5.36	6.93	5.42	4.14	5.39	4.19	5.08	6.52	5.21	6.52	6.61	6.68	5.6	98%
1982	6.09	6.26	6.5	6.07	5.39	5.8	6.8	5.07	5.89	5.88	5.23	5.41	5.9	102%
1983	5.38	4.85	4.9	5.1	5.54	4.2	4.51	4.56	5.83	6.09	5.52	6.92	5.3	92%
1984	5.98	6.29	4.38	5.44	4.55	4.41	4.26	4.41	5.34	5.28	6.54	6.22	5.3	93%
1985	7.43	6.35	6.63	5.53	6.17	4.67	4.46	5.88	5.65	7.66	7.45	6.84	6.2	108%
1986	5.41	6.43	4.78	5.56	6.03	6.41	4.44	5.42	5.95	4.57	6.19	6.33	5.6	98%
1987	6.46	6.23	5.88	5.91	5.36	5.51	4.58	5.33	5.58	6.13	5.26	6.11	5.7	100%
1988	5.89	7	5.78	5.6	4.85	4.82	4.62	5.12	5.78	5.59	5.61	7.24	5.7	99%
1989	7.86	9.07	5.35	5.97	5.9	4.95	4.62	5.33	6.33	7.95	5.77	6.38	6.2	108%
1990	7.39	7.04	4.7	4.62	6.53	5.41	5.24	5.55	6.36	5.48	6.36	6.96	6.1	106%
1991	4.88	7.42	6.43	4.99	7.06	6.44	4.85	5.25	6.27	5.43	4.83	6.68	5.8	101%
1992	5.21	4.88	5.99	4.56	3.73	5.78	4.67	6.12	4.99	5.59	5.3	7.02	5.3	93%
1993	6.6	7.77	6.06	5.25	5.84	4.79	4.92	6.06	6.03	4.51	6.19	6.15	5.8	102%
1994	5.3	5.51	6.88	4.96	4.73	4.88	4.37	4.82	5.79	5.76	8.15	7.04	5.6	98%
1995	5.3	6.7	5.57	4.83	5.79	4.38	5.97	5.03	5.62	6.39	4.47	6.08	5.6	97%
1996	5.03	8.57	6.14	6.08	5.1	6.6	4.37	4.68	6.82	4.99	7.04	6.25	5.9	104%
1997	6.16	4.66	4.92	4.48	5.01	4.65	3.73	5.32	6.05	4.71	5.49	5.88	5.0	87%
1998	4.96	3.72	7.65	7.11	6.49	5.38	4.58	6.57	6.14	6.09	5.64	7.8	6.0	105%
1999	6.3	6.89	5.71	6.49	5.23	4.94	4.87	5.17	5.3	4.96	5.77	6.62	5.7	99%
2000	6.34	9.01	7.01	5.24	5.14	6.06	4.93	5.6	5.82	5.66	6.69	8.58	6.2	108%
2001	6.13	7.12	6.05	6.14	5.99	5.05	5.64	5.1	5.6	6.44	6.35	6.34	6.0	105%
2002	6.9	7.0	6.5	6.3	5.8	4.4	5.3	4.6	6.6	6.6	5.6	6.4	6.0	105%
2003	6.3	5.6	6.0	5.7	5.6	5.5	4.6	4.9	4.7	5.7	7.2	6.5	5.7	99%
2004	5.5	5.7	6.1	5.9	5.2	5.2	4.5	5.1	5.8	6.7	6.7	7.0	5.8	101%
AVG	6.12	6.42	5.94	5.42	5.45	5.16	4.81	5.24	5.69	5.81	6.01	6.62	5.7	100%

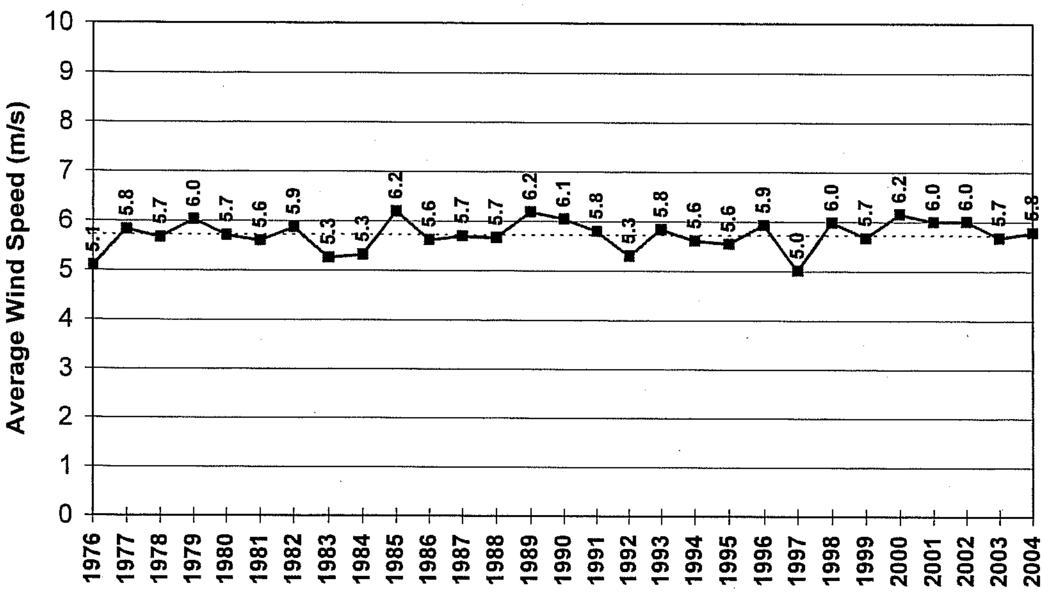


Figure 3. Annual Average Wind Speeds at 7-m Height at Port Heiden Airport Weather Station

Hourly wind speed measurements from the Port Heiden Airport weather station that are concurrent with recordings from the wind monitoring tower site were purchased from the National Climatic Data Center. Data between these sites was compared and a correlation coefficient of 0.90 was calculated (a value of 1 is perfect). This suggests that, although the actual wind speed values at the two sites are different, the pattern of wind speed fluctuations is similar between the sites. Based on this correlation a long-term estimate of the wind speed at the wind tower site was developed.

WIND DATA RESULTS FOR WIND TOWER SITE

Table 3 summarizes the amount of data that was successfully retrieved from the anemometers at the wind tower site.

Table 3. Data Recovery Rates for Met Tower Data

Month	Data Recovery
January	48%
February	91%
March	100%
April	100%
May	100%
June	100%
July	89%
August	47%
September	95%
October	99%
November	98%
December	100%
Annual Avg	**89%**

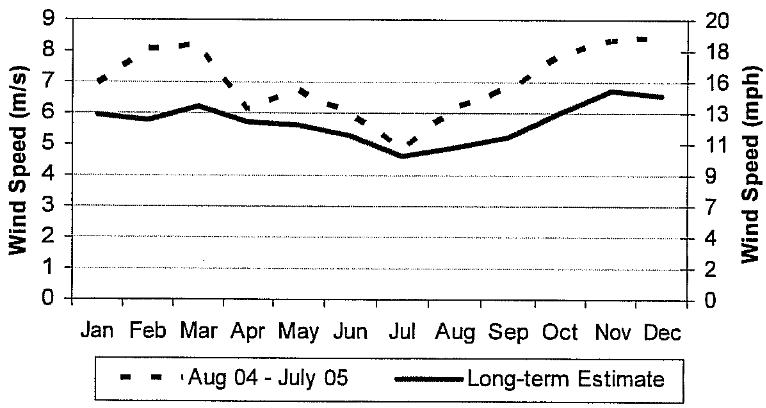
Table 4 and Table 5 summarize the wind resource data measured at the wind tower site as well as the estimated long-term data for this site.

Table 4. Measured Wind Speeds at 26-m Height at Wind Tower Location, Aug 2004 - July 2005 (m/s)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0	7.1	7.9	8.7	6.1	6.4	5.1	4.6	6.3	7.1	7.4	8.5	8.1	7.0
1	7.8	8.1	8.4	6.0	5.9	5.3	4.8	6.4	6.8	7.7	8.4	8.4	7.0
2	7.9	8.2	7.9	6.0	6.3	5.1	4.8	6.2	6.8	8.4	9.1	8.3	7.1
3	7.8	7.9	8.1	5.7	5.9	5.4	4.6	5.7	6.8	8.3	9.3	8.1	7.0
4	7.9	8.5	8.4	5.3	5.9	5.1	4.2	5.9	6.6	8.0	9.3	8.0	6.9
5	7.7	8.8	8.4	5.3	6.3	5.3	4.3	6.1	6.9	8.2	9.3	8.2	7.1
6	6.9	8.9	8.2	5.3	6.4	5.2	4.5	5.3	7.1	8.2	9.6	8.3	7.0
7	7.0	8.7	8.0	5.2	6.3	5.0	4.1	5.2	6.9	8.2	9.5	8.8	6.9
8	6.9	8.4	8.3	5.2	6.3	5.4	4.3	5.9	6.7	8.2	9.1	9.0	7.0
9	7.4	8.1	8.4	5.7	6.8	6.1	4.6	6.6	6.7	8.2	9.0	9.2	7.2
10	8.6	8.4	8.7	6.3	7.3	6.7	4.8	6.2	7.2	8.6	8.1	9.5	7.5
11	8.6	8.5	9.3	6.5	7.8	7.1	5.2	6.4	7.2	9.1	8.2	9.7	7.8
12	8.3	8.6	9.3	6.6	8.0	7.6	5.8	6.6	7.1	9.3	8.5	9.2	7.9
13	7.5	8.4	9.2	7.1	8.3	7.9	6.1	6.5	7.4	9.6	8.2	9.0	7.9
14	6.9	8.5	9.2	7.7	8.5	8.3	6.0	7.2	7.4	9.6	8.5	9.3	8.1
15	6.8	8.1	9.5	7.8	8.6	8.1	6.4	7.4	7.4	8.8	8.1	9.1	8.0
16	6.9	8.5	9.0	7.9	8.5	7.7	6.3	7.2	7.5	8.3	8.0	8.6	7.9
17	6.8	8.6	8.8	7.8	8.3	7.2	6.0	7.1	7.6	7.9	7.9	8.3	7.7
18	6.5	8.8	8.3	7.5	7.7	6.8	6.1	7.1	7.3	7.1	8.2	9.0	7.5
19	6.5	9.1	7.9	7.0	7.6	6.6	5.8	7.2	7.1	7.2	8.3	9.1	7.5
20	5.5	8.8	7.8	6.7	7.1	6.3	5.2	6.9	7.0	7.4	8.3	8.8	7.1
21	6.4	8.3	7.7	6.4	6.5	5.6	5.0	6.2	7.3	7.7	8.7	8.9	7.1
22	6.9	8.4	8.2	6.2	6.2	5.2	4.6	6.0	7.0	7.9	9.1	8.6	7.0
23	6.8	8.2	8.5	6.3	6.2	5.4	4.6	6.2	7.1	7.6	9.1	8.4	7.0
Avg	7.2	8.4	8.5	6.4	7.0	6.2	5.1	6.4	7.1	8.2	8.7	8.7	7.3

