Selawik, Alaska

AVEC and Wind Generation

Presented by Brent Petrie

WEATS

August 2007

AVEC

AVEC has considered wind generation options in the past, but there were obstacles:

- **Lack of appropriately sized machines**
- **Reliability concerns of equipment**
- **Lack of sufficient machines to support service providers**
- **Difficulty in integrating intermittent wind with small diesel systems**

Over the past eight years, several changes have occurred.

- Robust equipment in the 66 kW range has been successfully demonstrated by Kotzebue Electric Association
  - Atlantic Orient 66 KW machine with a 15-meter rotor
  - KEA installed 12 of them at Kotzebue and 2 at Wales
- A new 100 kW machine built for cold weather by Northern Power Systems entered the market
  - AVEC ordered thirteen for delivery in 2005-2007
  - Refurbished machines modified for cold weather have potential

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Northwind 100

Tower #2

Toksook Bay

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Lessons Learned

- AVEC and KEA have learned lessons from the high-penetration demonstration project at Wales
  - Integration with small diesels (avoid retrofits where possible)
  - Management of secondary loads for use of excess wind energy (electric heaters)
  - Logistics (try to combine wind work with other work to reduce cost)
  - Operations and maintenance (make sure personnel or contractors can readily get to the site)

How can wind generation be of value to AVEC?

- Let’s take a look at the location of AVEC villages

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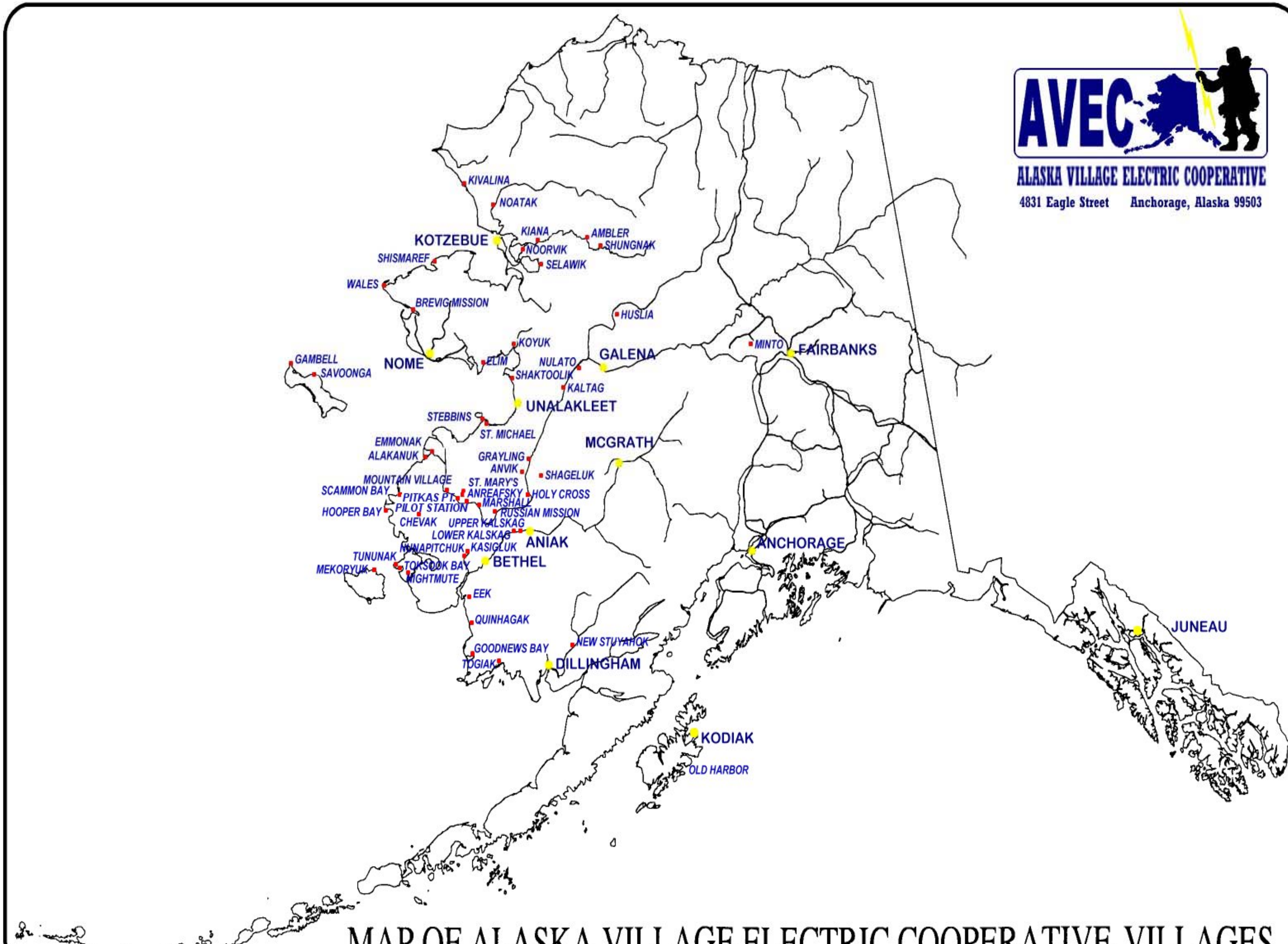
ALASKA VILLAGE ELECTRIC COOPERATIVE

