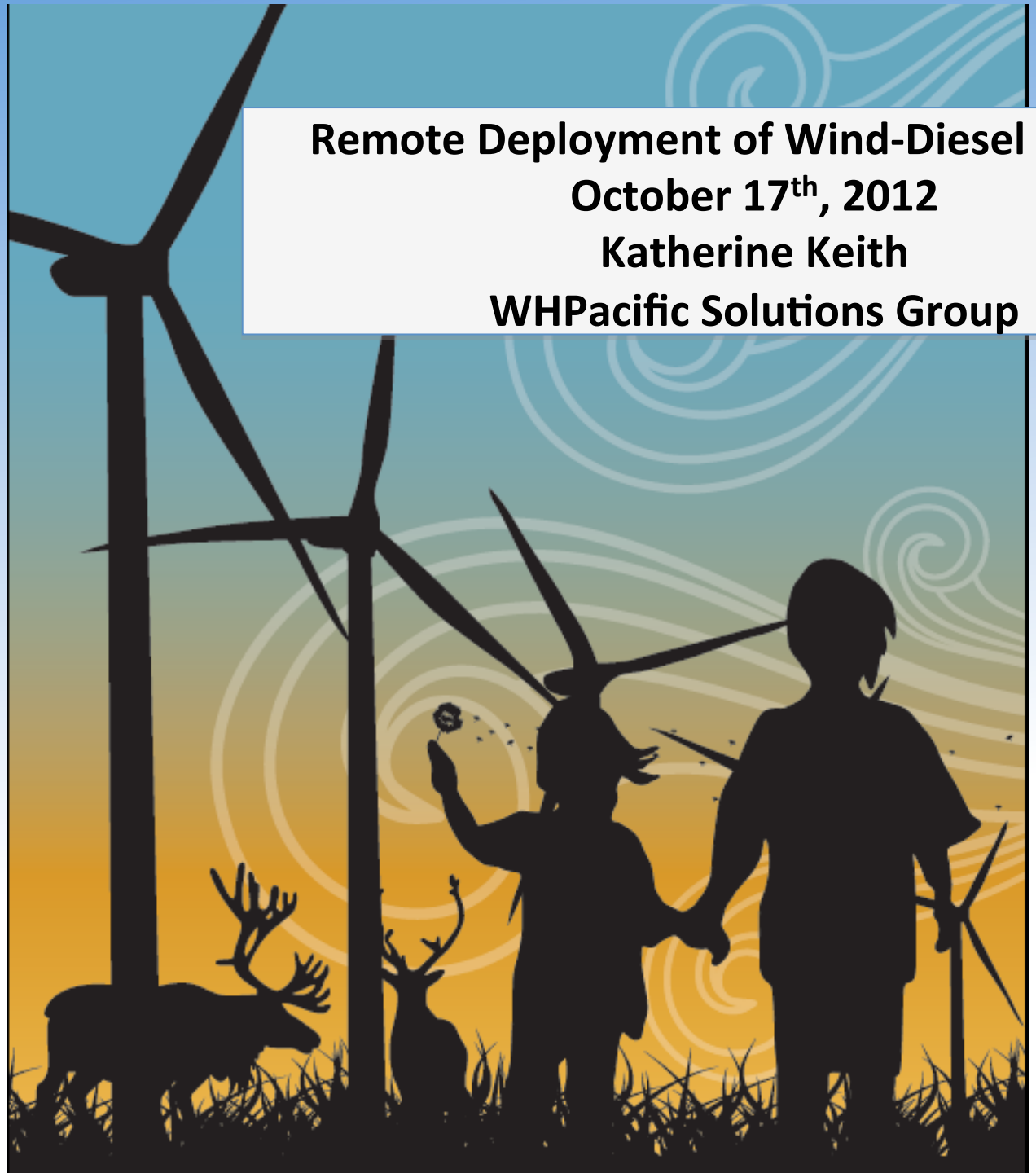
Remote Deployment of Wind-Diesel Systems

October 17th, 2012

Katherine Keith
WHPacific Solutions Group



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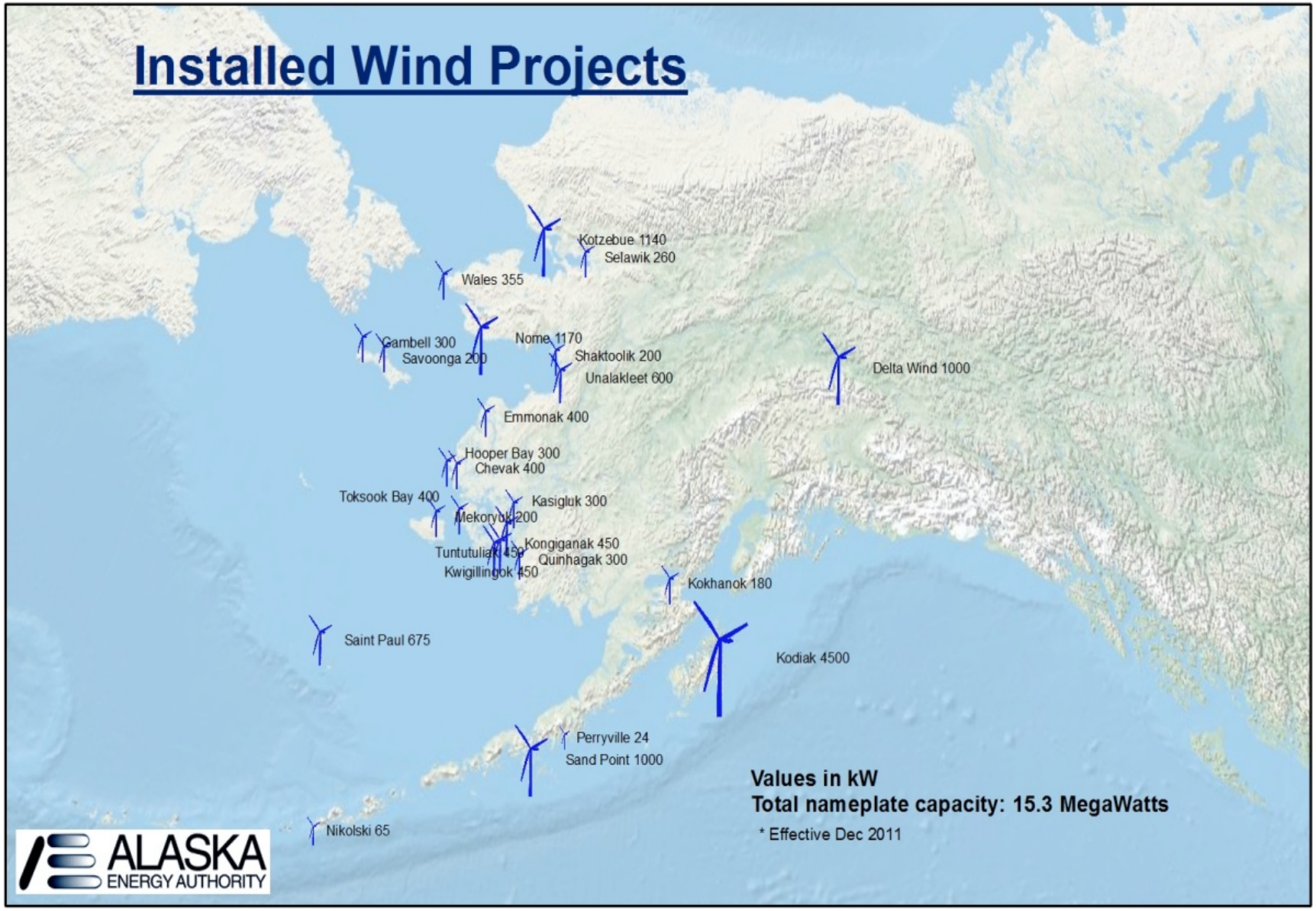
Looking Back…



Wind-Diesel Power Systems

- Intended to reduce diesel consumption
- Needs good resource to be economically viable

- However, wind fluctuates…
- Power quality must be maintained despite the variable wind.

Diesel Gen-Set:
Great Prime Movers

Reliable, Well Understood, Easily Transported Fuel

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Negatives?