Table 5. Estimated Long-term Wind Speeds at 26-m Height at Wind Tower Location (m/s)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0	7.7	6.7	7.1	6.0	5.6	5.7	5.0	5.6	5.4	6.7	8.1	7.6	6.4
1	7.5	6.8	7.0	6.2	5.6	5.4	5.0	5.5	5.6	6.5	8.0	7.5	6.4
2	7.2	6.2	6.9	5.7	5.6	5.2	4.8	5.2	5.5	6.6	8.4	7.5	6.2
3	7.1	7.1	7.2	5.8	5.8	5.0	4.8	5.1	5.0	6.6	8.5	7.9	6.3
4	6.8	6.9	6.8	5.6	5.7	5.0	4.6	4.9	5.5	6.6	8.5	7.6	6.2
5	6.8	6.8	7.0	5.7	5.4	5.1	4.5	4.9	5.5	6.8	8.3	7.6	6.2
6	6.8	6.6	7.0	5.4	5.7	5.0	4.5	4.9	5.7	7.0	8.4	7.6	6.2
7	7.1	6.4	7.0	5.2	5.6	5.5	4.7	4.7	5.7	6.9	8.3	7.7	6.2
8	6.5	6.1	6.9	6.0	6.0	6.1	5.2	5.4	5.6	7.4	7.9	8.2	6.4
9	6.8	7.0	7.2	6.2	6.8	6.3	5.3	5.9	5.9	7.8	8.1	8.4	6.8
10	6.4	6.4	7.5	7.0	7.3	6.9	5.7	6.2	6.9	8.1	8.0	8.9	7.1
11	7.1	7.1	8.0	7.5	7.6	7.4	5.9	6.4	7.4	8.4	8.4	8.6	7.5
12	7.7	7.6	8.8	8.3	8.3	7.5	6.2	6.6	7.8	8.6	8.7	8.6	7.9
13	8.3	8.2	8.6	9.0	8.7	7.9	6.7	6.7	7.9	8.8	8.9	8.7	8.2
14	7.9	8.7	9.1	9.3	8.9	8.2	6.9	6.9	7.8	9.0	8.7	8.6	8.3
15	8.5	8.7	9.4	9.1	9.1	8.3	7.0	7.1	8.2	8.9	8.9	8.8	8.5
16	7.9	7.7	9.1	9.0	8.7	8.1	7.0	7.6	8.0	8.3	8.7	8.2	8.2
17	7.5	7.6	8.6	9.1	8.6	7.9	6.7	7.3	7.8	8.0	8.6	7.9	8.0
18	7.5	6.9	8.2	8.9	8.3	7.8	6.6	7.2	7.5	7.2	8.3	8.3	7.7
19	7.5	6.9	7.8	8.1	8.1	7.2	6.3	6.9	6.6	7.1	8.0	8.4	7.4
20	7.3	6.8	7.0	7.1	6.9	6.4	5.9	6.3	6.0	6.4	8.1	8.1	6.9
21	7.3	7.1	7.3	6.6	6.5	5.8	5.5	5.9	5.7	6.7	8.1	8.1	6.7
22	7.5	6.7	7.0	6.5	5.9	5.5	4.9	5.6	5.6	6.7	8.4	8.4	6.5
23	7.5	6.7	6.9	6.3	5.5	5.6	5.0	5.6	5.5	6.9	7.8	7.9	6.4
Avg	7.3	7.1	7.6	7.1	6.9	6.4	5.6	6.0	6.4	7.4	8.3	8.1	7.0



Month	Aug 04 - July 05 m/s	Aug 04 - July 05 mph	Long-term Estimate m/s	Long-term Estimate mph
Jan	6.9	15.5	6.0	13.3
Feb	8.1	18.1	5.8	12.9
Mar	8.2	18.2	6.2	13.9
Apr	6.1	13.7	5.7	12.9
May	6.7	15.1	5.6	12.6
Jun	6.0	13.4	5.3	11.8
Jul	4.9	10.9	4.6	10.3
Aug	6.1	13.8	4.9	11.0
Sep	6.8	15.2	5.2	11.7
Oct	7.9	17.6	6.0	13.5
Nov	8.3	18.6	6.7	15.1
Dec	8.4	18.7	6.6	14.7
Avg	**7.0**	**15.7**	**5.7**	**12.8**

Figure 4. Monthly Average Wind Speeds at Wind Tower Site (26m Height)

As shown, the highest wind month is typically November and the lowest wind month is typically July. As shown below, the diurnal variation is more pronounced during the summer months than the winter months, with winds typically lowest in the morning and increasing in the afternoon.

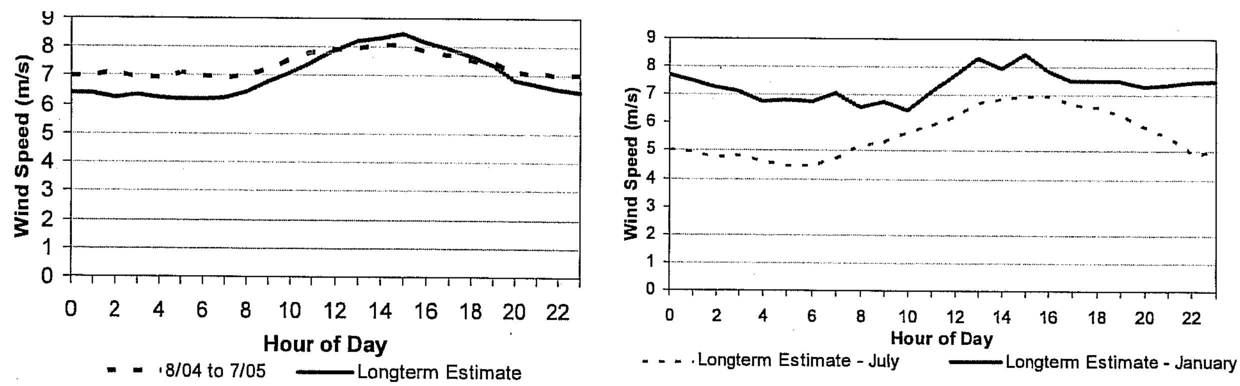
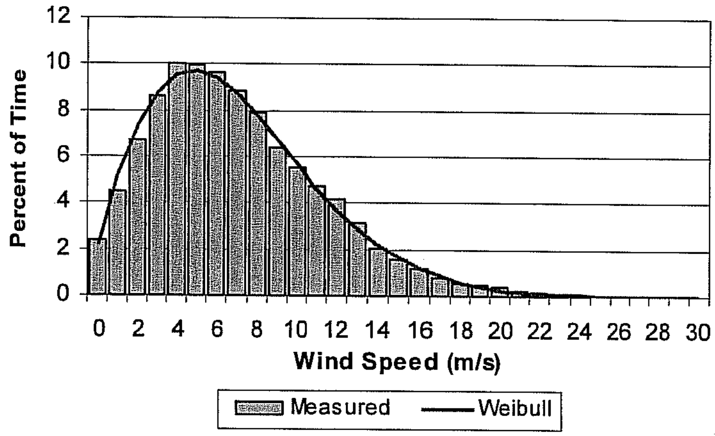


Figure 5. Hourly Average Wind Speeds at Wind Tower Site (26m Height)

A common method of displaying a year of wind data is a wind frequency distribution, which shows the percent of the year that each wind speed occurs. Figure 6 shows the measured wind frequency distribution as well as the best matched Weibull distribution (c = 8.3, k= 1.8).



Bin m/s	Measured Hours	Bin m/s	Measured Hours
0	209	15	136
1	392	16	102
2	589	17	69
3	752	18	47
4	881	19	39
5	872	20	32
6	846	21	22
7	777	22	12
8	690	23	6
9	559	24	5
10	483	25	3
11	414	26	1
12	370	27	1
13	276	28	0
14	177	29	0
		Total:	8,760

Figure 6. Wind Speed Frequency Distribution of Wind Tower Data

The cut-in wind speed of many wind turbines is 4 m/s and the cut-out wind speed is around 25 m/s. The frequency distribution shows that a large percentage of the wind in Port Heiden falls within this operational zone.

Table 6 shows the annual wind rose at the wind tower site versus the wind rose at the Port Heiden airport. The predominant wind energy direction at both the wind tower and the airport is SE, with summer winds coming from the SW.

Table 6. Annual Wind Rose for Wind Tower Site and Airport Site

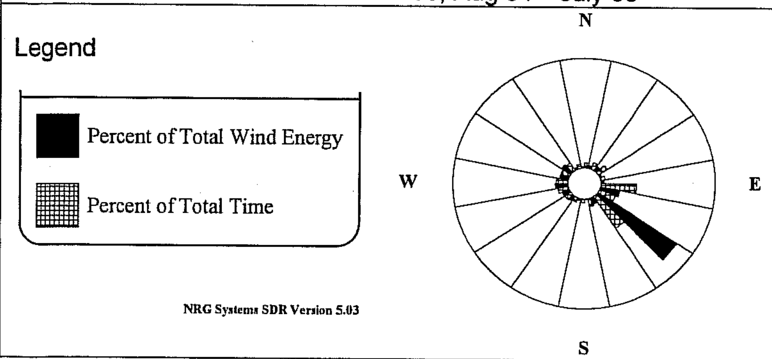
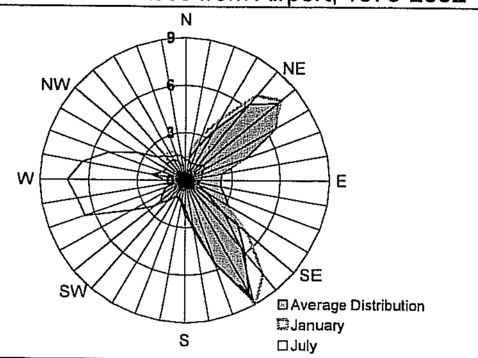
Met Tower Site Wind Rose, Aug 04 – July 05	Annual Wind Rose from Airport, 1973-2002
	

Table 7 breaks the annual wind rose at the wind tower site into monthly wind roses.