4831 Eagle Street Anchorage, Alaska 99503



MAP OF ALASKA VILLAGE ELECTRIC COOPERATIVE VILLAGES


Now let's take a look
at the high-class wind
regimes that overlay
the AVEC villages.
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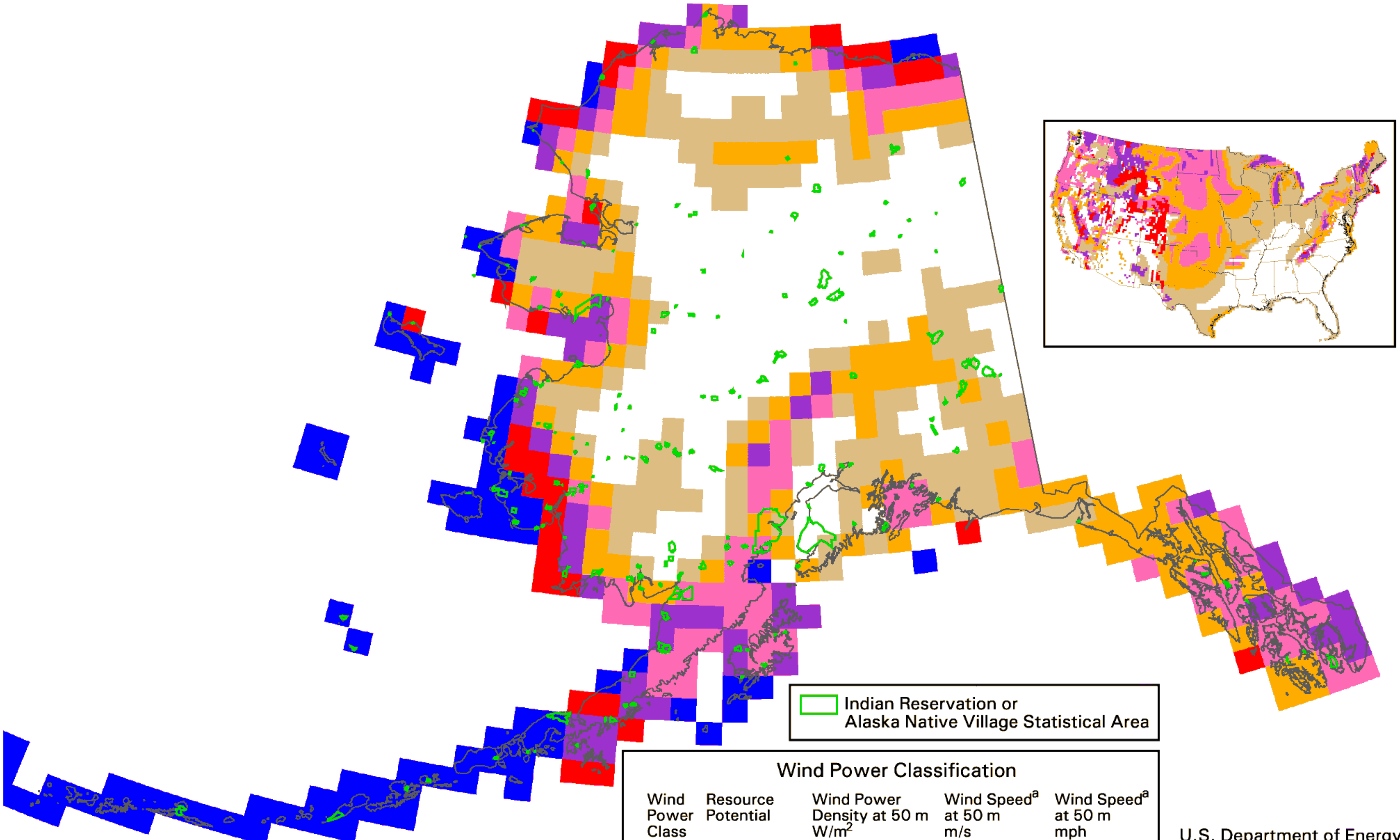
Alaska - Wind Resource Map



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m²	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

Source: Pacific Northwest National Laboratory - DOE, 1987.