- **Variable cost of diesel fuel**
- **Produces emissions-CO2,NOx, and Particulate Matter**
- **Fuel must be stored**

Photo: J. Wilson

Alaska Turbine Sizes

- Small (<10kW)
  - Residential
  - Farms
- Intermediate (10-250kW)
  - Small Hybrid Systems
  - Distributed Power
- Large(250kW-2 MW)
  - Centralized Generation

Perryville
Small…

Medium…

Large…

Kodiak-Pillar Mountain

Renewable Contribution

$$\text{Instantaneous Penetration} = \frac{\text{Wind Power Output (kW)}}{\text{Primarly Electrical Load (kW)}}$$

$$\text{Average Penetration} = \frac{\text{Wind Energy Produced (kWh)}}{\text{Primarly Energy Demand (kWh)}}$$

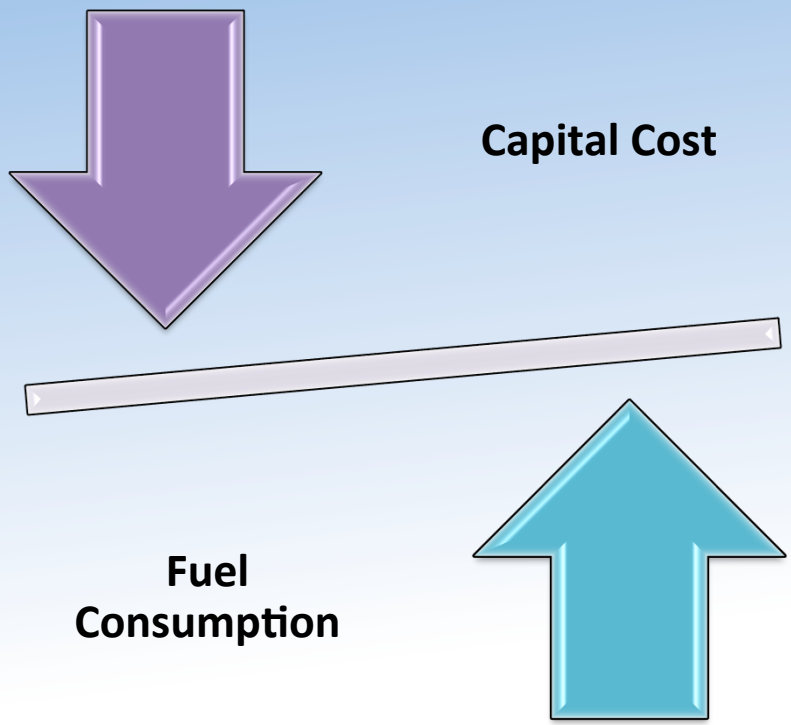
$$\text{CapacityFactor} = \frac{\text{Actual Power Produced}}{\text{Total Rated Power Possible}}$$

Wind-Diesel Classes

High
- 50-90% fuel savings
- Capital Cost-High

Med
- 15-50% fuel savings
- Capital Cost-Med

Low
- Up to 15% fuel savings
- Capital Cost -Low



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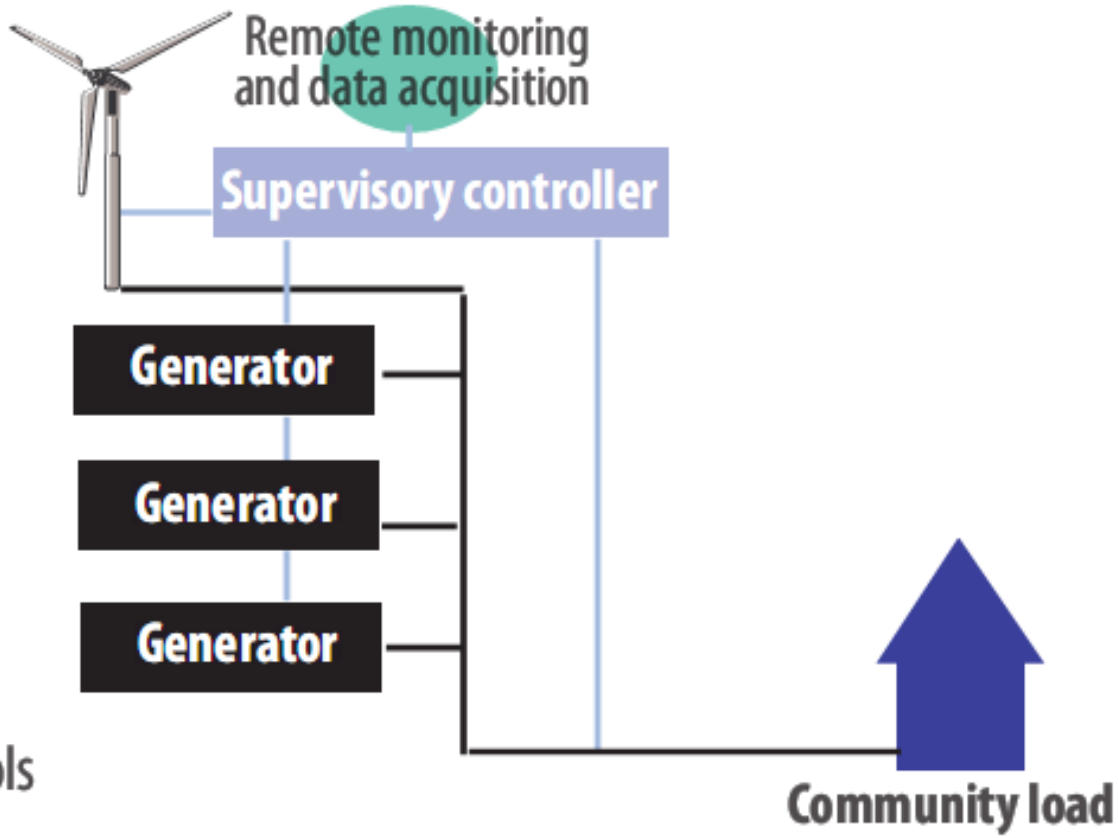
Wind-Diesel System, Low Penetration[a]

- Diesel generators must run at all times
- Wind power reduces load on generators
- All wind energy goes to primary community electrical load
- Annual average wind penetration under 20%
- Fuel savings up to 15%
- Lower installation costs, because system requires less complex controls



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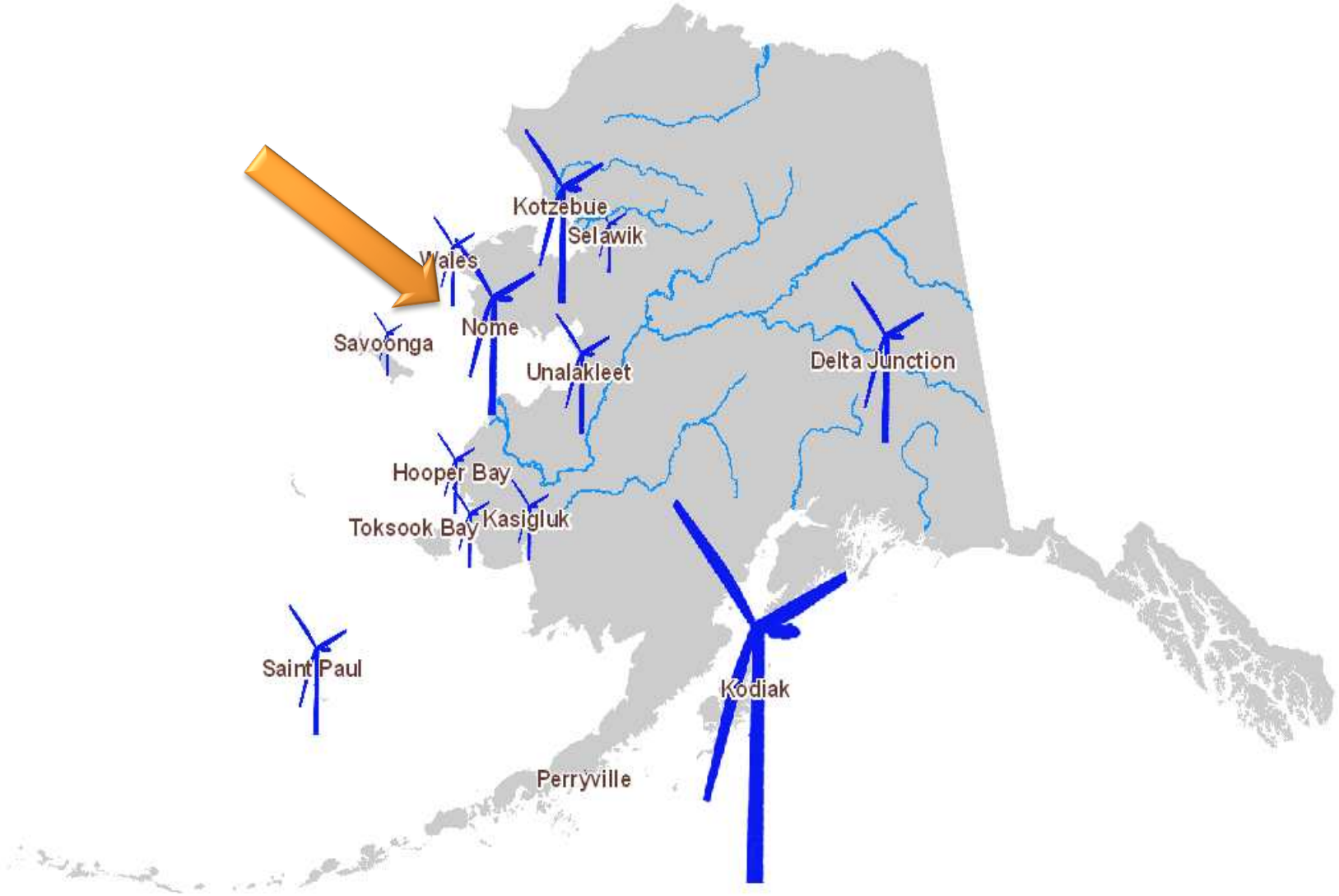
Installed Wind Capacity - Alaska Utilities