Table 7. Monthly Wind Roses for Wind Tower Site

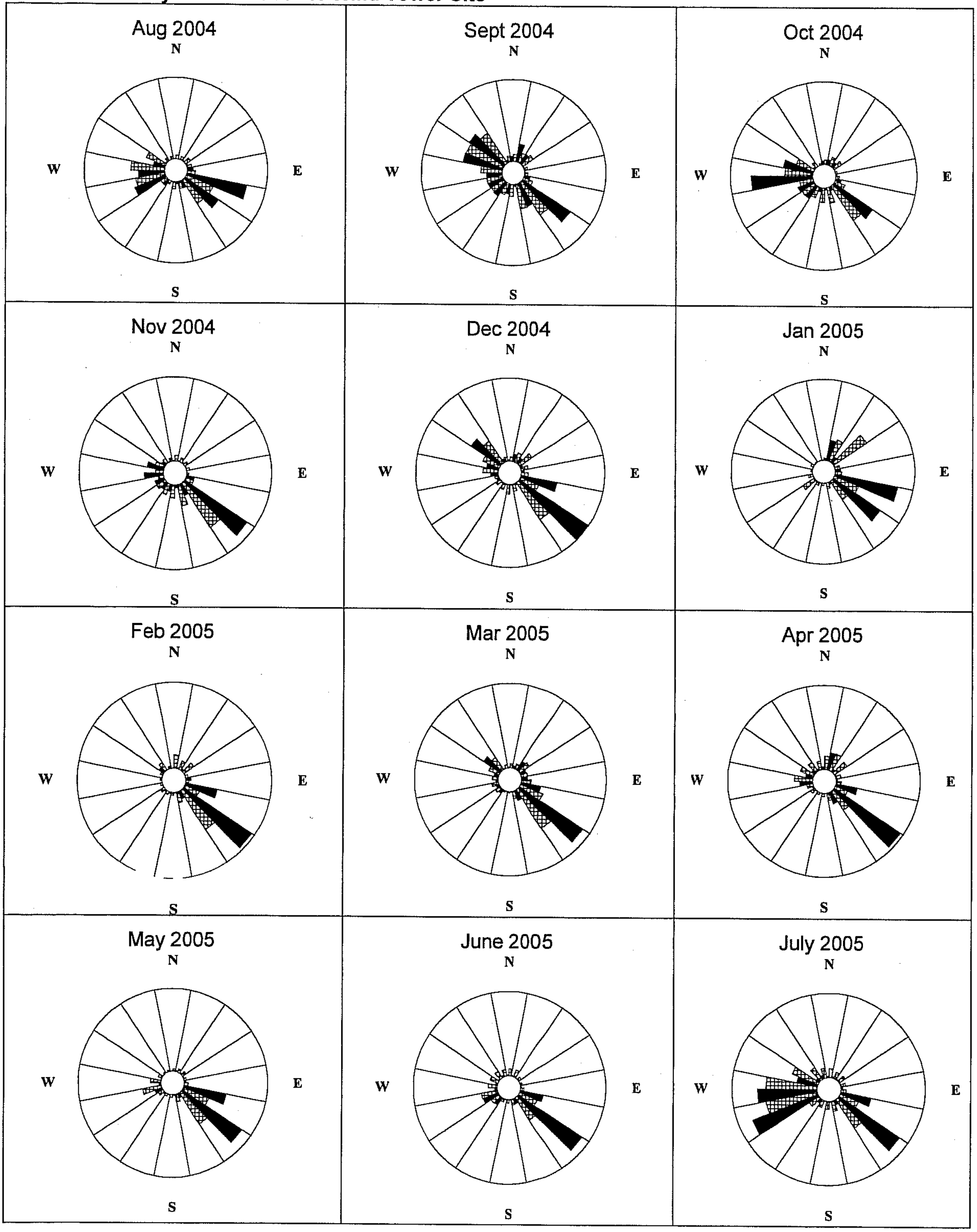
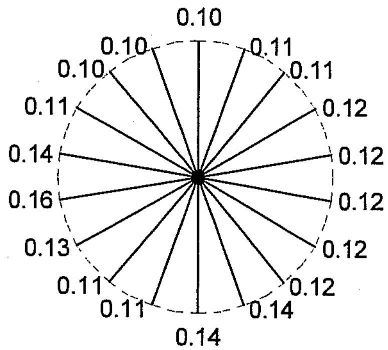


Table 8 summarizes the monthly turbulence intensity at the wind tower site. The turbulence intensity of 0.10 to 0.16 is considered moderate and unlikely to contribute to excessive wear of wind turbines.

Table 8. Monthly Turbulence Intensity at Wind Tower Site

Month	Turbulence Intensity
Jan	0.11
Feb	0.10
Mar	0.12
Apr	0.12
May	0.12
Jun	0.12
Jul	0.12
Aug	0.12
Sep	0.11
Oct	0.11
Nov	0.10
Dec	0.11
Annual Avg	**0.11**

Figure 7. Turbulence Intensity by Direction, Aug 2004 - July 2005



The air temperature can affect wind power production in two primary ways: 1) colder temperatures lead to higher air densities and therefore more power production, and 2) some wind turbines shut down in very cold situations (usually below -25°C). Since the temperature sensor at the wind tower was not functioning properly, the following information comes from data recorded at the Port Heiden airport weather station. Between January 2001 and August 2005, the temperature dropped below -25°C for about 1 hour and was below -20°C for about 13 hours.

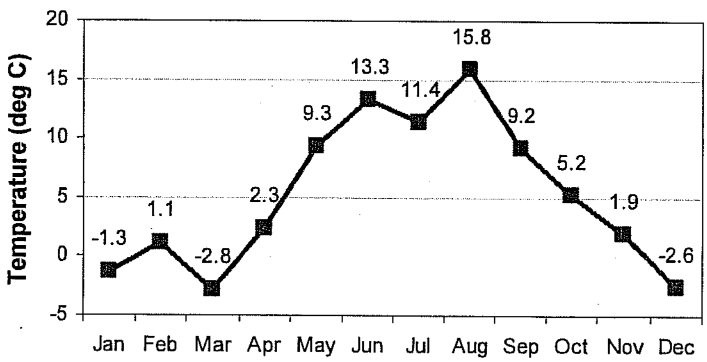


Figure 8. Monthly Average Temperatures in Port Heiden

POTENTIAL POWER PRODUCTION FROM WIND TURBINES

Table 9 lists a number of parameters used to characterize the power production potential of a particular site.

Table 9. Summary of Power Production Potential of Met Tower Site

Average Wind Power Density (30m)	490 W/m^2
Wind Power Class	5-6
Rating	Excellent

Various wind turbines, listed in Table 12, were used to calculate the energy production at the met tower site based on the long-term wind resource data set. Although different wind turbines are offered with different tower heights, to be consistent it is assumed that any wind turbine rated at 100 kW or less would be mounted on a 30-meter tall tower, while anything larger would be mounted on a 50-meter tower. The wind resource was adjusted to these heights based on the standard wind shear of 0.14. The wind resource was also adjusted for local air density. Table 10 summarizes the estimated energy production from various wind turbines at the met tower site.

Table 10. Gross Annual Energy Production from Different Wind Turbines at Met Tower Site (kWh)

Month	Proven 2.5kW	Proven 6kW	Bergey 10 kW	FL30	Entegrity	FL100	NW100	FL250	V27	V47
Jan	847	2,147	2,339	10,645	17,819	34,809	28,515	79,642	72,500	240,127
Feb	693	1,763	1,910	8,762	14,596	28,484	23,343	65,447	59,454	197,511
Mar	836	2,152	2,417	10,828	17,544	34,512	28,354	79,193	72,654	246,969
Apr	644	1,657	1,745	8,225	13,038	25,590	20,840	59,714	54,583	187,440
May	682	1,774	1,935	8,919	13,804	27,378	22,366	64,177	58,658	203,360
Jun	572	1,487	1,597	7,320	11,263	22,506	18,416	53,020	48,383	165,982
Jul	456	1,222	1,272	6,202	8,752	17,492	14,174	42,975	39,125	142,568
Aug	556	1,461	1,542	7,264	11,063	21,878	17,898	51,833	47,546	166,276
Sep	566	1,486	1,600	7,442	11,084	22,192	18,072	52,914	48,340	170,126
Oct	733	1,886	1,985	9,423	14,946	29,289	23,825	68,265	62,539	214,067
Nov	881	2,248	2,367	11,277	18,612	35,918	29,362	84,447	76,267	257,599
Dec	912	2,323	2,534	11,605	19,303	37,705	30,887	86,460	78,743	261,782
Annual	8,378	21,607	23,243	107,911	171,825	337,751	276,053	788,086	718,792	2,453,808
Annual kWh/m^2	853	878	573	782	956	950	949	1,108	1,204	1,339

Table 10 also lists the annual energy production per square meter of swept area (kWh/m^2). This allows one to directly compare the efficiency of one wind turbine against another, as shown in Figure 1.

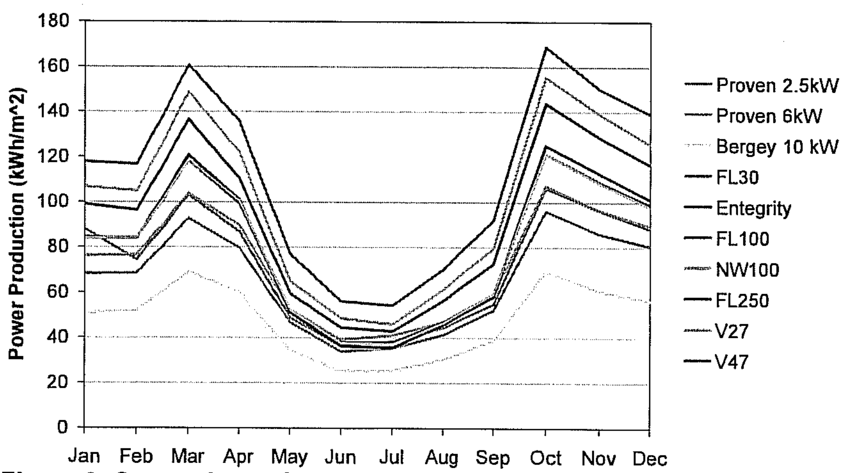


Figure 9. Comparison of Power Production per Square Meter of Swept Area from Various Wind Turbines

Table 11 summarizes the gross capacity factor of the wind turbines per month. Gross capacity factor is the amount of energy produced based on the given wind resource divided by the maximum amount of energy that could be produced if the wind turbine were to operate at rated power during that entire period. The gross capacity factor could be further reduced by up to 10% to account for transformer/line losses, turbine downtime, soiling of the blades, icing of the blades, yaw losses, and extreme weather conditions.