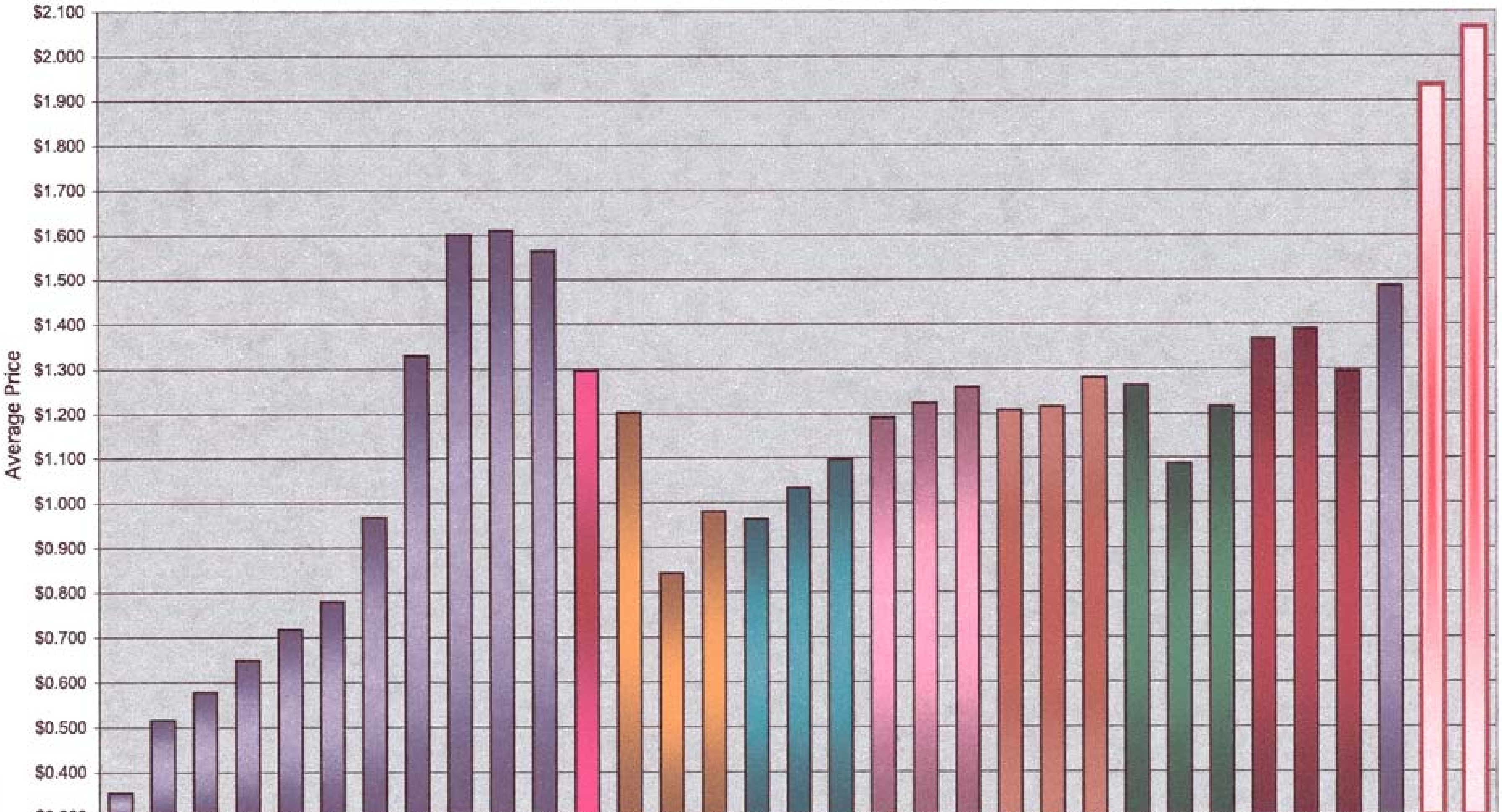
U.S. Department of Energy
National Renewable
Energy Laboratory

DM Heimiller 01-MAY-2001 1.1.9

Background Information

- 27 of AVEC's 52 villages are in wind regimes of class 4 or better.
- Given the characteristics of an NW/100, this means that one machine should be able to produce about 250,000 kWh per year.
- Given a diesel efficiency of 14 kWh/gallon generated by our new diesel sets, this means that one 100-kW wind turbine might displace about 17,800 gallons per year of diesel fuel use for power generation. A mini-wind farm of three units would displace about 53,400 gallons per year.

AVEC Fuel Prices



	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Average	$0.354	$0.515	$0.578	$0.649	$0.718	$0.779	$0.968	$1.330	$1.601	$1.610	$1.565	$1.296	$1.203	$0.842	$0.980	$0.964	$1.033

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Average	$1.097	$1.190	$1.224	$1.259	$1.208	$1.215	$1.281	$1.263	$1.088	$1.216	$1.367	$1.389	$1.294	$1.486	$1.936	$2.065

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Consider that in 2006 AVEC:

- Purchased 5.1 million gallons of diesel fuel
- Actively used nearly 550 fuel tanks for storage
- Took on fuel in 160 separate deliveries (including 41 by air)
- Has only one village – Minto – that can be supplied by a fuel truck
- Continued to experience electric load growth driven by new water and sewer systems, airports, schools and housing in the villages
    - This load growth increases fuel use and fuel storage needs

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Therefore, successful integration of wind generation could mean the following to AVEC:

- A hedge against increasing fuel costs
- A hedge against the increasing costs of marine deliveries
- Extension of on-hand fuel supplies which may translate to favorable delivery scheduling by marine transporters
- A reduction of the need to build expensive, additional storage on hard-to-acquire or difficult-to-construct sites.