Source: Alaska Energy Authority

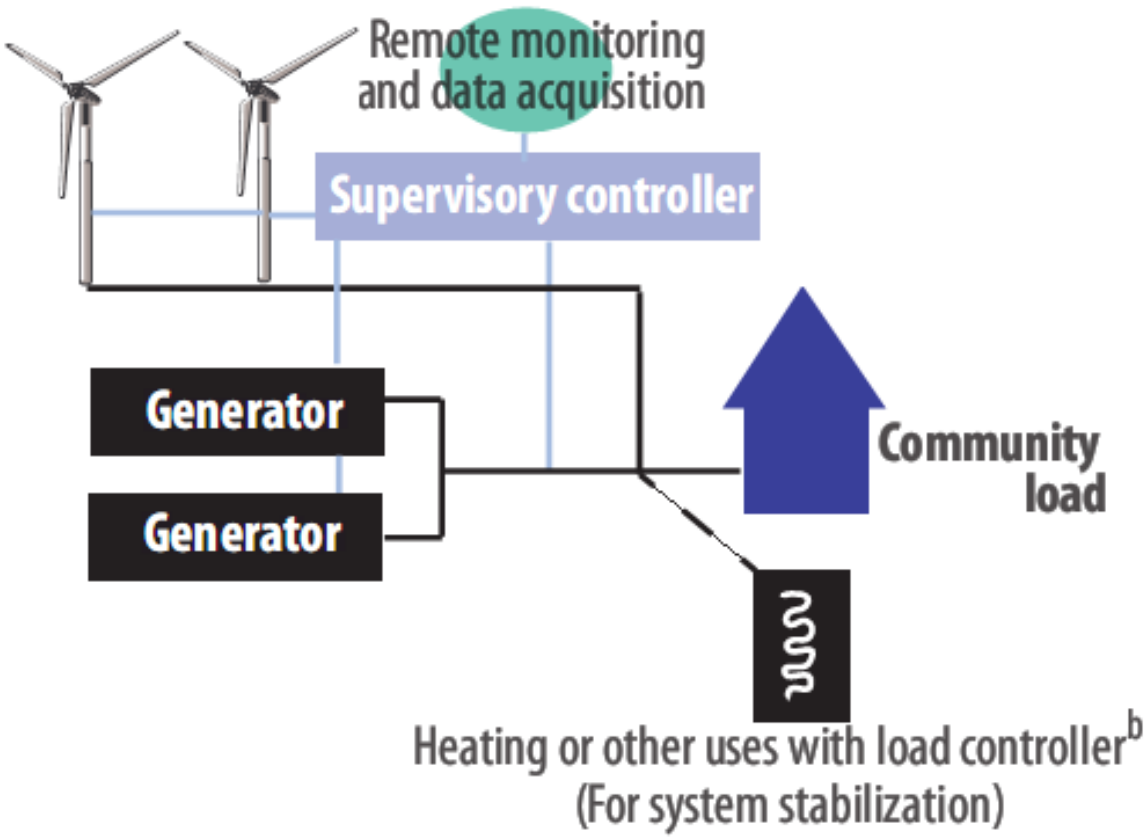
NOME - BANNER PEAK

Photo Courtesy of Bob Hafner, Banner Peak

- Average load 4000kW
- 1170 kW Installed Wind
- Installed December 2008
- Bering Straits NC and Sitnasuak NC

Wind-Diesel System, Medium Penetration[a]

- Diesel generators must run at 40% or more of their capacity at all times
- At high wind power production, part of wind energy diverted for space heating, or wind generation is curtailed
- Annual average wind penetration 20% to 50%
- Fuel savings 15% to 50%
- System controls must be more advanced, which increases installation costs



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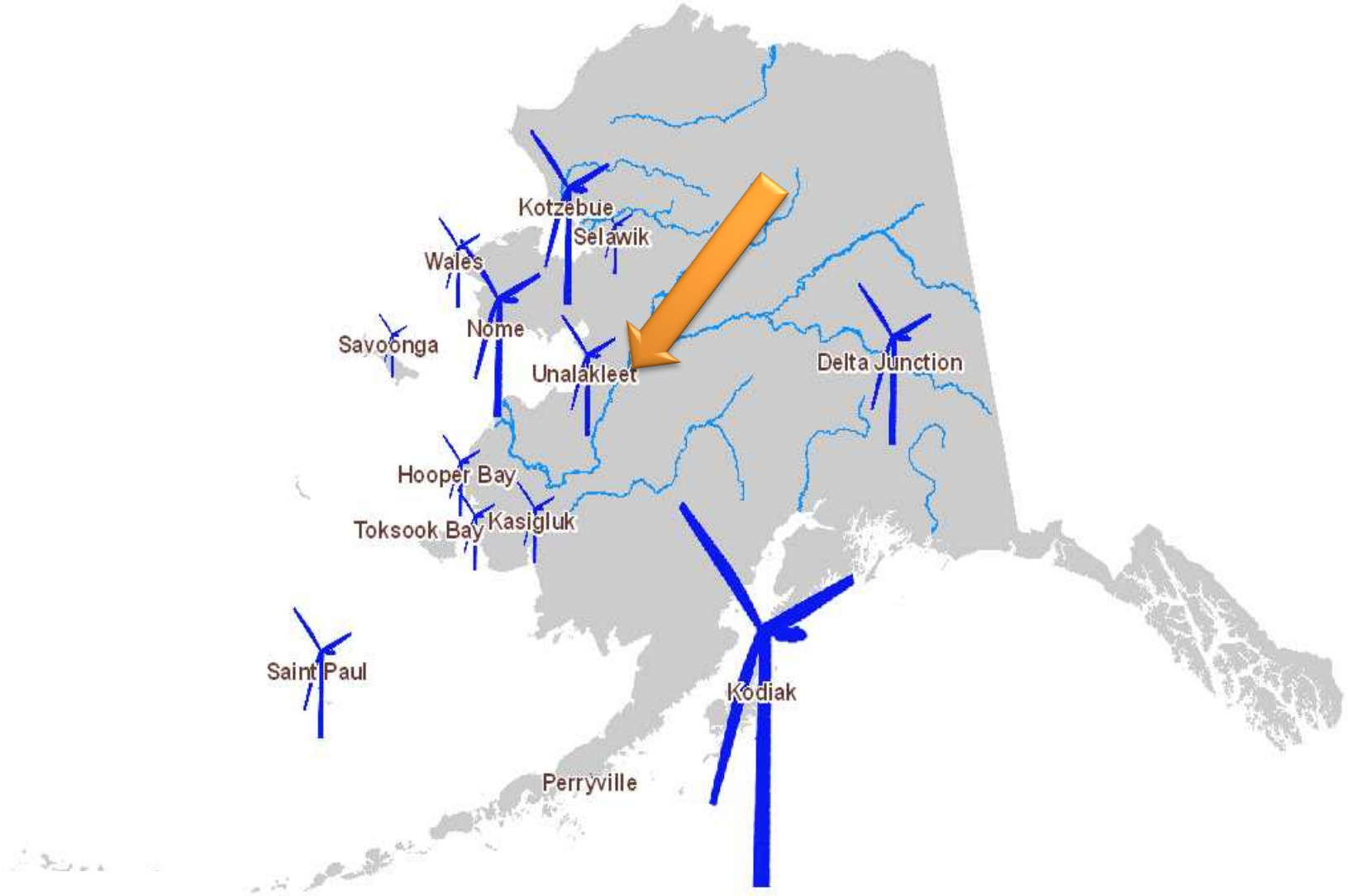
Installed Wind Capacity - Alaska Utilities



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Source: Alaska Energy Authority

Unalakleet

Secondary Loads

- Resistive Heater
  - Frequency stabilization (ms to seconds)
  - Thermal Value
- Energy Storage
  - Frequency stabilization (ms to seconds)
  - Load shifting (minutes to hours).
- Other Alternative Uses
  - Electric vehicles, Hydrogen generation, etc…
- Centralized and decentralized