Table 11. Gross Capacity Factor of Different Wind Turbines at Met Tower Site

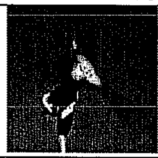
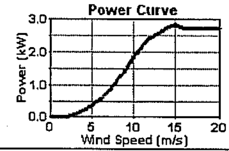
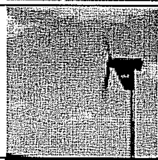
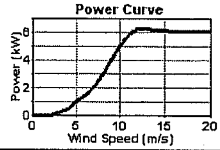
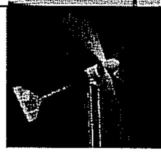
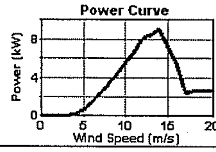
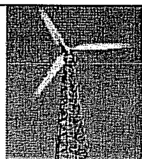
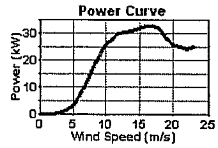
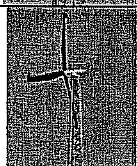
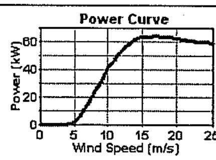
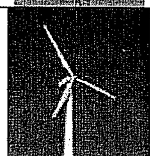
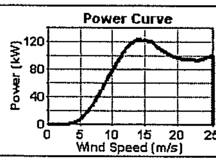
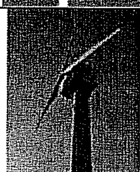
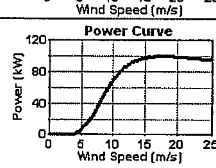
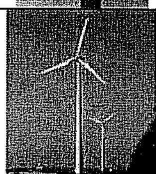
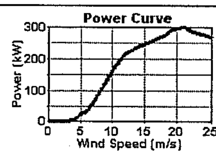
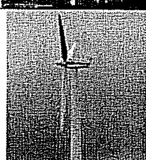
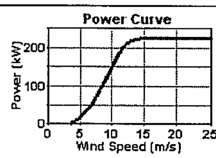
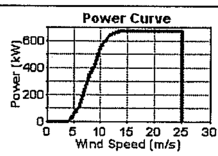
Month	Proven 2.5kW	Proven 6kW	Bergey 10 kW	FL30	Entegrity	FL100	NW100	FL250	V27	V47
Jan	46%	48%	31%	48%	36%	47%	38%	43%	43%	49%
Feb	41%	44%	28%	43%	33%	42%	35%	39%	39%	45%
Mar	45%	48%	32%	49%	36%	46%	38%	43%	43%	50%
Apr	36%	38%	24%	38%	27%	36%	29%	33%	34%	39%
May	37%	40%	26%	40%	28%	37%	30%	35%	35%	41%
Jun	32%	34%	22%	34%	24%	31%	26%	29%	30%	35%
Jul	25%	27%	17%	28%	18%	24%	19%	23%	23%	29%
Aug	30%	33%	21%	33%	23%	29%	24%	28%	28%	34%
Sep	31%	34%	22%	34%	23%	31%	25%	29%	30%	36%
Oct	39%	42%	27%	42%	30%	39%	32%	37%	37%	44%
Nov	49%	52%	33%	52%	39%	50%	41%	47%	47%	54%
Dec	49%	52%	34%	52%	39%	51%	42%	46%	47%	53%
Annual	38%	41%	27%	41%	30%	39%	32%	36%	36%	42%

CONCLUSION

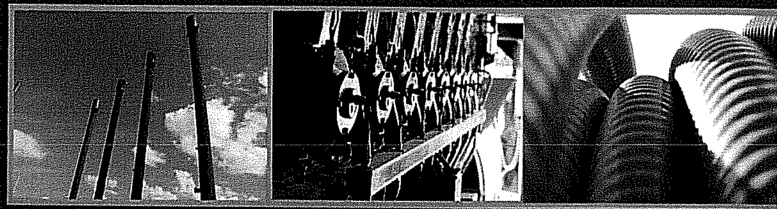
This report provides a summary of wind resource data collected from August 2004 through July 2005 in Port Heiden, Alaska. The data was compared to long-term trends in the area. Based on correlations with the long-term weather station at the Port Heiden airport, estimates were made to create a long-term dataset for the Port Heiden wind tower site. This information was used to make predictions as to the potential energy production from wind turbines at that site.

It is estimated that the long-term annual average wind speed at the wind tower site is 7.0 m/s at a height of 26 meters above ground level. Taking the local air density into account, the average wind power density for the site is 490 w/m^2. This information means that Port Heiden has a Class 5 to 6 wind resource, which is excellent for wind power development.

Table 12. Wind Turbine Models Used in Power Production Analysis

Proven 2.5 kW http://www.provenenergy.com			Tower Height: 30 meters Swept Area: 9.6 m^2 Turbine Weight: 190 kg
Proven 6 kW http://www.provenenergy.com			Tower Height: 30 meters Swept Area: 23.8 m^2 Turbine Weight: 500 kg
Bergey 10 kW www.bergey.com			Tower Height: 30 meters Swept Area: 38.5 m^2 Weight: not available
Fuhrlander FL30 30 kW www.lorax-energy.com			Tower Height: 30 meters Swept Area: 133 m^2 Weight (nacelle & rotor): 410 kg
Entegrity 66 kW www.entegritywind.com			Tower Height: 30 meters Swept Area: 177 m^2 Weight (drivetrain & rotor): 2,420 kg
Fuhrlander FL100 100 kW www.lorax-energy.com			Tower Height: 30 meters Swept Area: 348 m^2 Weight (nacelle & rotor): 2,380 kg
Northern Power NW100/19 100 kW www.northernpower.com			Tower Height: 30 meters Swept Area: 284 m^2 Weight (nacelle & rotor): 7,086 kg
Fuhrlander FL250 250 kW www.lorax-energy.com			Tower Height: 50 meters Swept Area: 684 m^2 Weight (nacelle & rotor): 4,050 kg
Vestas V27 225 kW (refurbished, various suppliers)			Tower Height: 50 meters Swept Area: 573 m^2 Weight: not available
Vestas V47 660 kW www.vestas.com			Tower Height: 50 meters Swept Area: 1,735 m^2 Weight: not available

TDX WIND REPORT
PORT HEIDEN, ALASKA



Wind Power Feasibility Study:

Port Heiden, Alaska

Submitted by:

TDX power
4300 B Street Suite, 402
Anchorage, AK 99503
(907) 278-2312

May 20, 2005

TDX power

Anchorage, AK Saint Paul, AK Philadelphia, PA

Port Heiden Wind Power Feasibility Study

Executive Summary:

This report supplements the Conceptual Design Review, prepared by the Alaska Energy Authority for a new diesel fueled power plant in Port Heiden, Alaska. Included in this report is a detailed model outlining various options for including wind power as a source of both electricity and heat in the new power plant. Low, medium and high penetration options are all addressed, with equipment options from two utility grade suppliers of wind turbines. In the high penetration model, excess electricity from the wind turbines would be used to create thermal energy and stored for immediate use for space heating or other beneficial application through a hot water storage and distribution system at the adjacent school.

Recommendations:

TDX Power recommends installation of a high penetration wind diesel hybrid plant in Port Heiden with a thermal recovery system integrated into the existing heating system at the school. While we acknowledge different perspectives on the economic analysis of such a project, it is clear to us this wind diesel configuration would produce the greatest potential future savings for the community, the greatest leverage against increasing fuel prices and other liabilities associated with diesel only generation, and flexibility for future electric and thermal load growth in the community.

Some specific components of this recommendation include:

- Three Northwind 100 wind turbines. While several aspects of the Fuhrlaender wind turbine appeal to us, including their industry experience in mass producing wind turbines in the competitive European market and their specific experience and track record producing and supporting both their 100 and 250 kw machines, the increased cost of this machine (primarily as a result of the Euro exchange rate) simply does not support its selection.

- Completion of a detailed geotechnical analysis is required to confirm the technical feasibility and construction cost estimates for this project.

- Negotiation of a firm support agreement from Northern Power, including clearly defined warranty and turbine support parameters and costs for the first three years.

- Negotiation of an EPC contract with appropriate guarantees for project milestones, timelines and budget.

TDX power

Anchorage, AK Saint Paul, AK Philadelphia, PA

Installation Cost, Operational Economics & Maintenance Considerations for a Wind Power System Addition to the New Port Heiden Diesel Power Plant

Background

The Alaska Energy Authority plans to supply a new diesel technology powerhouse to the village of Port Heiden for the purpose of improving the community's electric supply reliability and operating efficiency. The load following powerhouse will consist of a four-unit engine generator configuration with total nameplate capacity of 466 Kilowatts. Deploying engine generators rated at 192, 150, 86 and 38 Kilowatts, the AEA system is designed to match engine size to demand and provide significant redundancy for safety purposes. The AEA plant will comfortably meet the average annual community electric load of approximately 90 Kilowatts, accommodate off peak demand of approximately 70 Kilowatts and peak demand of approximately 180 Kilowatts through load sensing, automatic switchgear.

Coincidental to the planning process for the new Port Heiden diesel generating facility, the Alaska Energy Authority is interested to evaluate the cost and operating economics of integrating a wind energy generation component into the diesel power plant. The AEA is aware that this type of wind/diesel hybrid integration now has considerable case history experience in Alaska and throughout the world. Properly located and designed, hybrid technology has successfully demonstrated the ability to significantly reduce fuel use and powerhouse maintenance through reduced engine run time. In order to evaluate the cost-benefit of wind integration in the Port Heiden diesel plant, AEA commissioned TDX Power to provide a detailed analysis of the expense and effect of adding wind generation to the planned Port Heiden generating facility.

TDX Power is an Anchorage based engineering services and generation equipment provider and is the owner/operator of two regulated Alaska electric utilities, located in Sand Point and Prudhoe Bay. TDX also designed and constructed the largest high penetration, cogenerating wind/diesel system in Alaska, located on Saint Paul Island. The 500 Kilowatt Saint Paul hybrid plant has been awarded a variety of DOE innovation and advanced efficiency awards and has been successfully operational since 1999.

This report consists of five sections: 1) recommended hybrid system design, 2) projected installed cost of a wind generation system and its ancillary components, 3) projected impact of the wind generation system on the diesel plant's operating economics, 4) operations and maintenance program considerations and cost, and 5) final observations.

Summary Wind/Diesel System Design

The decision path for high, medium, or low penetration includes analysis of the wind resource, the forecasted electric load and analysis of potential uses for thermal energy. The attached economic model, which incorporates results from multiple turbine manufacturers and configurations suggests a high penetration design provides superior cost/benefit performance compared to low or medium penetration configurations and therefore focused its primary attention on it.