To do such efforts cost effectively, we need to do good planning and coordinate efforts with other construction projects underway in the village.

- The recent bulk fuel tank farm and power plant priorities of the Denali Commission provide some opportunity to coordinate logistics and use specialty equipment such as pile drivers or cranes that may be on-site.

As a further means to reduce costs, AVEC is working to:

- Develop alliances with competent parties
- Work with vendors to develop a steady and reliable supply of parts and equipment.
- Encourage development of in-state expertise in tower foundation and erection.

As a further means to reduce costs, AVEC is working to:

- Encourage development of in-state expertise in resource assessment.
- Foster positive relationships with regulatory agencies dealing with environmental and siting issues.
- Provide feedback to critical financing entities such as USDA-RUS and the Denali Commission.
- Participate with specialty industry associations:
  - NRECA – Cooperative Research Network
  - UWIG – Utility Wind Interest Group

AVEC is also cost-sharing preparation of a high-resolution wind map in partnership with the Alaska Energy Authority and the National Renewable Energy Lab that will provide much more detailed resolution of wind resources for a portion of western Alaska.

- This effort is funded with money from:
  - NREL
  - AEA
  - AVEC

The following slide is an example of such before and after mapping in North and South Dakota. The map will be useful in determining where additional wind resource monitoring may or may not be useful.

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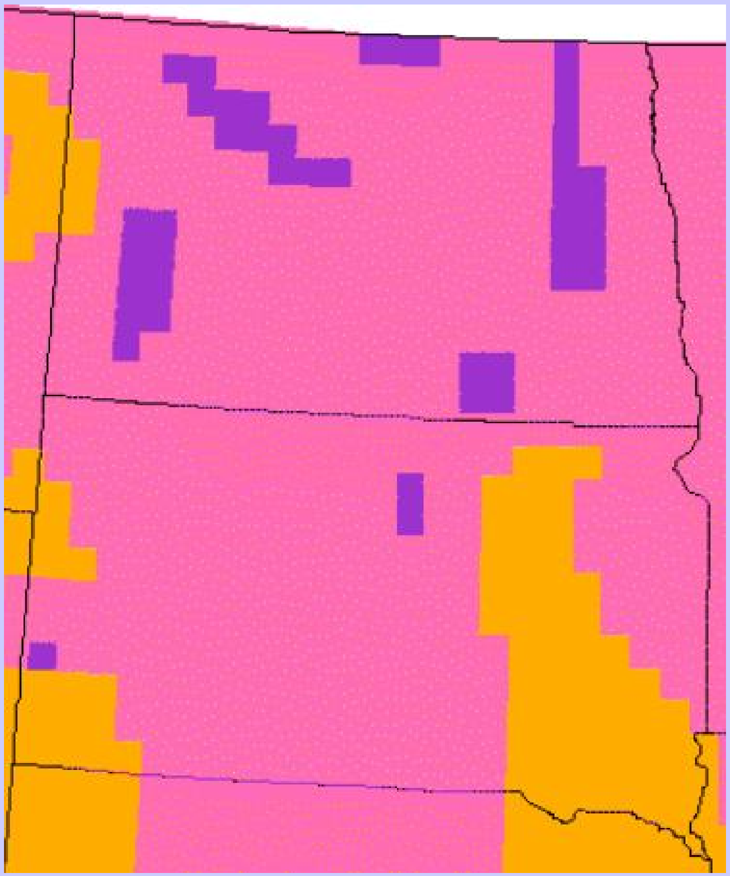
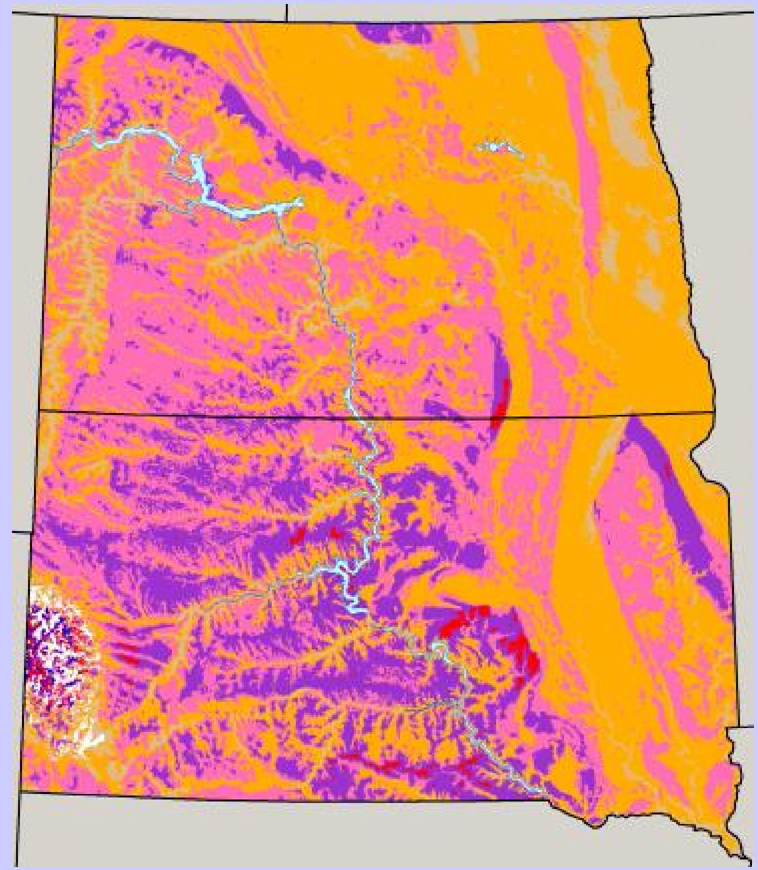
Comparison of Digital Wind Map from 1987 U.S. Wind Atlas and New (2000) High-Resolution (1-km^2) Wind Map North and South Dakota