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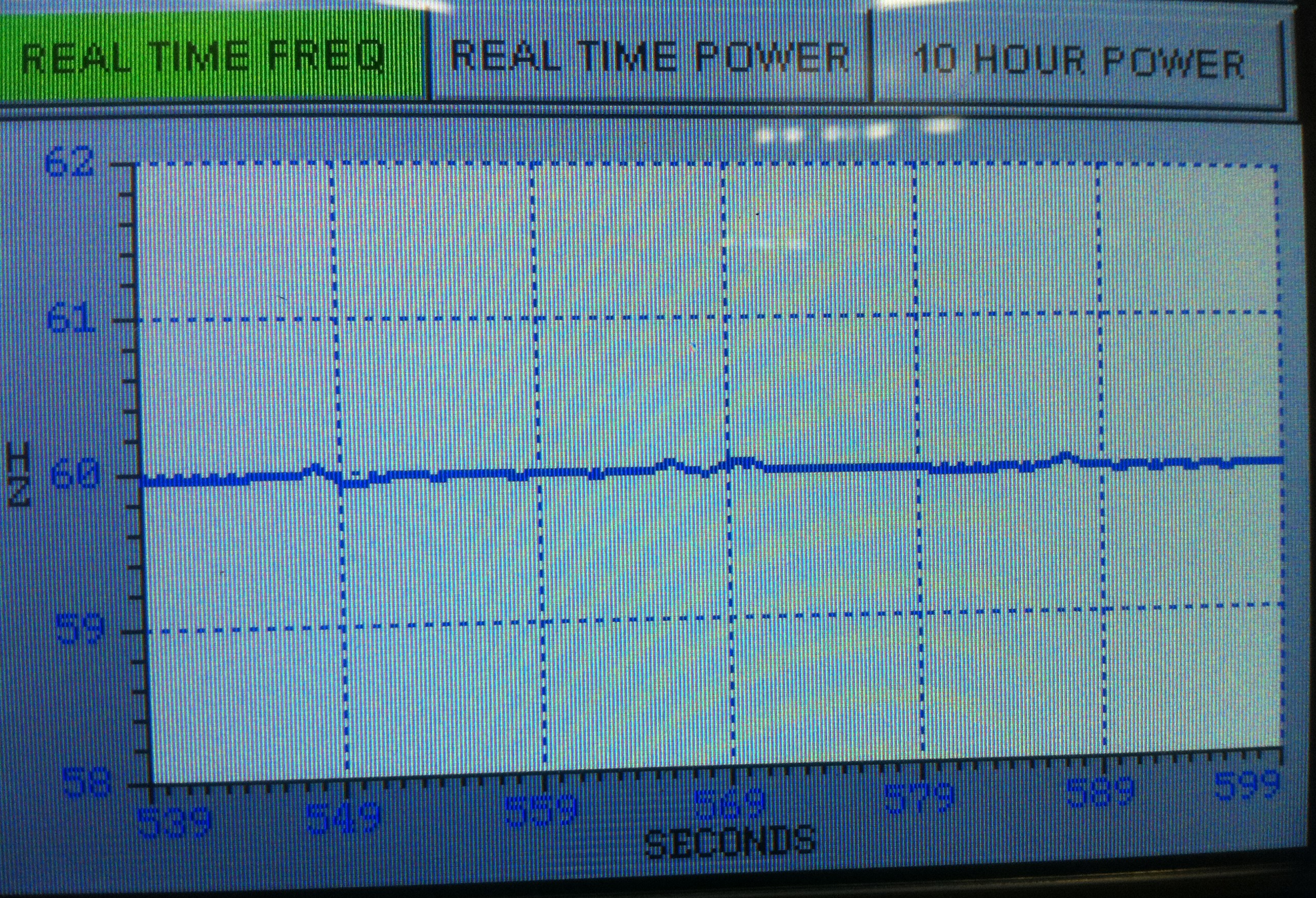
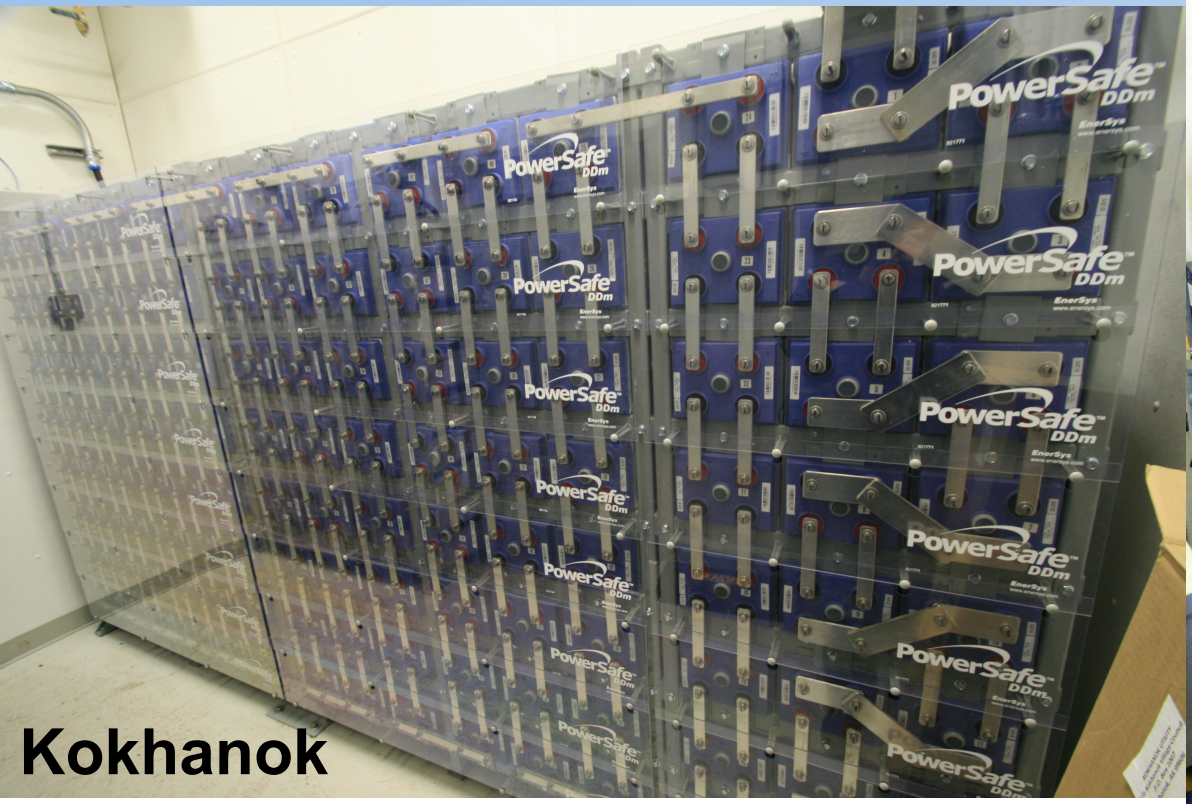

REAL TIME FREQ
REAL TIME POWER
10 HOUR POWER
62
61
60
59
58
HZ
539
549
559
569
579
589
599
SECONDS

Ni-Cads



Kokhanok

Wales

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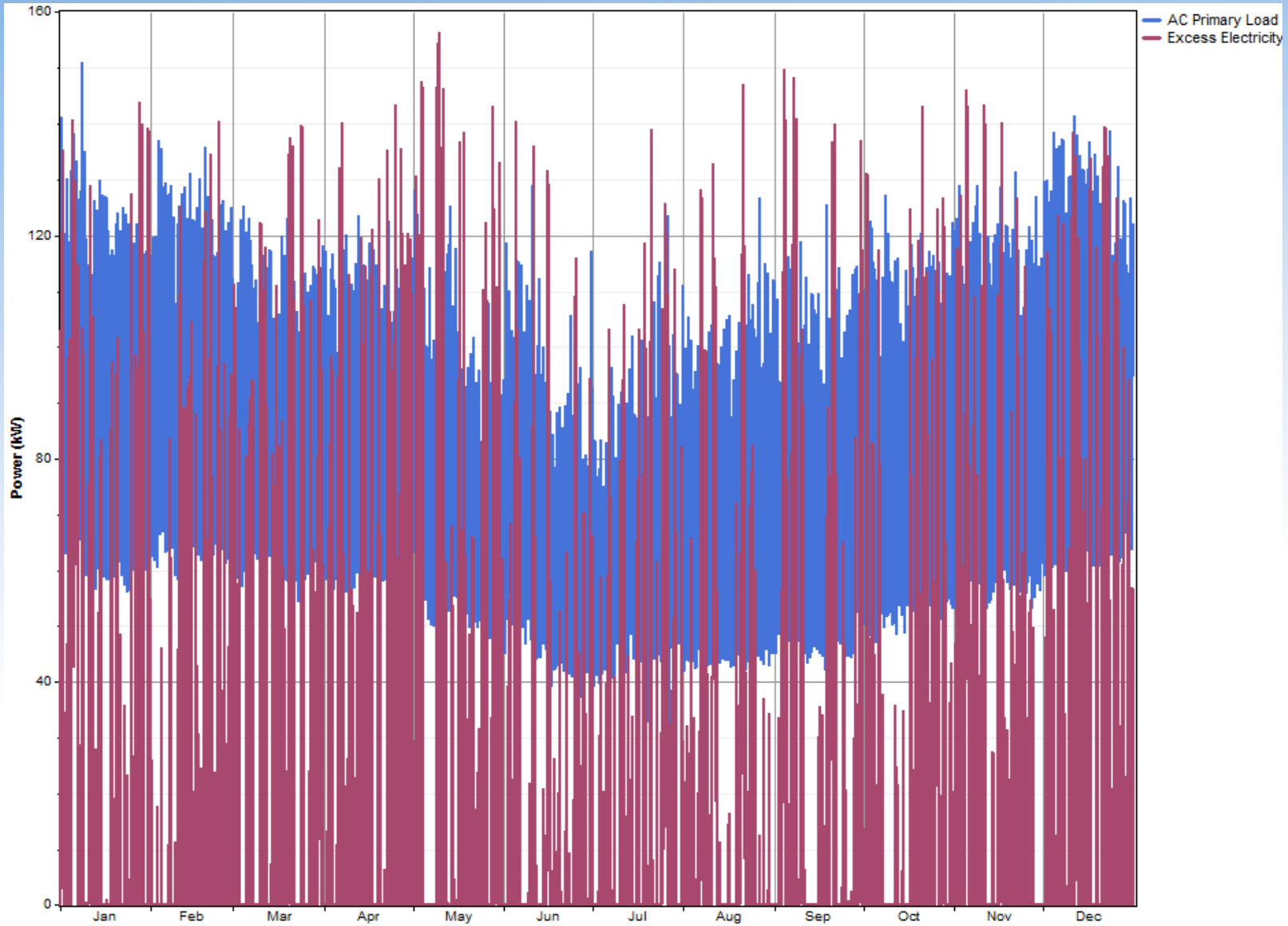
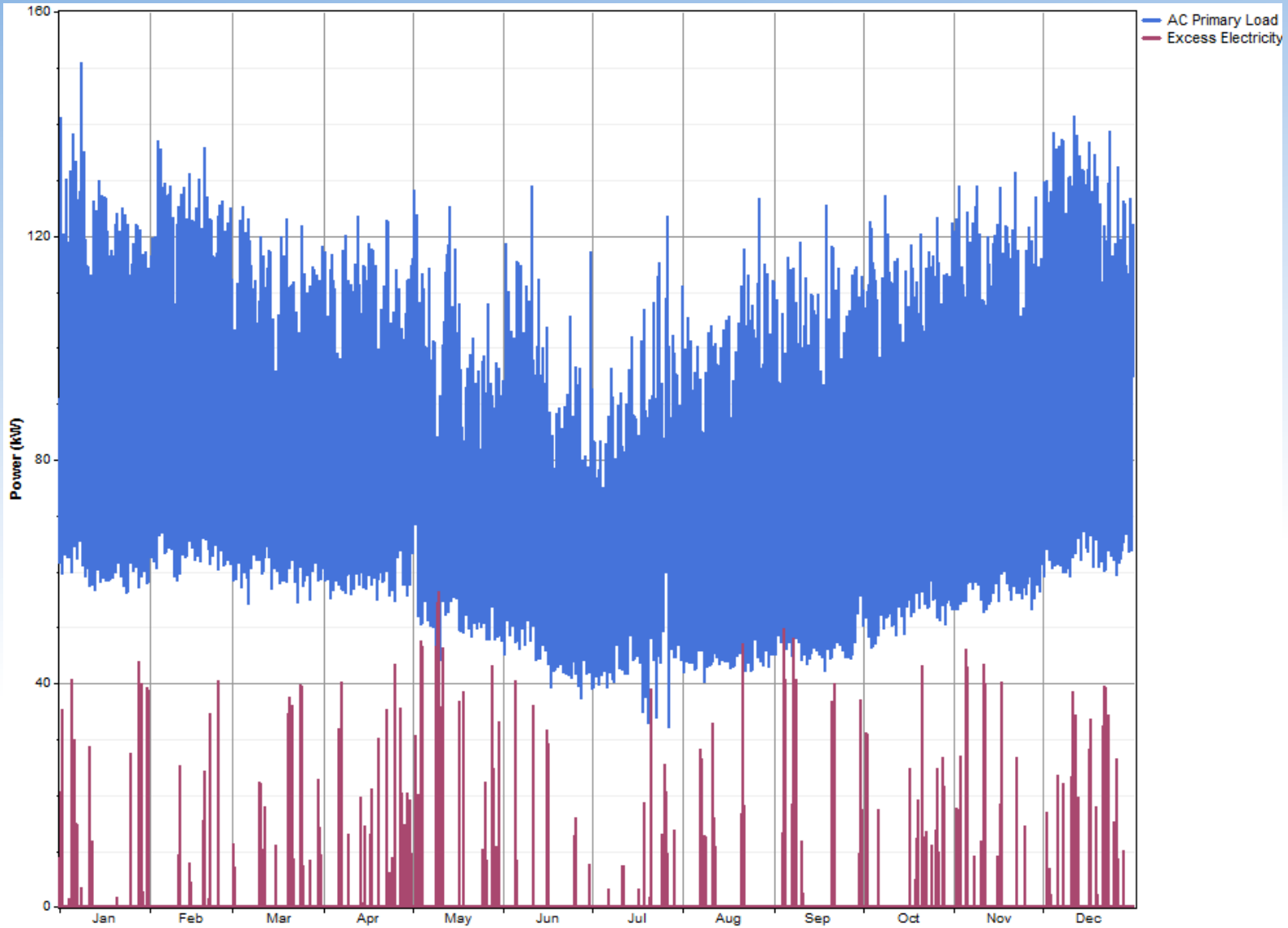
Excess Electricity with no Dump Load