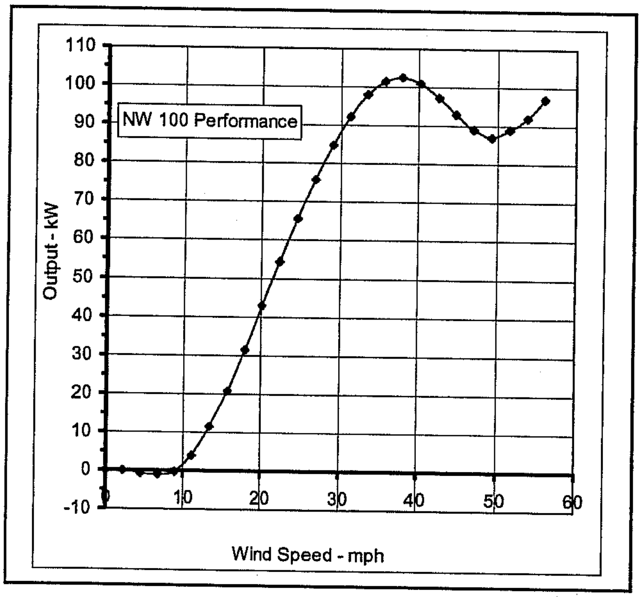
Comparison of an integrated wind diesel system to a diesel only powerhouse configuration was also performed. A diesel only operation is performed by setting the Wind Turbine Availability (note 15) to 0% and Diesel Jacket Water (note 14) also to 0%, (see Tab "Diesel Only") on "Analysis -Port Heiden Summary" file. Upon review of "Diesel Only" tab, the power required for the community is provided from the John Deere 6081H and 6068H Diesels. No jacket water is recovered, due to distance, some electric energy is used to keep the thermal tank at temperature during the school building heating seasons.

Based on this model, TDX Power recommends a high penetration wind diesel plant with coincident thermal energy generation design for the Port Heiden generating facility. The location's Class 5 rated wind resource provides the primary basis for this recommendation. In such a design, total wind generating capacity exceeds the community peak power demand by approximately 70 to 100%. Through such capacity and configuration, the engine generators will literally be shut off during periods of relatively high wind speed, defined as above 16 miles per hour. Additionally and importantly, during high wind periods the high penetration design will produce excess electric energy which is converted to thermal energy and stored for use as space heating or other beneficial application through a hot water storage and distribution system.

In a low penetration design, the diesel units must continue to run regardless of wind speed. The wind generators run in constant parallel with the diesel units, which only serves to reduce load on the diesel generators. Such a configuration produces no cogenerated by-product, such as hot water. And in medium penetration design, there is minimal production of a cogenerated by product and relatively little wind-only mode operations, which struggles to justify its investment. By sizing sufficient wind turbine generating capacity to have "wind only" generation periods, as well as the simultaneous production of a beneficial thermal product, the high penetration design produces far greater total fuel avoidance, lower engine maintenance expense, and superior long term total system operating efficiencies compared to the low or medium penetration system. Accordingly, TDX focused its analysis on the high penetration example.

As proven in the Saint Paul Island example, and dozens of similar high penetration wind/diesel installations around the world, the high penetration design functions with utility grade reliability and efficiency when properly designed, deployed and maintained. Such a system is relatively simple, using standard components. The primary building blocks of a high penetration system include the wind generation equipment, microprocessor based sensors that simultaneously monitor instantaneous load and wind speed, specialized switchgear that allow the diesels and wind turbines to function together either in parallel or singly, and a hot water storage tank with associated thermal energy delivery infrastructure.

A properly developed high penetration facility operates in diesel mode during periods of no wind, in wind-diesel parallel during moderate wind speed periods, and in full diesel-off, wind-only mode during wind periods of approximately 16 mph or higher. In a typical configuration, the electronic signal to commence wind-only mode occurs when the wind energy system is capable of producing approximately 120% of operating demand or a fixed incremental of output above the community load, for at least one hour. During these higher wind periods, the engine generator shuts off automatically and wind turbines follow community load and, in addition, supply excess energy to the water storage tank. In lower wind periods, the diesel generators supply intermittent charge to the water tank to maintain minimum temperature, typically set between 150 and 190 degrees Fahrenheit. The heated water can then be pumped through a piping and radiator network to supply space heating, or used in other beneficial community use application such as swimming pools or commercial activity. The excess-to-load wind energy offsets or eliminates heating fuel requirements.



The installation and operational cost analysis provided in this report is based on the integration of three Northwind 100 wind generators into the planned AEA diesel plant. While several aspects of the Fuhrlaender wind turbines appeal to us, including their industry experience in mass producing wind turbines in the competitive European market and their specific experience and track record producing and supporting both their 100 and 250 kw machines, the increased cost of their equipment simply does not support its selection.

TDX believes Northern Power and Fuhrlaender are the only manufacturers capable of supplying and after-sale supporting the type of small scale, high quality equipment appropriate for Port Heiden. Another producer of small wind turbines, Atlantic Orient Corporation, could also be considered for this project. However, after-sale support is often limited due to the Company's small size, and the turbine's downwind design is less than ideal for a high penetration configuration in Port Heiden due to high wind speed and turbulent conditions. Further, the AOC's lattice tower would probably create a variety of issues with the

Fish and Wildlife Service which could delay or perhaps ultimately prohibit the project's implementation. Beyond these three manufacturers, the world's leading wind machine vendors now only offer 750 Kilowatt class and larger equipment. In TDX's opinion, these units are far too large for village power application.

Wind System Installation Cost

TDX Power estimates a total cost of $1,446,000 to fully construct and integrate a three unit, Northwind 100 wind generation facility, with an associated thermal storage and delivery system. Following is an itemized breakdown of the major components included in the cost projection:

1. 3 Northwind 100 wind turbines = $765,000
2. Site construction = $450,000
3. Switchgear & controls = $190,000
4. Thermal storage and distribution infrastructure = $21,000
5. System components shipment from Seattle = $20,000

The cost analysis assumes three Northwind 100 machines, which would be supplied FOB the Port of Seattle and complete with all necessary subsystems including towers and controllers. TDX Power believes that the wind energy component of the new AEA power system must have at least 250 kilowatts of total gross capacity in order to achieve optimum wind-only mode, high penetration design results. As any less than three Northwind generators do not meet the capacity criteria, three are suggested and modeled.

The site construction estimate was supplied by Jim Saint George and includes turbine foundations. The construction estimate was based on certain assumptions such as piling design foundations, and assumptions of probable soil and subsurface aquifer conditions. While the cost estimate seems reasonable under the circumstances, TDX cautions that geotechnical work has not been completed at the probable Port Heiden location and subject to these further investigations, the construction cost estimate could change.

The switchgear cost estimate is based on TDX's assumption and recommendation of Kohler paralleling gear in a five section line up. This equipment contains circuit breakers and PLC based controls, a master control section and a section for feeder control. The Kohler system is controlled from a local touch screen and capable of remote operation via a standard WEB browser. The operator interface uses the Advantech touch screen for alarm display, alarm and status logging (500 events), user selectable remote alarms, digital synchronizer, digital real (KW) and reactive (KVAR) load sharing, system information and data display, manual synchronizing and operator control. The engine generator control cells, master section and sectionalizing cells are bussed together. The main buss is rated at 2,000 amps at a typical buss voltage of 480, 3-phase, 4-wire. The Kohler system has the ability to control and monitor a variety of diesel/generator equipment and provide operating personnel with the ability to operate in a total manual mode in the event of PC or PLC failure.

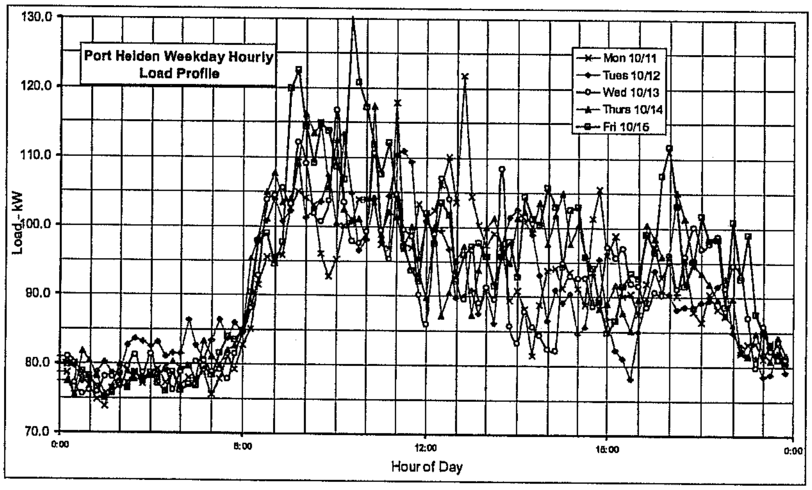
The thermal storage and hot water delivery system price is based on the assumption and recommendation of 8,000 gallons of storage capacity, to be located near or adjacent to the Port Heiden school boiler house. The cost estimate includes the insulated storage tank and all necessary piping and pumps to circulate water at an average temperature of 170 degrees F. The hot water in the storage tank will replace or considerably offset fuel oil use for the school's thermal requirements. The school and outbuilding thermal use heat use, from September 1 through May 31, was provided by AEA's Mia Devine.

Should a decision to pursue a low or medium penetration design be preferred, installation of one or two Northwind 100 turbines would decrease the installation costs. In addition to the savings on turbine costs, some savings would also be realized on site construction, and the switchgear and controls. TDX Power estimates the total installed capital costs for a low penetration system with only one turbine to be $746,000. Installation of a medium penetration system with two turbines would be $1,046,000.

A power plant site plan is attached in Appendix B with three turbines sited around the power plant. As previously referenced, the siting of the wind turbines is somewhat subjective at this point, pending a geotechnical evaluation. However, a rough estimate of where the wind turbines could be placed is included to provide a general idea of distances. Both Northern Power and Fuhrlaender wind turbines should have the minimum 2 1/2 - 3 rotor diameters between them, and no less than 10 diameters downwind. Based on data provided by AEA, we have assumed the prevailing winds are westerly, south westerly.

Economic & Operational Impact of Wind Integration

TDX's analysis of the effect of wind generation on the planned Port Heiden diesel plant was based on a full year of local met tower wind speed measurement. TDX was limited by partial data for community load analysis. AEA supplied detailed load figures for, essentially, the month of October. Through this incremental data, however, TDX was able to create a multiplier formula which allows the October data to be extrapolated over an entire year with good accuracy.



Accompanying and integral to this report is a detailed spreadsheet model that calculates and presents the operational and economic impact of the Northwind 100 based wind generation system on the AEA Port Heiden diesel plant. The information contained in the spreadsheet represents the bulk of TDX's analysis for this assignment and should be studied carefully. Again, the results presented in the spreadsheet are based on extrapolating a months worth of community load data. The information which follows in this section summarizes certain data extracted from the spreadsheet. To see the full presentation, all associated methodology and the support data, please refer to the CD which accompanies this report.