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[a] Wind speeds are based on a Weibull k value of 2.0

AVEC is also participating with the Alaska Energy Authority on placing wind monitoring equipment in several western Alaska villages.

Wind Resource Assessment and Analysis is:

- Critical to determining the estimated output of a project
- Time consuming, but is a small cost compared to cost of a misplaced project.

In addition to the wind resource, we also have to consider:

- Land ownership and land use in the area
- Geotechnical considerations for foundations
- Possible historical and cultural resources on the site
- Bird issues
- Equipment access for construction
- Access to power lines.

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Foundations in permafrost are a challenge

- They must not settle, tilt or be uplifted
- Pile foundations (six to eight piles) may extend 1/3 to 2/3 the height of the tower into the ground

Access for specialty equipment required to place foundations and erect turbines is a challenge.

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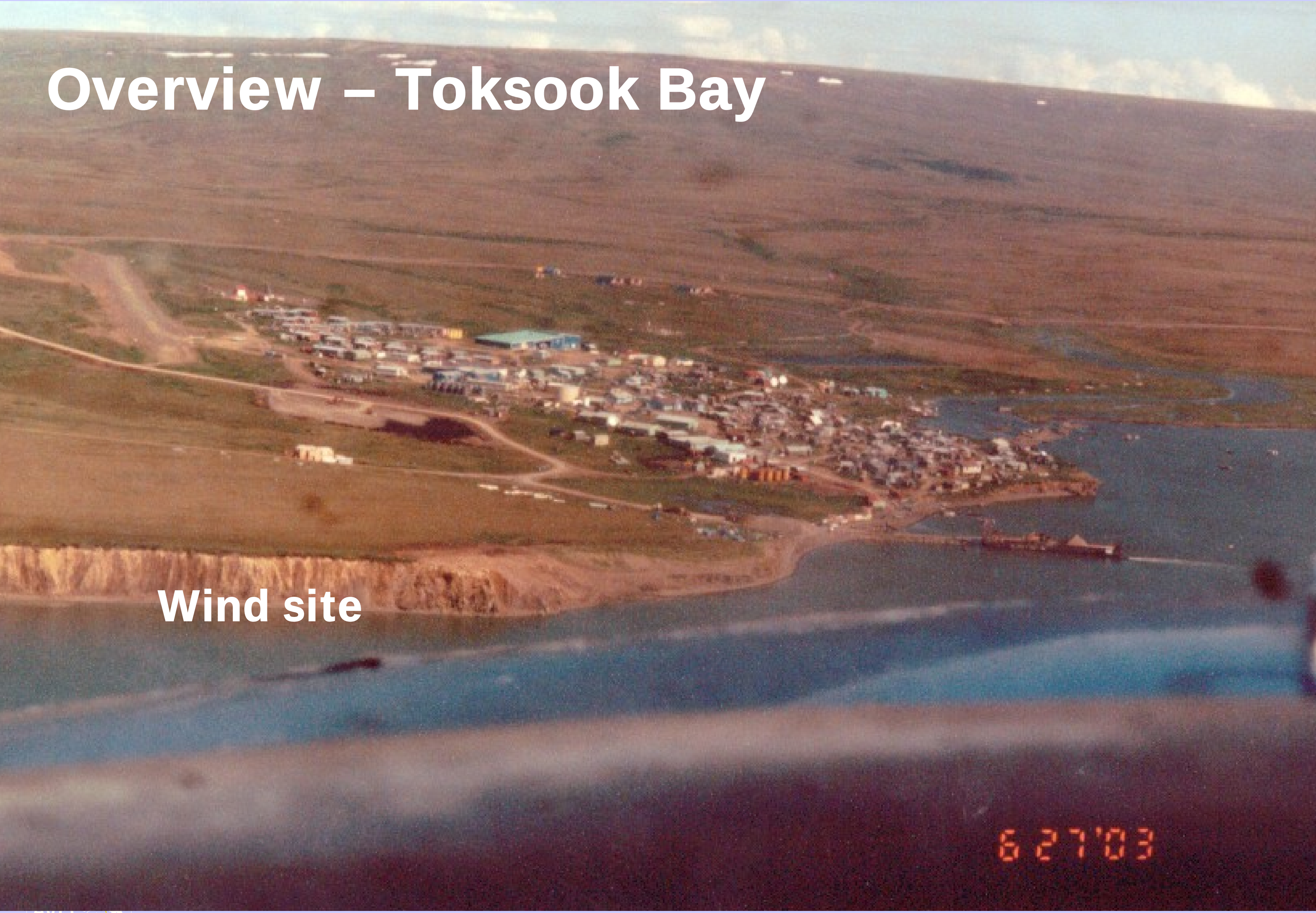
Poor roads, water and sewer lines, boardwalks and existing overhead power and phone lines present obstacles and challenges.