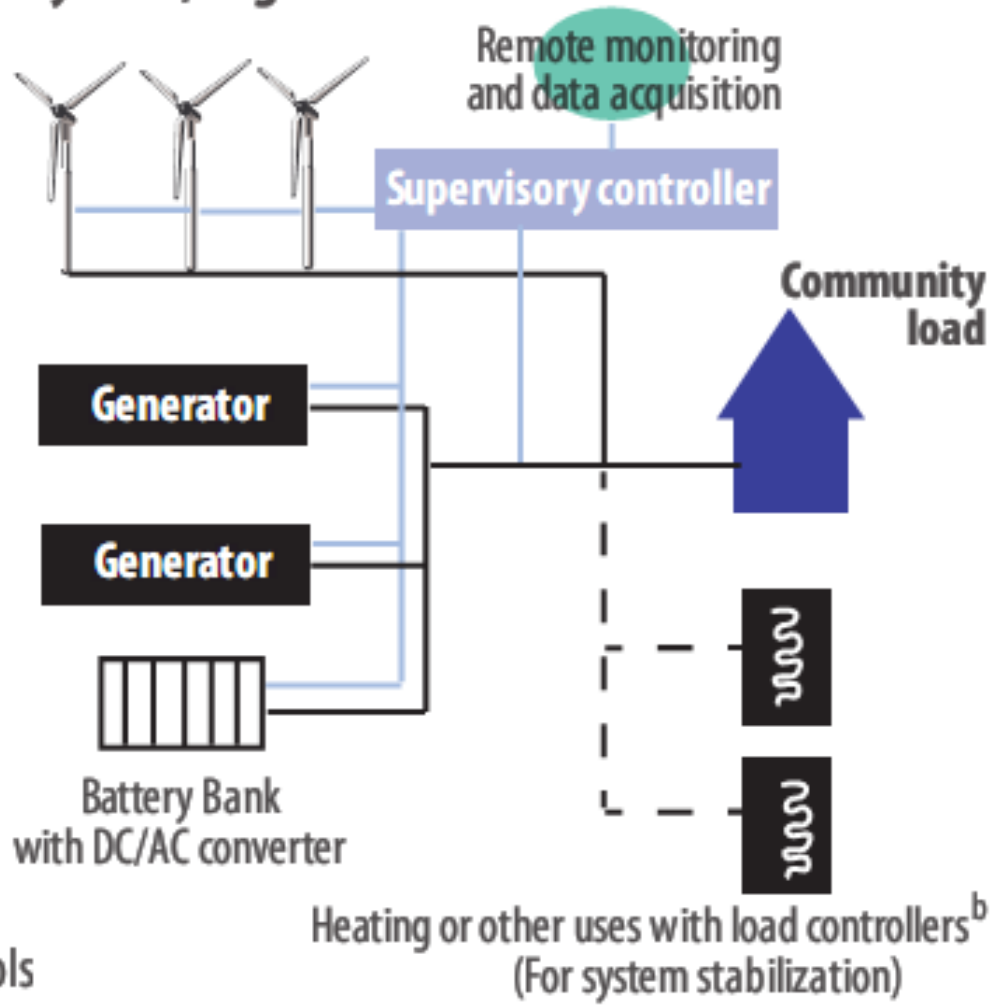


Excess Electricity with Dump Load



Wind-Diesel System, High Penetration[a]

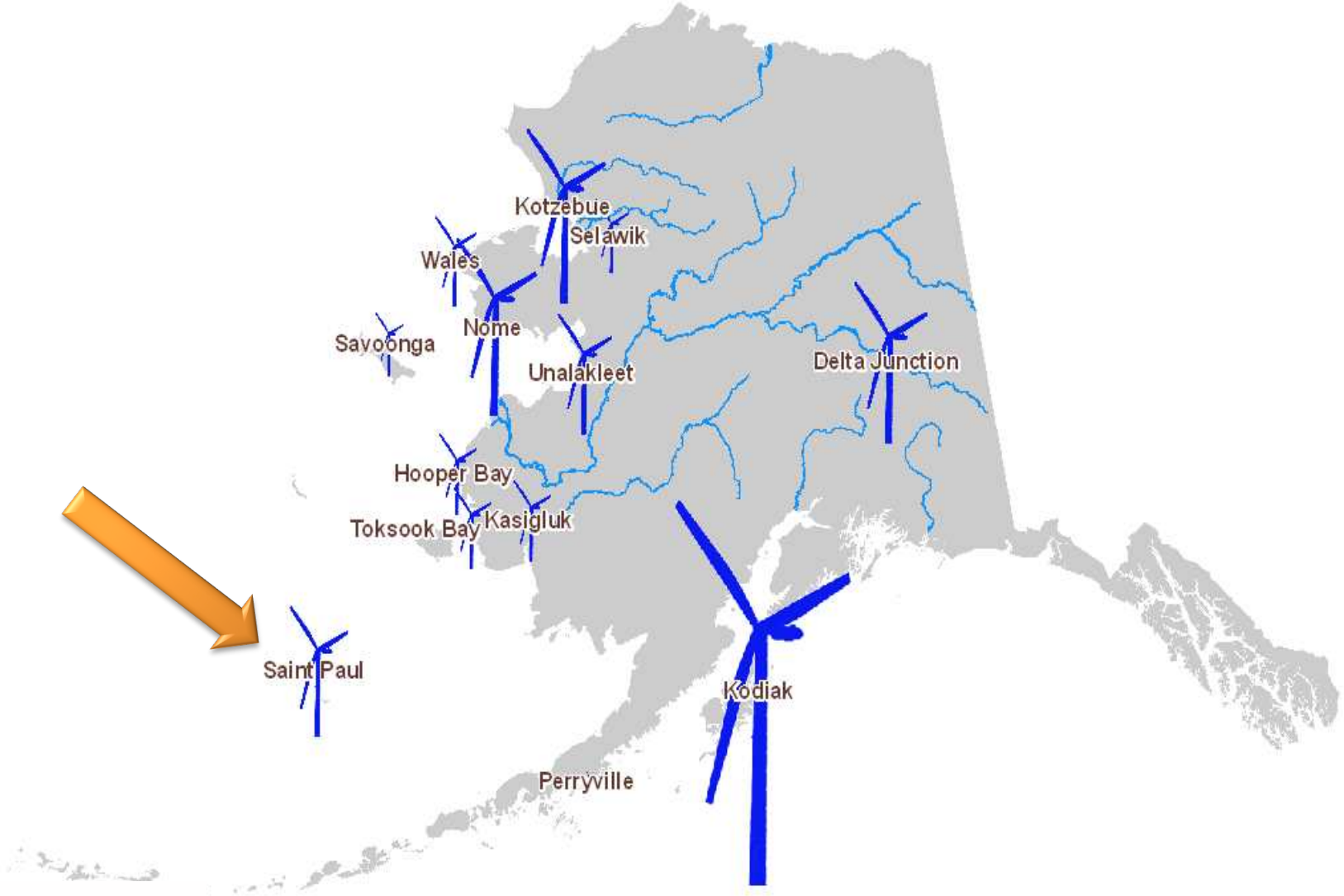
- If properly configured, diesel generators may be shut down when wind power exceeds electrical demand
- Auxiliary components regulate voltage and frequency when needed
- Power in excess of what is needed for primary electrical load can be used for space heating or stored in batteries
- Annual average wind penetration 50% to 150%
- Fuel savings 50% to 90%
- Higher installation costs, because system requires sophisticated controls
- Operators must be highly skilled