Following is a summary of the methodology TDX used to reach its conclusions:

For the diesel plant analysis, TDX obtained performance data from John Deere for the units being deployed by AEA in Port Heiden. TDX calculated partial loading fuel consumption by unit from OEM data and TDX's own heat rate analysis, then determined engine generator load following sequencing through professional judgment of best economic operating strategy. To create the operational and associated economic model of the AEA diesel plant when it is fully integrated with the wind energy component, TDX assumed the AEA facility would cycle and sequence its engine generators as follows:

- When required diesel load is > 97 KW, the 192 KW machine is used
- When required diesel load is 38 to 97 KW, the 150 KW machine is used
- When required diesel load is 23 to 38 KW, the 86 KW machine is used
- When required diesel load is 23 to 9 KW, the 38 KW machine is used

Port Heiden High Penetration Wind-Diesel System
Summary of Equipment Use

Unit Number	Operating	Manu-facturer	Model	MWH	Run Hours	Number Starts	Avg Output kW	Avg Loading
Diesel Generators								
Unit 1	Yes	J Deere	6081H	237.4	2,166	572	109.6	57.2%
Unit 2	Yes	J Deere	6068H	259.6	3,365	907	77.1	51.4%
Unit 3	Yes	J Deere	4045H	11.1	366	285	30.4	35.3%
Unit 4	Yes	J Deere	3029T	4.7	289	225	16.4	43.0%
			Total	**512.9**	**6,186**	**1,989**		
Wind Turbines								
Unit 1	**Yes**	Northern Power	NW 100	240.3	6,035	NA	39.8	38.8%
Unit 2	**Yes**		NW 100	239.7	6,029	NA	39.8	38.8%
Unit 3	**Yes**		NW 100	239.7	6,029	NA	39.8	38.8%
		Total		**719.6**	**6,031**	**Over**	**8760**	
Percent of total system				58.4%	68.8%			

AEA provided 10 minute incremental wind speed data over the entire year. TDX reviewed establish hourly wind speed averages and potential speed variation. The wind turbine electric production for each operating hour, along with the probable instantaneous variation (increase or decrease) in output, was obtained from Northern Power 100/19 output performance curve [page 4] via a "Lookup" function within the spreadsheet.

The Port Heiden community electric demand data was supplied by AEA. The data was broken down by 15 minute increments covering the timeframe from October 7, 2004 through October 28, 2004. From this, TDX determined one hour average demand averages with potential instantaneous variation, increase or decrease, in demand. TDX then determined an hourly demand multiplier for each hour of each day for a typical weekly period. Monthly variations, relative to October, were determined based on generation figures for Port Heiden from PCE program records over the past 10 years. TDX then compared hourly village demand to the coincidental turbine output.

The overall TDX analysis logic assumed: 1) During periods of no wind, total power is supplied by the diesel generators, which also supply as-necessary intermittent charge to the thermal tank to maintain desired water temperature range. 2) In wind-diesel mode, additional load above village demand is provided based on the potential wind turbine output decrease due to normal real time variations and the desired preset margin. 3) The system's switch to wind-only mode occurs when excess wind generation (compared to actual village load) is greater than the suggested preset margin, approximately 120% of measured load, plus the potential wind turbine output decrease due to normal real time variations. 4) In wind-only mode all excess turbine generated energy is sent to the thermal storage tank.

Following is a summary of TDX's modeling results for total integrated hybrid system operations:

- Diesel only operations will consume 63,937 gallons of fuel oil annually, with total diesel plant production of 871.9 megawatt hours.
- Fully integrated with the three wind generators, the diesel operations consumption will be reduced to 38,214 gallons annually and total diesel plant production will be reduced to 514.4 megawatt hours.
- The hybrid integration reduces powerhouse fuel use by 40%.

Following is a summary of TDX's modeling of the output of each diesel engine generator when operating with the wind component:

- For the 192 KW rated Unit 1, total annual run hours = 2,226 with average output KW of 109.6, resulting in average engine loading of 57.2%.
- For the 150 KW rated Unit 2, total run hours = 3,305 with average output KW of 77.1, resulting in average engine loading of 51.3%.
- For the 86 KW rated Unit 3, total annual run hours = 285 with average output KW of 30.4, resulting in average engine loading of 35.3%.
- For the 38 KW rated Unit 4, total annual run hours = 289 with average output KW of 16.4, resulting in average engine loading of 43%.

The high penetration design allows excess energy production relative to village load during high wind speed periods. Again based on a full year, following is the amount of excess energy which would be diverted to the thermal storage tank:

- Total wind energy contribution to the thermal storage tank = 1239.9 mmBtu's
- Equilavent gallons of heating fuel supplied frm wind energy = 11,653
- Net Gallons of heating fuel offset by the wind energy contribution = 11,037

TDX assumes that all the thermal energy can be consumed throughout the school year. However, thermal energy is not provided during the summer months as designated by the data provided by Mia Devine. Energy from normal or excess power wind, Diesel and/or jacket water requires dissipation by other means during this period. As a result, during non-heating season, no energy saving credit is taken for thermal tank. Further, during the heating season, no excess thermal energy above the hourly requirement is sent to the thermal tank. Essentially this means the program does not store energy if there is a deficit preceding it. Thermal energy, as required by the school and out buildings is consumed on an instantaneous hourly basis

Summary of High Penetration Wind-Diesel System					
	Fuel Use		Electric	Thermal Tank	
	Gallons	mmBtu	MWH	mmBtu Delivered	Gallons Reduction Note 18
Diesel Generation Only					
Diesel Engines	63,937	8,504	872	66	616
Assumed no jacket water recovery					
Wind-Diesel System					
Diesel Units	38,109	5,068	513		
Wind Units	0	0	720	-	
Total	38,109	5,068	1,232	1,238	11,631
Savings	**25,828**	3,435	**359.1**	**1,172**	**11,015**
% Saved	**40.4%**	**40.4%**			
Total Annual Fuel Savings		**36,844 Gallons**			

The TDX model for the full year shows that adding the gross rated 300 Kilowatt wind energy component to the AEA Port Heiden diesel plant would provide generating fuel savings of 40%, a reduction of projected consumption from 64,000 gallons to 38,000 gallons. In addition, the model shows the wind component would contribute a total of 719.6 megawatt hours, the equivalent of 11,653 gallons of fuel, to the thermal tank.

Operations and Maintenance

TDX expects that reduction of engine run time will have generally commensurate and proportional effect on diesel powerhouse maintenance expense. At minimum, the run time reduction caused by the contribution of the wind energy component will extend the otherwise expected intervals for scheduled, preventative top and bottom end inspections and maintenance.

O&M specific to the wind generation system, however, creates a new and critical category of operational responsibility and expense. Without a systematic preventative maintenance regime for the wind generators, performed by a knowledgeable and conscientious technician, TDX doubts the long term viability of such a project in Port Heiden. Although TDX is confident that the Northwind 100 is an advanced design capable of sustained duty in harsh environments, constant observation, basic care and the ability to immediately address alarm conditions is mandatory.

In TDX's experience in similar climate conditions, gearbox failure is the most common cause of catastrophic turbine failure and unscheduled downtime. This will not be a factor if AEA uses the Northwind 100 as it uses a variable speed direct drive synchronous generator which eliminates a gearbox interface to the alternator. This arrangement should simplify the O&M program. Additionally, as the Northern units produce synchronous power, their use in this project would eliminate the need for a synchronous condenser, which is commonly used in hybrid designs to condition power produced by induction machines. Elimination of the condenser not only eliminates a key maintenance item, it eliminates approximately 15 Kilowatts of system parasitic load. These features of the Northern turbine will reduce operations complexities and some costs, but will in no way negate the need for systematic O&M procedures.

The key component of a successful maintenance program is human. TDX strongly suggests that someone within the Port Heiden community be identified to address this job scope. The person needs to be of sufficient health to be able to routinely climb the towers, but otherwise age or gender should make no difference. Experience in the power generation field or experience with sophisticated equipment should not be a factor. TDX believes the main ingredients required to create a capable plant operator are attitude and training. The person who will succeed will want the job and the responsibility, and will be enthusiastic about learning. With the right person, TDX believes that approximately three weeks of factory training and two weeks on site training will enable the trainee to begin functioning professionally.

From such a beginning, based on TDX's experience with similar situations, the operator will require between one and two years of steady support, which in most cases can be provided by telephone. Such ongoing contact increases operator confidence, improves system performance and pays long term dividends in lower costs and less unscheduled downtime. Northern Power, TDX or a variety of other experienced companies could provide these support services at minimal expense. Ideally, the wind plant operator would also be responsible for the entire hybrid plant, including its thermal component. TDX estimates that such an employee would expect an annual salary in the $40,000 to $50,000 per year range.

In addition to training and support programs, TDX recommends an inventory of spare parts be maintained in Port Heiden. Also, equipment manufacturers publish rigid service interval recommendations, and strict observance is the key to reliability. On site spares are vital, and the inventory contributes to the operator's understanding of how equipment is actually being used.

TDX suggests that the type and quantity of spares on-hand should target equipment that is either subject to high stress cycles or equipment that significantly contributes to the system's peak performance and reliability. These target areas include:

- Critical engine and control system spares
- Engine control and master control cells
- Distribution feeder cell spares
- Wind turbine and ancillary control system spares
- Thermal storage system spares

Equipment failure is most likely to occur during initial start-up through approximately the first years' operation. Repair and most parts will be covered by manufacturer's warranties in this timeframe and the spares inventory should be adjusted based on events, experience and trends. Operations through the second and third year typically involve scheduled component change, which should follow the recommended protocol specified by the manufacturer. As is typical with virtually all new power plants, the most critical time is the fourth and fifth year of operation. During this prone-to-failure period the parts inventory should be thoughtfully adjusted to address general local experience and historical failure trends.

TDX suggest a budget of $12,800 for an adequate spare inventory covering the first full year of Port Heiden hybrid operations.

Final Observations

TDX based its modeling on the Northwind 100 in a three unit configuration as this level of turbine capacity created optimized fuel savings performance in wind-only mode. If the AEA wishes to see a one or two machine performance profile, the attached model allows for these configurations.

The price of the Northwind machine was surprising. TDX paid approximately $350,000 for the 225 Kilowatt Vestas V27 deployed in its Saint Paul project, equal to $1,555 per installed nameplate Kilowatt. (The V27 is no longer made as Vestas is now focused on megawatt class machines for application in major scale, grid connected wind farms.) The Northern quote for the Northwind 100 is equivalent to $2,550 per nameplate Kilowatt. However, perspective was gained when TDX researched the list price for the Fuhrlaender turbines, in both the 100 and 250 Kilowatt size. The price of the Fuhrlaender 100 was $379,764, equivalent to $3,797 per Kilowatt. The Fuhrlaender 250 price was $520,411, or $2,122 per nameplate Kilowatt.