Selawik, Alaska

New modular power plant, bulk fuel tank farm, four wind turbines, and waste heat recovery system

Aerial view of new power plant, tank farm, and wind turbines at Selawik, Alaska.

Overview – Toksook Bay



- Holes pre-drilled
- Piles driven to refusal
- Piles later cut

- Drilling out center of piles

  20’ below end of pile

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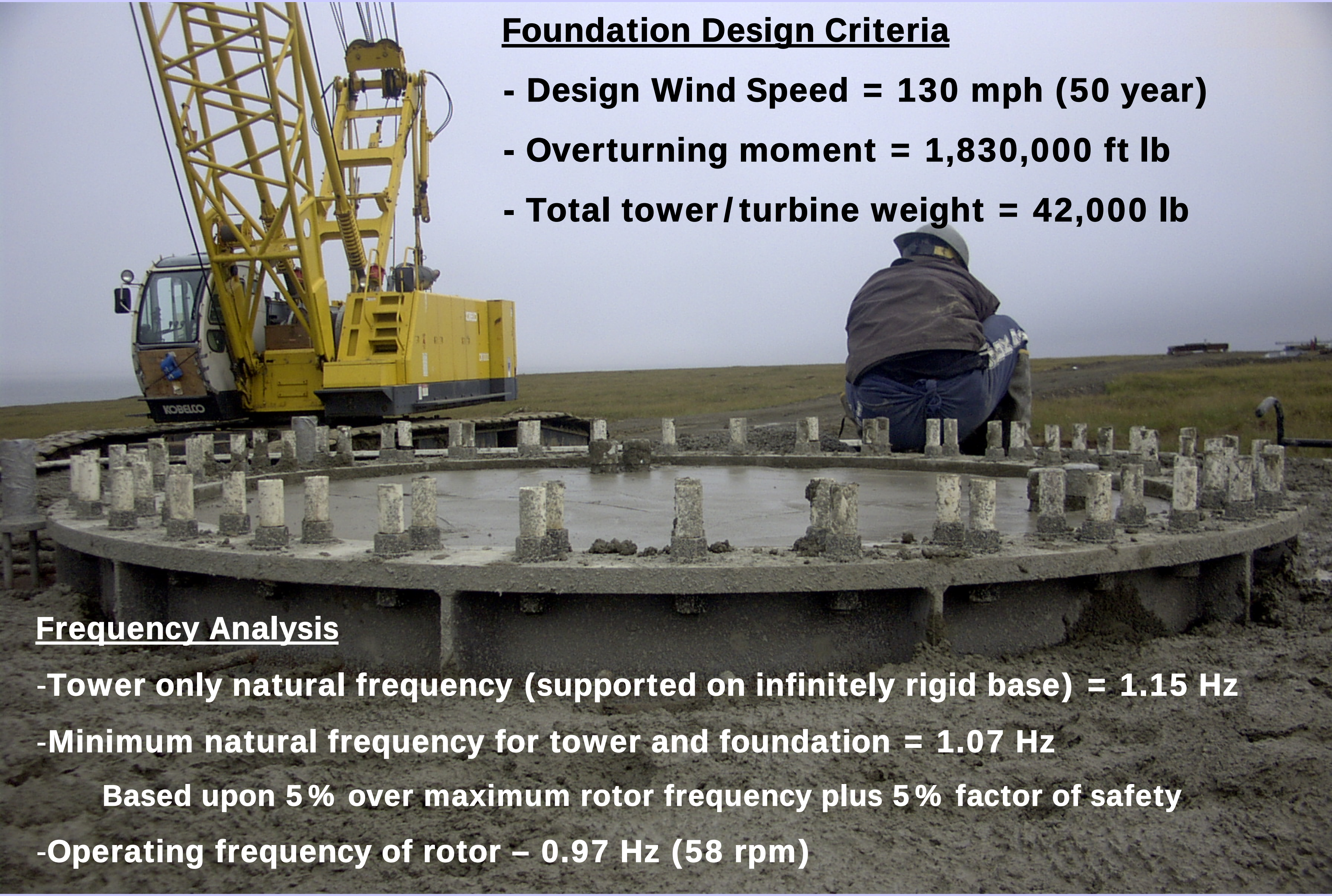
Six piles for a single tower foundation