[a]Wind penetration is the percentage of electricity supplied by wind.
[b]Besides residential or commercial heating, possible other uses include charging electric cars.
Note: These are examples of systems; other configurations exist.

Sources: Adapted from Ian Baring-Gould and Steve Drouilhet, National Renewable Energy Laboratory

Installed Wind Capacity - Alaska Utilities



Source: Alaska Energy Authority

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- **3 Vestas V-27 for total of 675 kW**
- **Electric boiler for hot water**
- **2006- <u>60% capacity factor</u>**
- **Average Load: 70kW electrical & 50 kW Thermal**
- **Class 7 wind resource**
- **Average wind penetration : 55%**
- **Average Capacity Factor: 32%**

- March 2008- diesels ran only **<u>27%</u>** of the time!

St. Paul Island

Kokhanok, Alaska

Kokanhok
Photo Courtesy of Marsh Creek

The Benefits of Diesel-Off

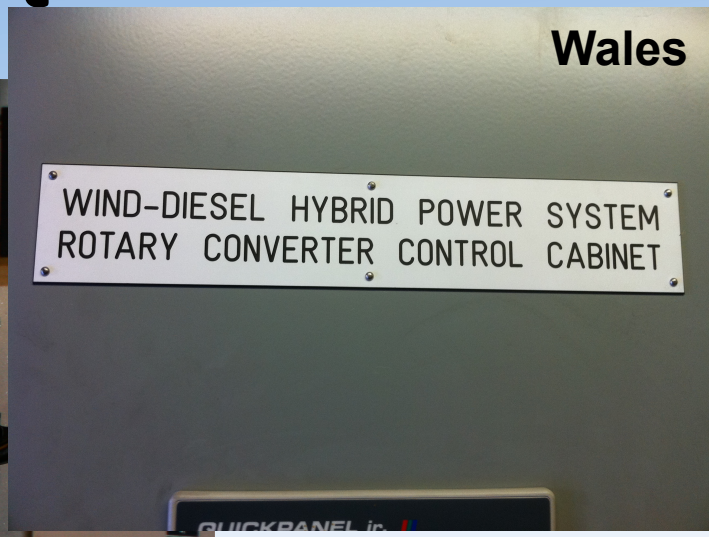
- Excess wind energy can be transferred to secondary loads.
- Economic benefits from reduction in diesel increases exponentially when the diesels can be shut off.
- Offset over 50% of diesel for electrical generation.
- Diesel can be offset for thermal loads

Multiple Solutions for Diesel-Off

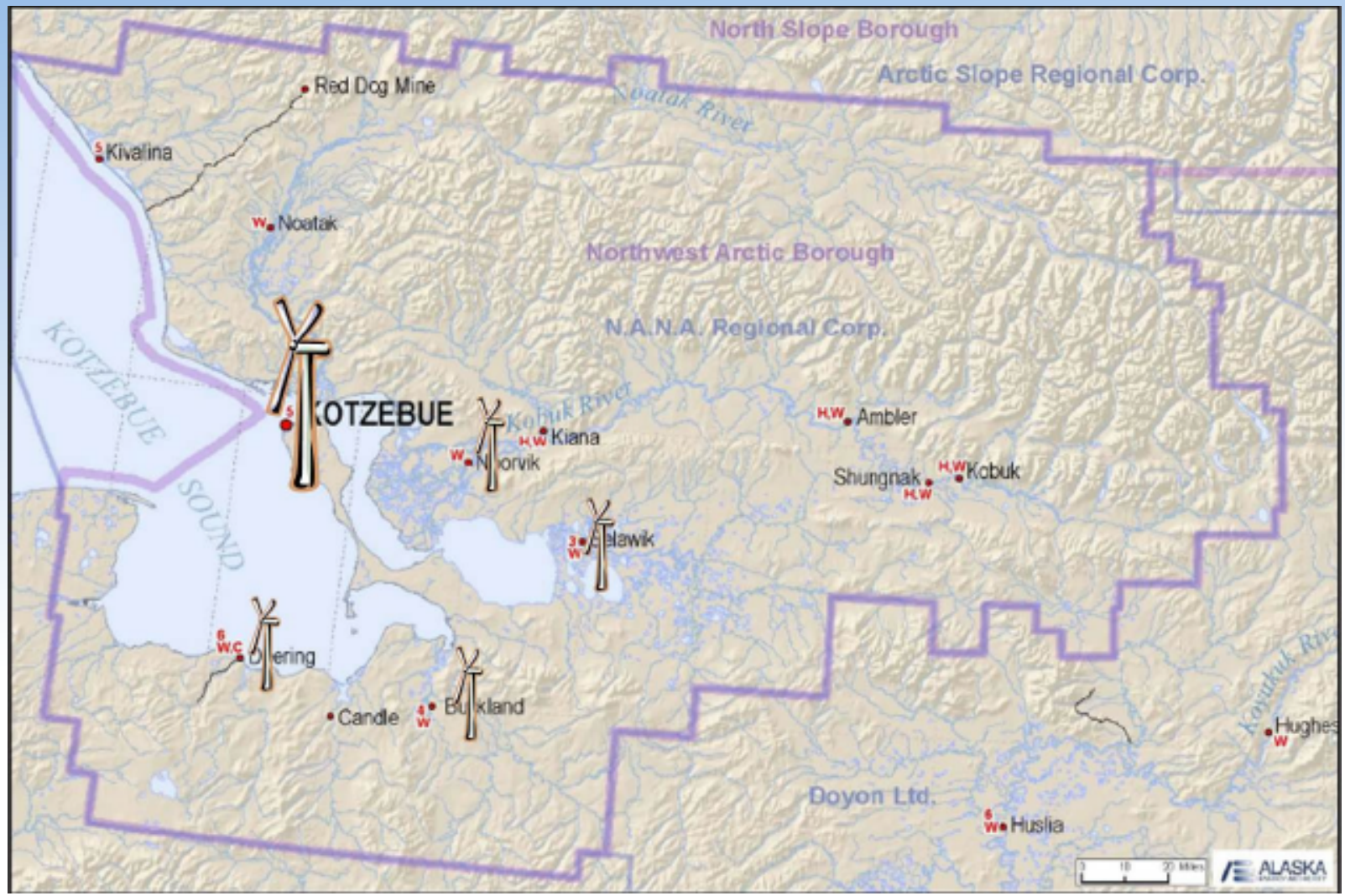
- VARs can be provided by a synchronous condenser or an inverter.
- Frequency is balanced with a secondary load controller.
- Voltage must be regulated with power electronics.
- The need for spinning reserve can be reduced with energy storage.