Finally, AEA will note that TDX assumed full turbine availability in its analysis. From TDX's experience on Saint Paul Island, such reliability is quite achievable with first class equipment and a dedicated, conscientious O&M regime.

Appendix A: Notes to Spreadsheets

Each of the four spreadsheets supplied by TDX to AEA begin with extensive descriptive notes. Following are general comments on these notes, which track the Note numbers of the submission:

Note 1: Hourly wind data provided by AEA, adjusted to wind turbine height of 30 m for generic 8760 hour year.

Note 2: Port Heiden community load data provided by AEA. Typical variation by day and hour for a week was determined and used as a predictor for weekly use. [See Table 1]

Note 3: Similar to Note 2 above. The monthly variations were obtained from Port Heiden PCE data over ten years and used to determine the monthly variation. The variation was then applied to the respective months. October, 2004 is used as the base period.

Note 4: Holidays used are New Years Day, Memorial Day, July 4th, Labor Day, Thanksgiving, and Christmas Day.

Note 5: Variability of wind is used to place a value on the potential drop (change) in wind turbine output due to a drop in wind speed. The potential loss in power is added to the Diesel operating load, during wind-diesel combined operation mode, to make sure the Diesel engines can provide required power to the community, should the turbine output instantaneously drop the variable amount. Ten minute wind data from the initial 4231 hour data file was reviewed and analyzed. TDX determined that the turbine output varied by approximately 12.3 percent of its average load.

Note 6: A multiplier is added to simulate potential community load growth . The percentage increase is an input value.

Note 7: Operating Margin is the "safety factor" above which the wind turbines need to produce power before the diesels are allowed to shut down. The operating margin in kW is an input value.

Note 8: Minimum time for diesel to run is one hour.

Note 9: Turbine parasitic load accounts for electrical switchgear and/or synchronous condenser load. The Northern 100 is the net output, while the Fuhrlaender output does not include probable synchronous condenser losses. The parasitic load in kW is an input value.

Note 10: Heat loss from thermal tank of approximately 10,000. TDX calculated the heat loss from an 8,000 gallon tank (8 ft diameter and 21 ft long) with three inches of fiberglass insulation at an average temperature of 180 °F. This is converted to an electrical load and used to maintain (overcome) losses during the heating season. The load is added to the required Diesel Operating Load when the wind-diesel system is operating in Diesel Only mode during the heating season. The heat loss in Btu/hr is an input value.

Note 11: Describes the logic of determining Diesel Operating Load.

Note 12: School and outbuilding thermal load. This information was received from Mia Devin of AEA. Data is also used as a test to determine the maximum excess energy allowed to be supplied to the thermal system..

Note 13: Describes the logic of supplying heat to the thermal tank.

Note 14: The value is used to estimate jacket water energy available to supply energy to the thermal tank. No information is available for jacket water energy from the John Deere units, so a representative value based on fuel input is used. The percentage is an input value.

Note 15: Wind turbine availability or degradation provides a way to reduce output from the wind turbines. The availability percentage is an input value.

Note 16: Describes method of providing diesel engine fuel. A part load fuel use antilogarithm was determined for each of the four John Deere engines, based on performance data obtained from John Deere for these engines.

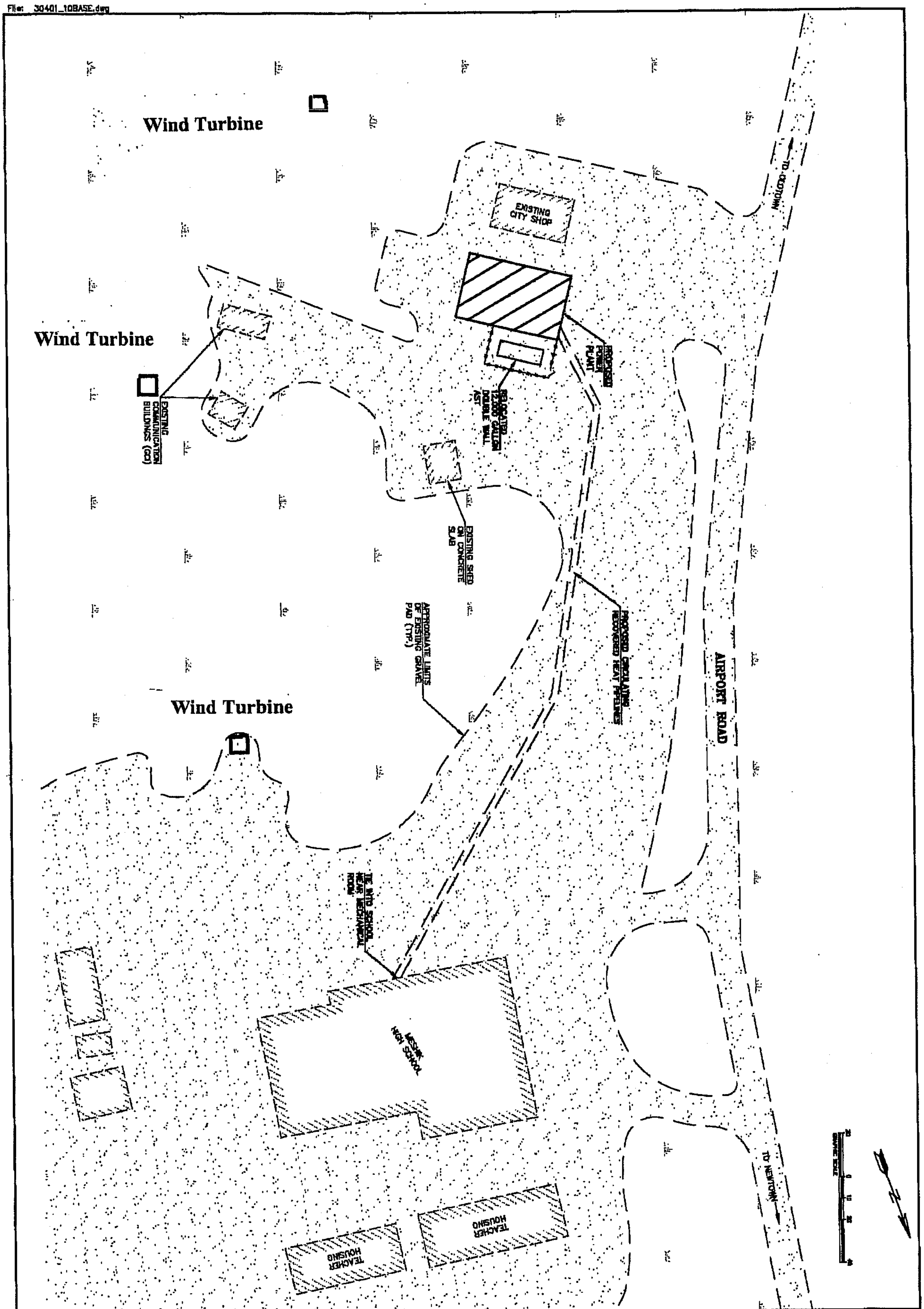
Note 17: Provides energy value of fuel oil for diesel operation and building heating. The Btu values per pound and per gallon (lower heating value basis) are input values.

Note 18: Provides an estimate of the school boiler efficiency. This is used to determine the gallons of fuel saved for the thermal tank part of the "Summary Table." The efficiency is an input value.

Note 19: Self description of major changes in model revision.

Appendix B: City of Port Heiden Power Plant Site Plan

File: 30401_10BASE.dwg



Sheet No.				
C1	Project No. 30401.10	REV / DESCRIPTION / BY / DATE	CITY OF PORT HEIDEN	CRW ENGINEERING GROUP LLC
SHEET 1 OF 4	Date AUGUST 2004		POWER PLANT SITE PLAN	State of Alaska Department of Community and Economic Development AIDEA/AEA Rural Energy Group 813 West Northern Lights Blvd. Anchorage, Alaska 99503
	Designed			ALASKA
	Drawn JAM			
	Approved			

AEA ECONOMIC ANALYSIS
WIND / DIESEL HYBRID SYSTEM
PORT HEIDEN, ALASKA

Economic Modeling of the Potential Wind-Diesel System in Port Heiden using HOMER

INPUTS

Project Lifetime

The economic lifetime of the project is assumed to be 20 years.

Diesel Fuel

The cost of diesel fuel is assumed to remain at a constant $2.00/gallon rate over the life of the project. HOMER is not able to model a fuel inflation rate at this time.

No economic value is applied to the diesel fuel that is used to heat the school since it is unknown whether or not the school will pay for heat recovered from the power plant or the wind turbine dump load.

Diesel Generators

The following table lists the cost and timing of major overhauls of the diesel generators. Minor overhauls are not included in the model; however, an hourly O&M cost is calculated based on the cost of regular oil changes and minor repairs. With this economic setup, there are no replacement costs of the diesel gensets, they simply continue to receive major overhauls throughout the life of the project.

Diesel Model	Major Overhaul Cost	Major Overhaul Period	O&M ($/hour of operation)
JD 86 kW	$20,000	15,000 hours	$5
JD 150 kW	$25,000	15,000 hours	$5
JD 192 kW	$70,000	25,000 hours	$5

The installed cost of the diesel power plant is input as a fixed system cost, since it will be included regardless of the number of wind turbines installed. A total cost of $1,800,000 is used.

Wind Turbines & Related Components

The table below lists the total installed cost and annual O&M cost of various wind turbine scenarios. The wind turbine models are the Northern Power Northwind100 (NW100), the Fuhrlander 100kW (FL100) and the refurbished Vestas (V27).

Wind Turbine Type and Number	Capital Cost of Wind System	Annual O&M Cost
1 x NW100	$565,000	$5,000/yr
2 x NW100	$970,000	$10,000/yr
3 x NW100	$1,400,000	$15,000/yr
1 x FL100	$650,000	$5,000/yr
2 x FL100	$1,200,000	$10,000/yr
3 x FL100	$1,750,000	$15,000/yr
1 x V27	$650,000	$20,000/yr

Interest Rate

The annual real interest rate (discount rate) is set at 3%.

Inter-annual Fluctuations in Assumptions

HOMER assumes that the electric load, thermal load, and wind resource will not change from year to year. HOMER is therefore modeling a typical year of data and basing its lifecycle economics on the results of that year. This tends to be a conservative method because if the village load grows, excess electricity from the wind turbines would displace the more expensive electric energy rather than the less valuable thermal energy.

OUTPUTS

Power Performance

The table below summarizes the power production and fuel consumption of each of the proposed power systems. Note that HOMER only allows 3 diesel generators, so the smallest generator was left out of the model. This isn't expected to have a significant impact on the results.