www.usfc.com
Steel Foundation Star
(Typical of 3)


Rebar cage
F168



Foundation Design Criteria

- Design Wind Speed = 130 mph (50 year)
- Overturning moment = 1,830,000 ft lb
- Total tower/turbine weight = 42,000 lb

Frequency Analysis

-Tower only natural frequency (supported on infinitely rigid base) = 1.15 Hz

-Minimum natural frequency for tower and foundation = 1.07 Hz

Based upon 5% over maximum rotor frequency plus 5% factor of safety

-Operating frequency of rotor – 0.97 Hz (58 rpm)

Wind Turbine Controller

Tower / Turbine Specifications

- 108 feet from ground level to center of rotor
- Rotor diameter (3 blades) = 61 feet

Nacelle at NPS production facility at Barre, Vermont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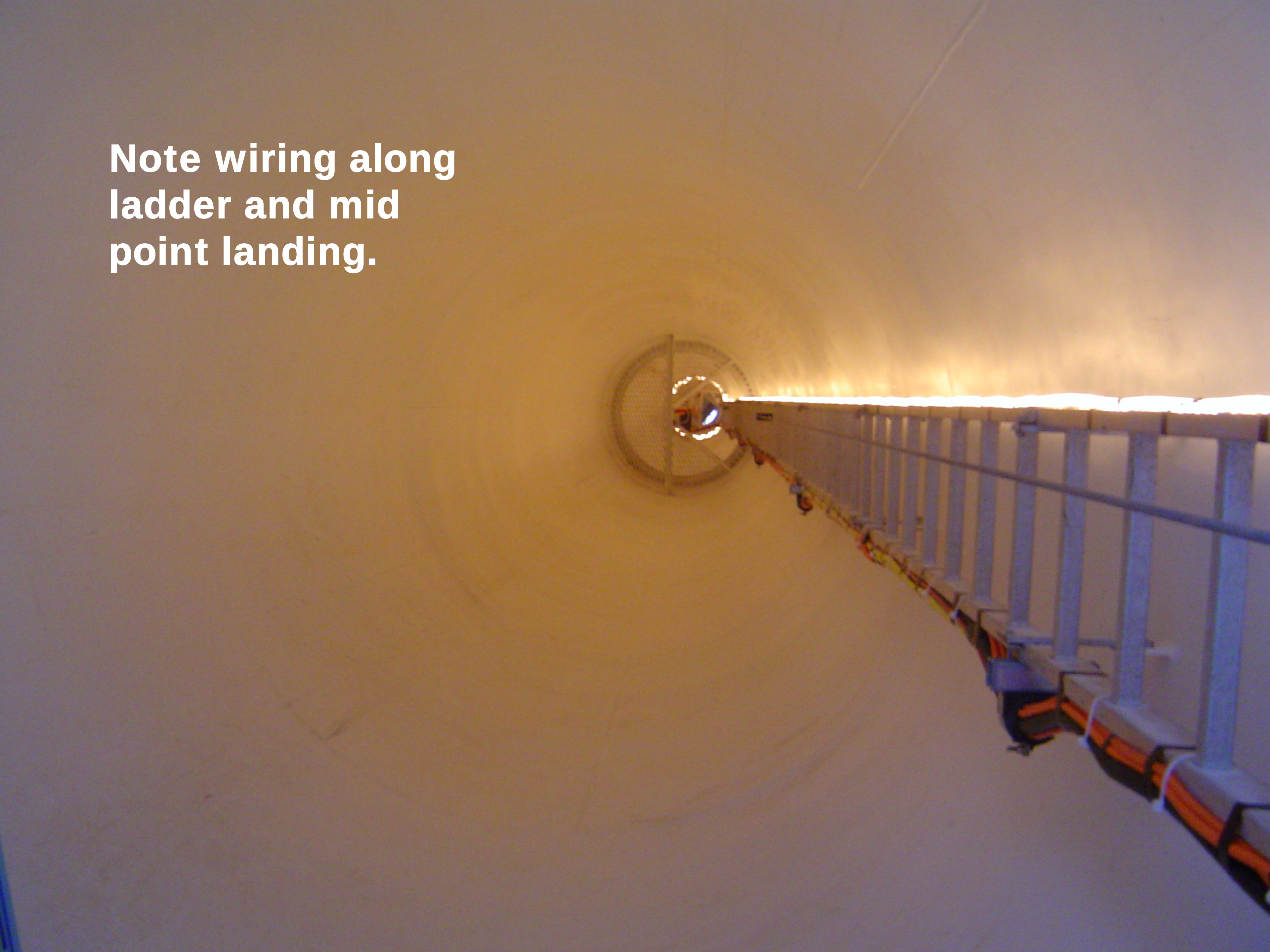
Second tower section
being put in place