VAR Support

SYNCHRONOUS CONDENSER
CONTROL CABINET
Kokhanok


Wales
WIND-DIESEL HYBRID POWER SYSTEM
ROTARY CONVERTER CONTROL CABINET

Northwest Alaska Economies of Scale

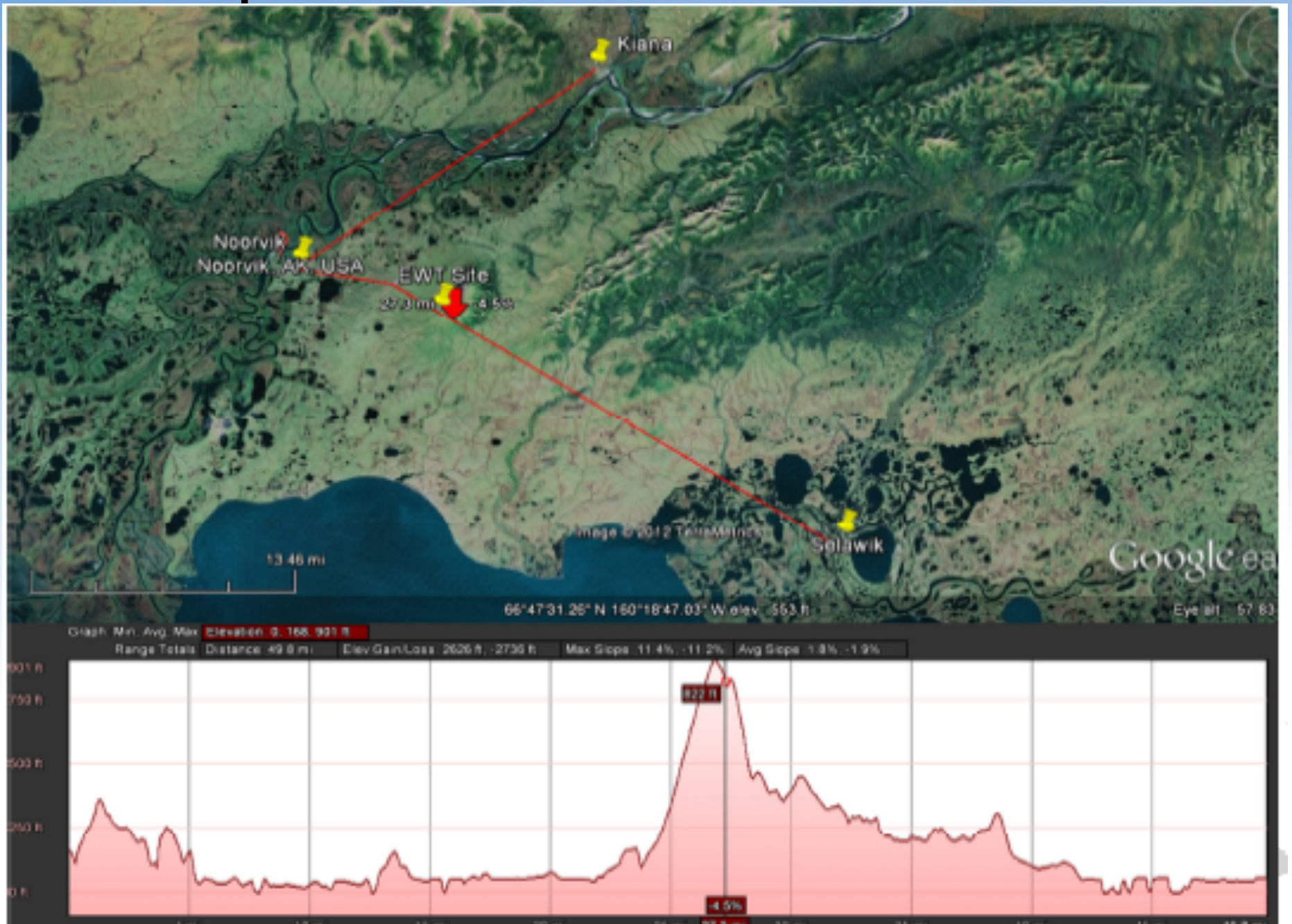


Regional Vision

- Developing wind projects regionally to improve long term sustainability
- Investigate interties which connect isolated villages to stranded resources in order to decrease cost of electricity
- Investigate stranded renewables for larger scale development

2008 North West Arctic Regional Energy Summit

Example of Intertie at Hotham Peak



Kotzebue Wind Farm Expansion

- 75% instantaneous penetration
- Increased installed capacity from 1.14 MW to 2.94 MW.
- Premium Power 3.74 MWh Flow Battery shipping was not adequate for the arctic climate
- Considering a synchronous condenser or static VAR support for power quality.

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Re-Powering Selawik

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Buckland, Deering, and Noorvik Wind-Diesel Construction

- Fall 2013

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Noorvik Photomontage

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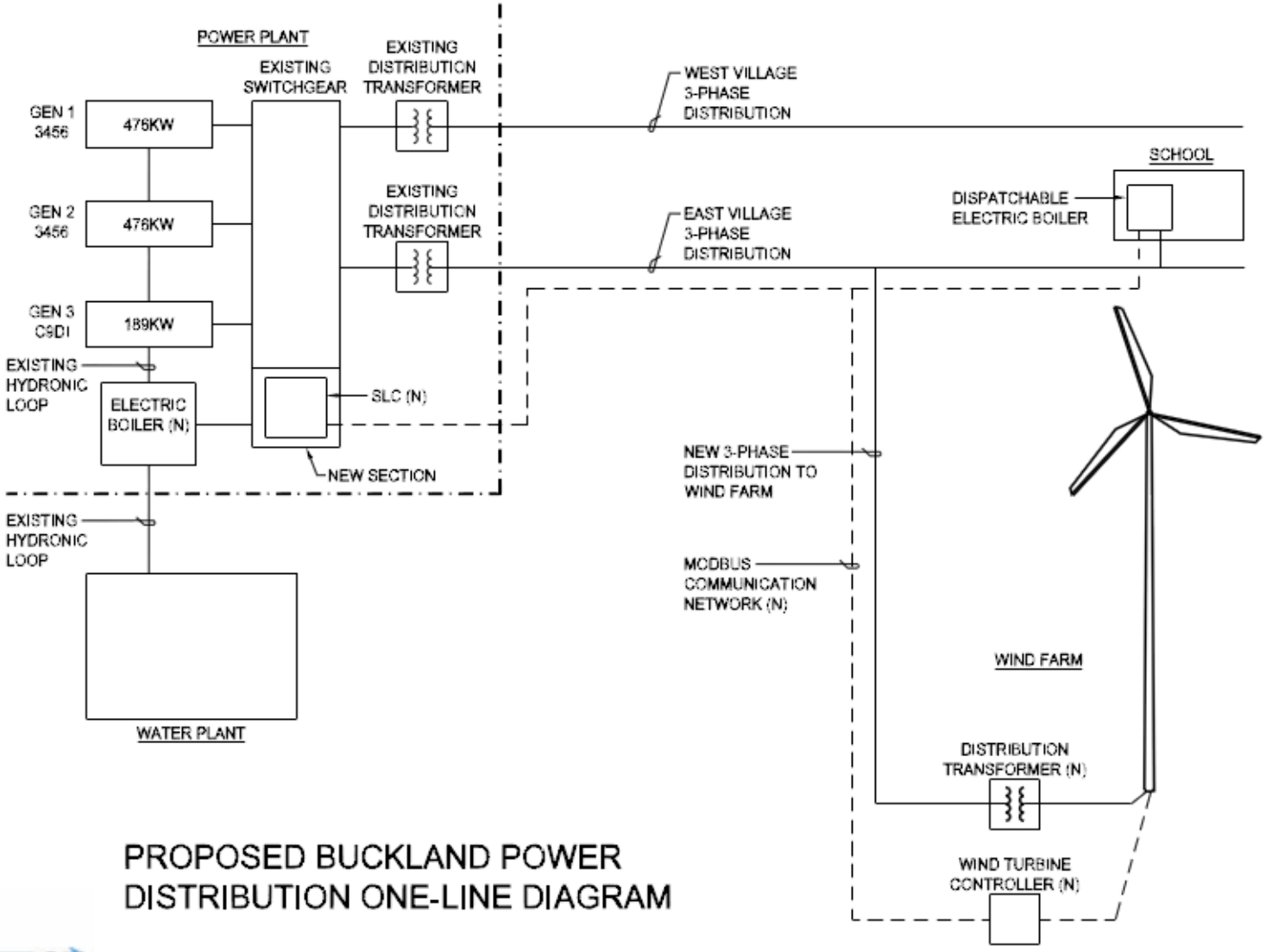
Proposed Buckland One-Line