	MWh Generated				Fuel Use (gal)		Fuel Savings (gal)		Diesel Generator Hours of Operation				
Power System	Wind turbines	192 kW genset	150 kW genset	86 kW genset	Power Plant	School	Power Plant	School	192 kW genset	150 kW genset	86 kW genset	38 kW genset	Total
Diesel-only w/ heat recovery	0	462	384	0	62,300	4800	0	7,700	4,281	4,479	0	-	8,760
1 x NW100	242	180	397	33	46,000	6,800	16,300	5,700	1,689	5,395	1,671	-	8,755
2 x NW100	484	149	303	31	36,600	5,700	25,700	6,800	1,397	4,094	2,033	-	7,524
3 x NW100	727	138	257	27	31,900	4,800	30,400	7,700	1,291	3,435	1,707	-	6,433
1 x FL100	340	150	348	39	40,800	6,900	21,500	5,600	1,413	4,723	2,579	-	8,715
2 x FL100	680	116	272	29	31,700	4,900	30,600	7,600	1,088	3,689	1,884	-	6,661
3 x FL100	1020	101	237	23	27,400	4,200	34,900	8,300	950	3,214	1,593	-	5,757
1 x FL250	760	98	260	28	29,400	4,800	32,900	7,700	922	3,636	1,834	-	6,392
1 x V27	665	6	348	62	31,700	5,000	30,600	7,500	45	4,069	2,460	-	6,574

Economics

The table below shows the economic results of each system configuration based on the assumptions described above.

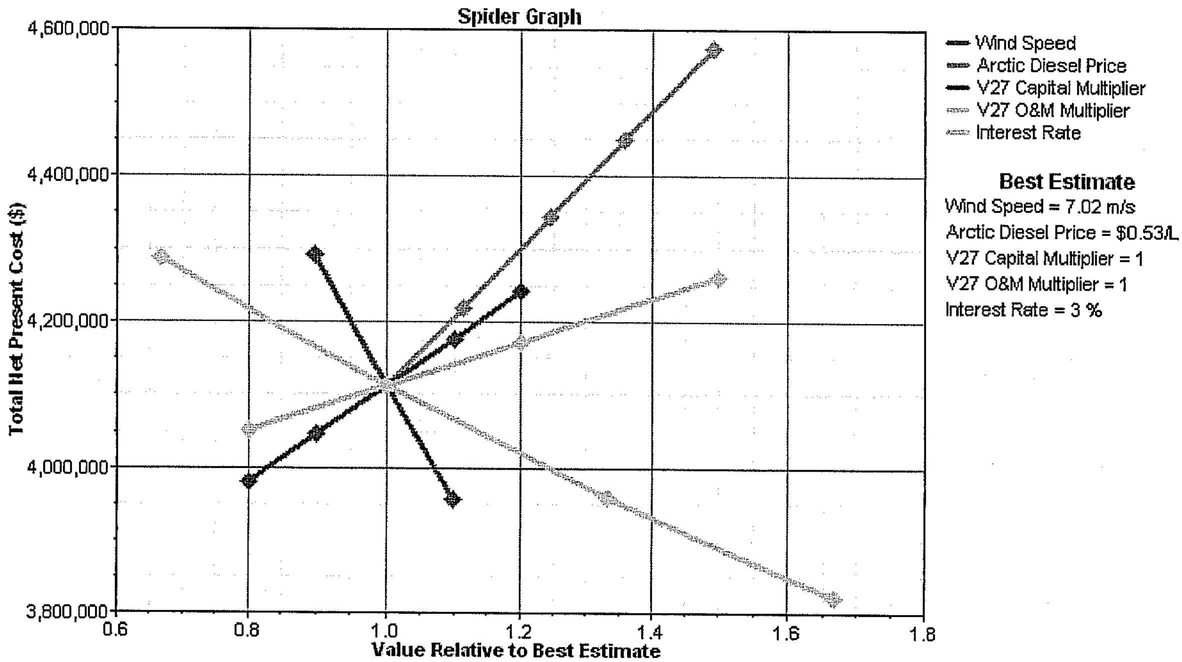
System Description	Initial Cost	Net Present Value of Costs
Diesel-only	$1,650,000	$4,320,000
1 x NW100	$2,340,000	$4,570,000
2 x NW100	$2,690,000	$4,600,000
3 x NW100	$3,100,000	$4,830,000
1 x FL100	$2,300,000	$4,370,000
2 x FL100	$2,850,000	$4,510,000
3 x FL100	$3,400,000	$4,920,000
1 x V27	$2,300,000	$4,110,000

As shown, the wind-diesel system utilizing the refurbished V27 wind turbine results in the lowest net present cost.

There are a number of benefits of the wind-diesel system that are not included in the economics, which may make the wind-diesel more appealing. These benefits include reduced emissions, less vulnerability to fluctuations in the price of fuel, reduced diesel fuel storage requirements, the potential value of thermal energy to the school, the potential sale of green tags, and adding to the experience and knowledge base of wind-diesel systems in Alaska.

Sensitivity Analysis

The spider graph below illustrates how the net present cost of the Vestas V27 case is affected by changes in the input variables. The point where all the lines intersect represents the net present cost of the most likely scenario based on the best estimate of all the variables.



As shown, the net present cost is most sensitive to the wind resource and the price of diesel fuel. In order for the wind-diesel system to have a higher lifecycle cost than the diesel only system, the wind resource would have to be 10% less than expected, the installed cost of the wind turbine would have to be 30% greater than expected, the O&M cost would have to be about 60% greater than expected, or some combination of these situations would have to occur.

APPENDIX E

CONSTRUCTION COST ESTIMATE

APPENDIX F

CONSTRUCTION COST ESTIMATES

	COST CATEGORIES													
	MATERIALS AND FREIGHT							LABOR				RENTAL		
TASK	ITEM	QTY	UNIT COST	MATL COST	UNIT WEIGHT	TOTAL WEIGHT	FREIGHT COST	CATEGORY	MAN HR	UNIT COST	LABOR TOTAL	RATE (MONTH)	COST	TASK SUB-TOTALS
1- Mob and Demob Task Description: Mob and demob covers all consolidation, barge loading and off loading, camp setup and staging of materials on site. This task will take approximately 2weeks.								Operators (2) Truck Drivers (1) Laborers (2)	240 120 240	$60 $60 $60	$14,400 $7,200 $14,400			Material $0 Freight $0 Labor $36,000 Rental $0 **Item 1 Total - $36,000**
2- Gravel Pad and Concrete Pedestal Foundation Task Description: Items will include all earthwork required to provide a stable gravel foundation pad, fabrication and placement of concrete foundation pedestals. This task will take approximately 1 week.	Pre-Cast Concrete (CY) Gravel Royalties- Foundation and Access Road	3 100	$500 $2	$1,500 $200	4000	12000	$7,200	Operators (1) Truck Drivers (1) Laborers (2)	60 30 120	$60 $60 $60	$3,600 $1,800 $7,200			Material $1,700 Freight $7,200 Labor $12,600 Rental $0 **Item 2 Total - $21,500**
3- 14' x 38' Modular Power Plant Fabrication and Field Erection* Task Description: Item will include fabrication of the module in Anchorage, setting the module, securing the module to the concrete pedestals, and performing all electrical and mechanical tasks necessary for startup. The field work portion of thel task will take approximately 2 week.	Lump Sum	1	$472,500	$472,500	60000	60000	$36,000	Fabrication Field Setup: Operator (1) Laborer (2) Electrician (1)	1100 120 240 120	$75 $60 $60 $85	$82,500 $7,200 $14,400 $10,200			Material $472,500 Freight $36,000 Labor $114,300 Rental $0 **Item 3 Total - $622,800**
4- Power Plant Fuel Storage and Delivery System Task Description: This item will include relocating an existing 12,000-gallon AST from the existing powerplant to the new site, plumbing the tank to the module and installing fence and signage. This task will take approximately 1 week.	Timber Pipe Supports Fence	10 120	$30 $45	$300 $5,400	35 10	350 1200	$210 $720	Operator (1) Welder (1) Laborers (2)	20 30 120	$60 $75 $60	$1,200 $2,250 $7,200			Material $5,700 Freight $930 Labor $10,650 Rental $0 **Item 4 Total - $17,280**
5- Distribution System Upgrades Task Description: This item will include installation new primary and secondary voltage buried conductor, new transformers and residential meters and other system repairs as necessary. This task will take approximately 4 weeks.	New Primary Conductor (ft) New Secondary Conductor (ft) 3-phase transformers 1-phase transformers Meters (50% of Existing)	3,000 1000 5 13 30	$50 $50 $6,000 $3,000 $500	$150,000 $50,000 $30,000 $39,000 $15,000	1 1 1000 600 75	3000 1000 5000 7800 2250	$1,800 $600 $3,000 $4,680 $1,350	Lineman (1) Operator (1) Laborer (1)	240 240 240	$85 $60 $60	$20,400 $14,400 $14,400			Material $284,000 Freight $11,430 Labor $49,200 Rental $0 **Item 5 Total - $344,630**
6- Miscellaneous**	Crew Per Diem (md) Crew Housing (mo) Superintendent Equipment Rental (mo) Tracked Excavator Wheeled Loader (966) Dozer (D6) Articulated Dump Drum Compactor Equipment Shipping- Naknek to Port Heiden* Equipment Shipping- Port Heiden to Naknek* Fuel Tool Rental Consumables	360 3 1 1 1 1 1 1 1 1 3 1	$40 $4,000 $10,000 $5,000 $5,000	$14,400 $12,000 $10,000 $15,000 $5,000	 70000 50500 45000 45000 25000	 70000 50500 45000 45000 25000	 See Below See Below See Below See Below See Below $40,000 $40,000		 720	 $95	 $68,400	 $12,000 $9,000 $7,000 $10,000 $5,000	 $12,000 $9,000 $7,000 $10,000 $5,000	Material $56,400 Freight $80,000 Labor $68,400 Rental $43,000 **Item 6 Total - $247,800**
CATEGORY SUBTOTALS				**$820,300**			**$135,560**				**$291,150**		**$43,000**	

TASK SUBTOTAL $1,290,010
10% CONTINGENCY $129,001
CONSTRUCTION SUBTOTAL **$1,419,011**

7- Other Project Costs	Insurance Engineering Construction Management	1 1 1	$30,225 $100,000 $100,000	$30,225 $100,000 $100,000										**Item 7 Total - $230,225**

Project Grand Total $1,649,236

*** *Costs for Item 3 are based upon an estimate prepared by Alaska Energy and Engineering, Inc.on June 15, 2004***
**** Equipment shipping costs include barge charter at $10,000 per day**