Note wiring along
ladder and mid
point landing.


Three wind turbines.
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Ice on turbine blades.
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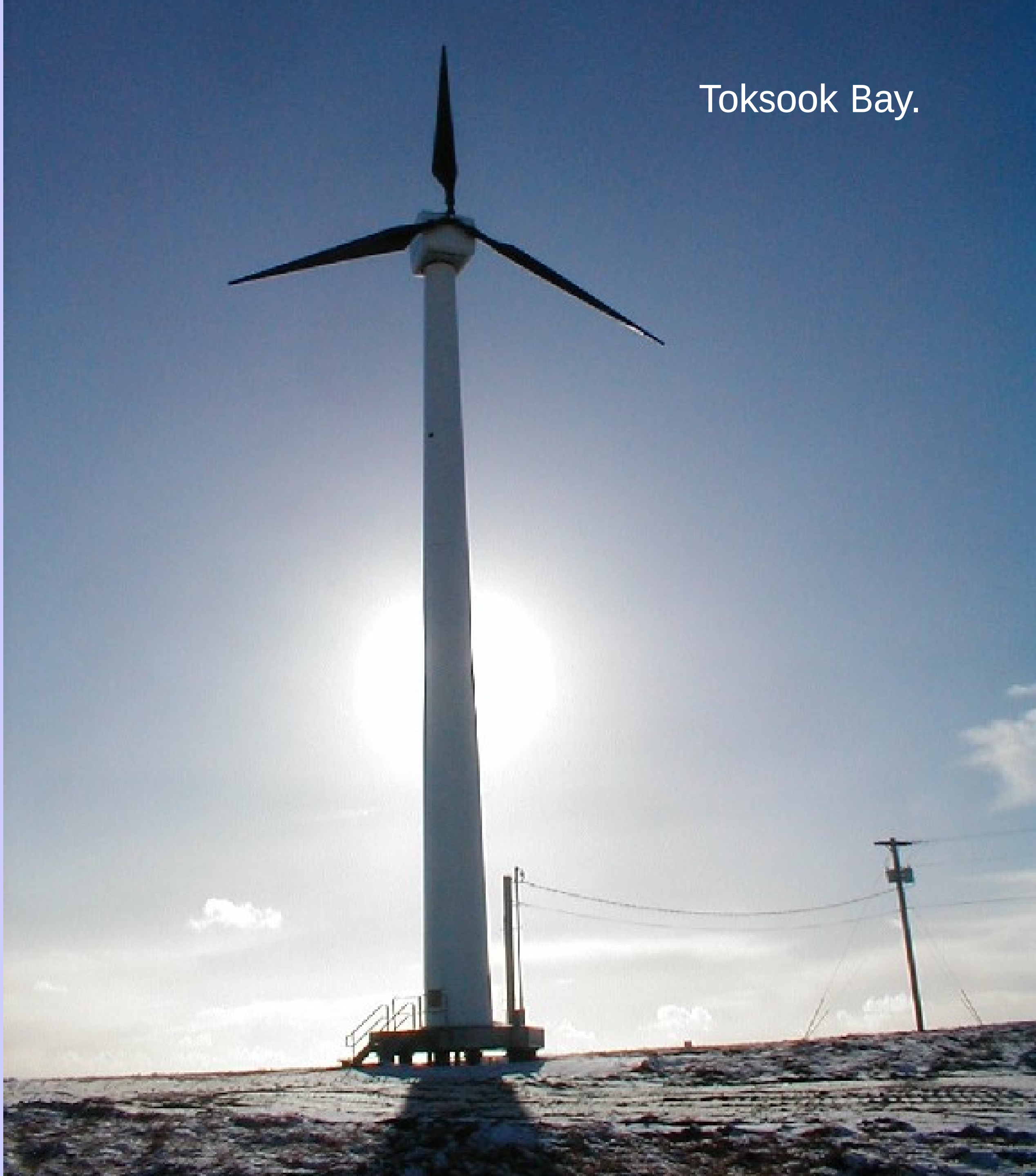
Any questions?



Presented by
Brent Petrie

Alaska Village
Electric
Cooperative

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