PROPOSED BUCKLAND POWER DISTRIBUTION ONE-LINE DIAGRAM

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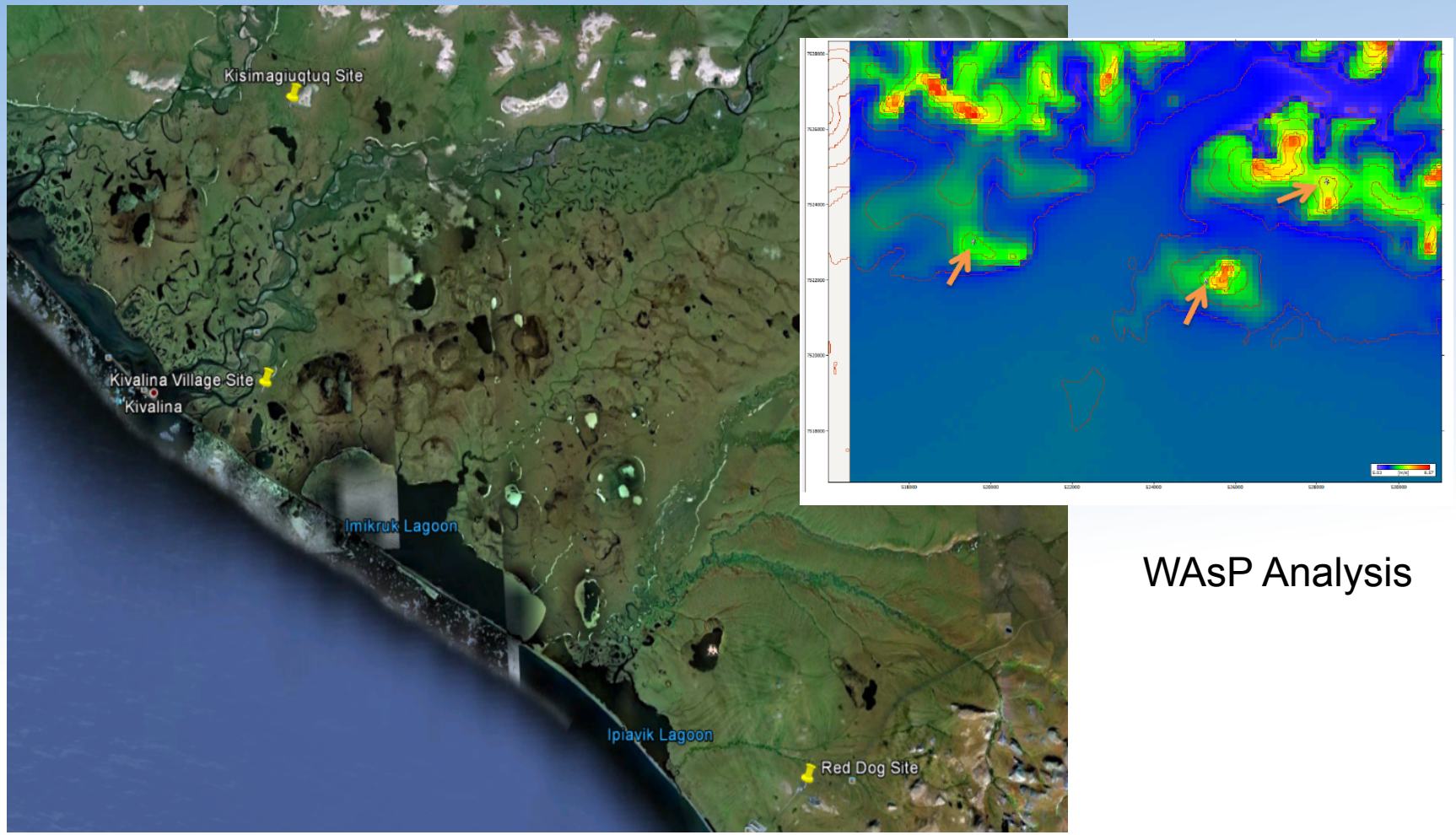
Kivalina Conceptual Design

- Village relocation due to coastal erosion.



WAsP Analysis

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Deployment Challenges

- Outdated switchgear which increases project capital cost
- No as-builts for existing power plants

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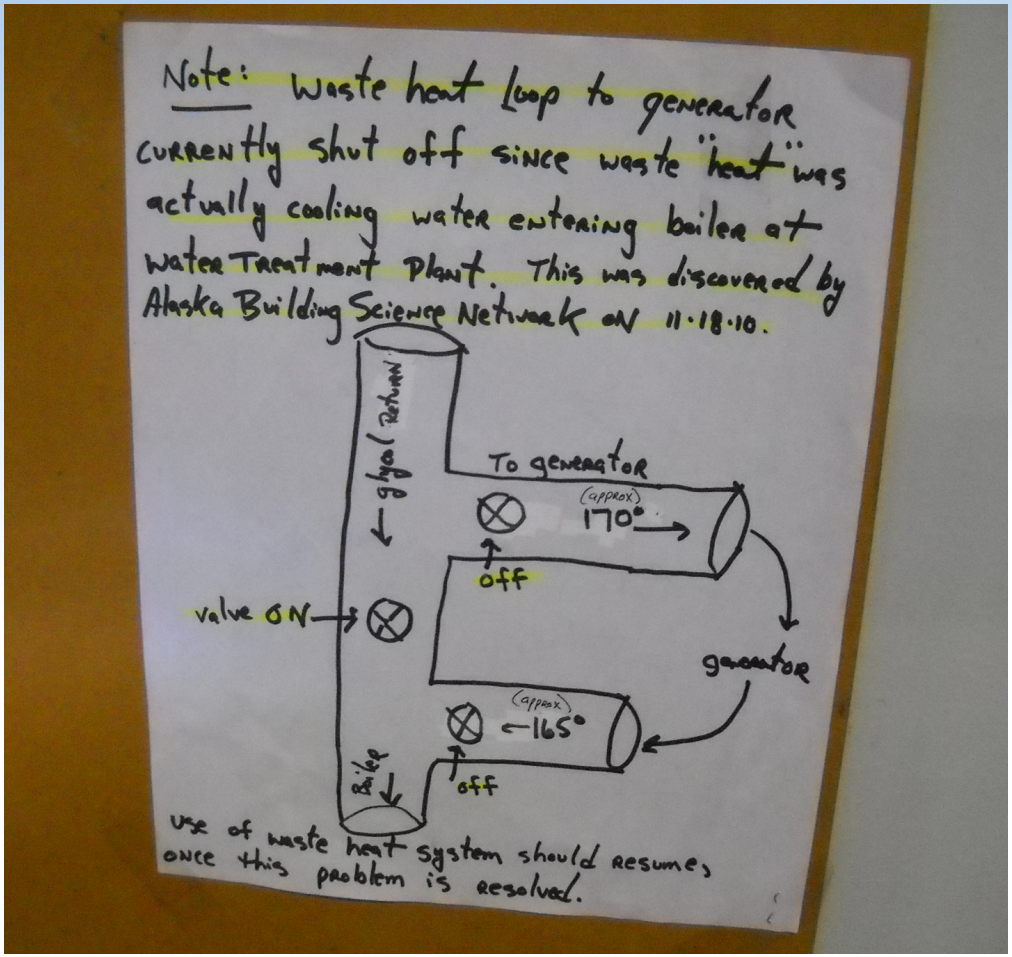
Deployment Challenges

- Existing diesel only and waste heat recovery systems are not running optimally and need attention.



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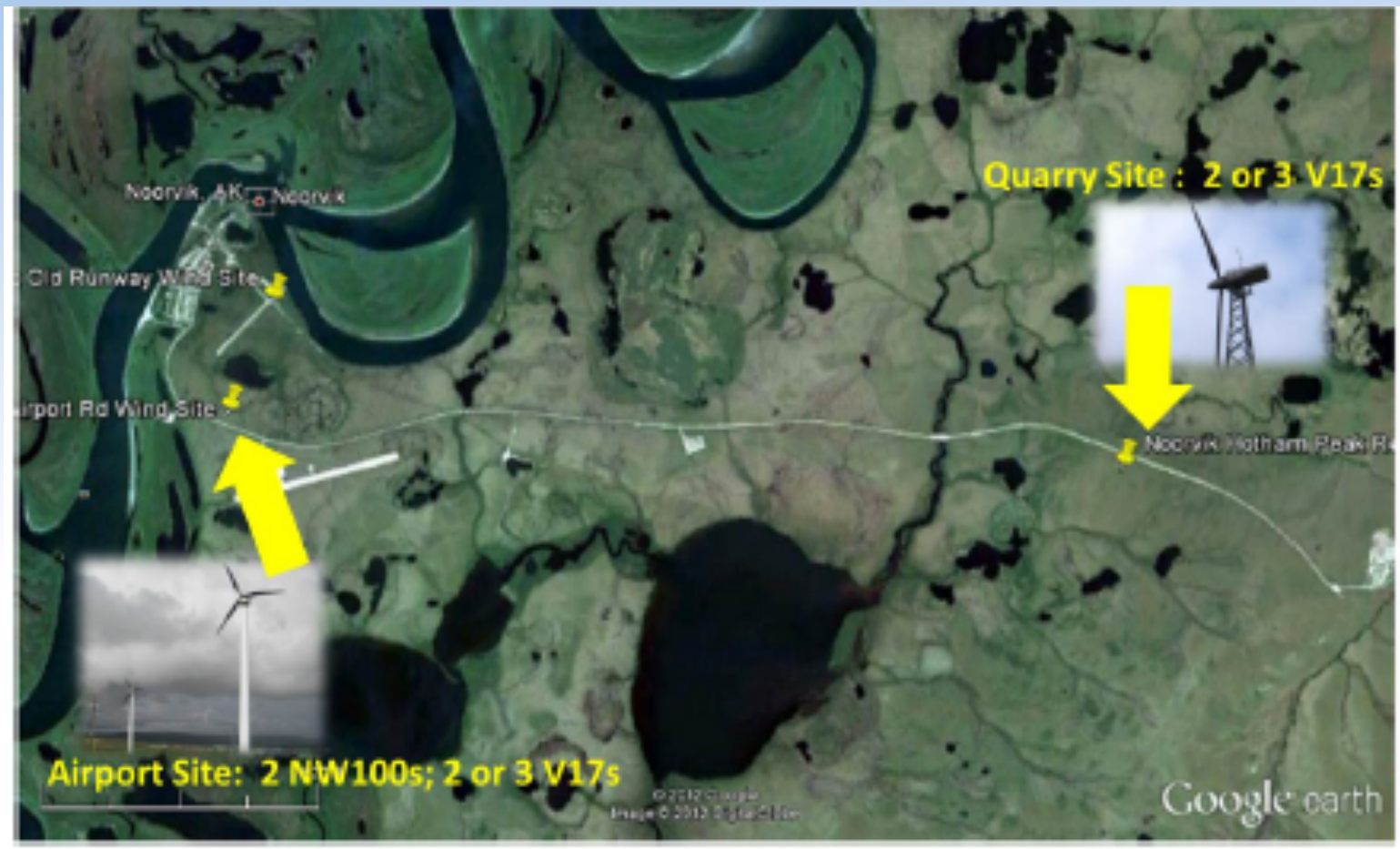
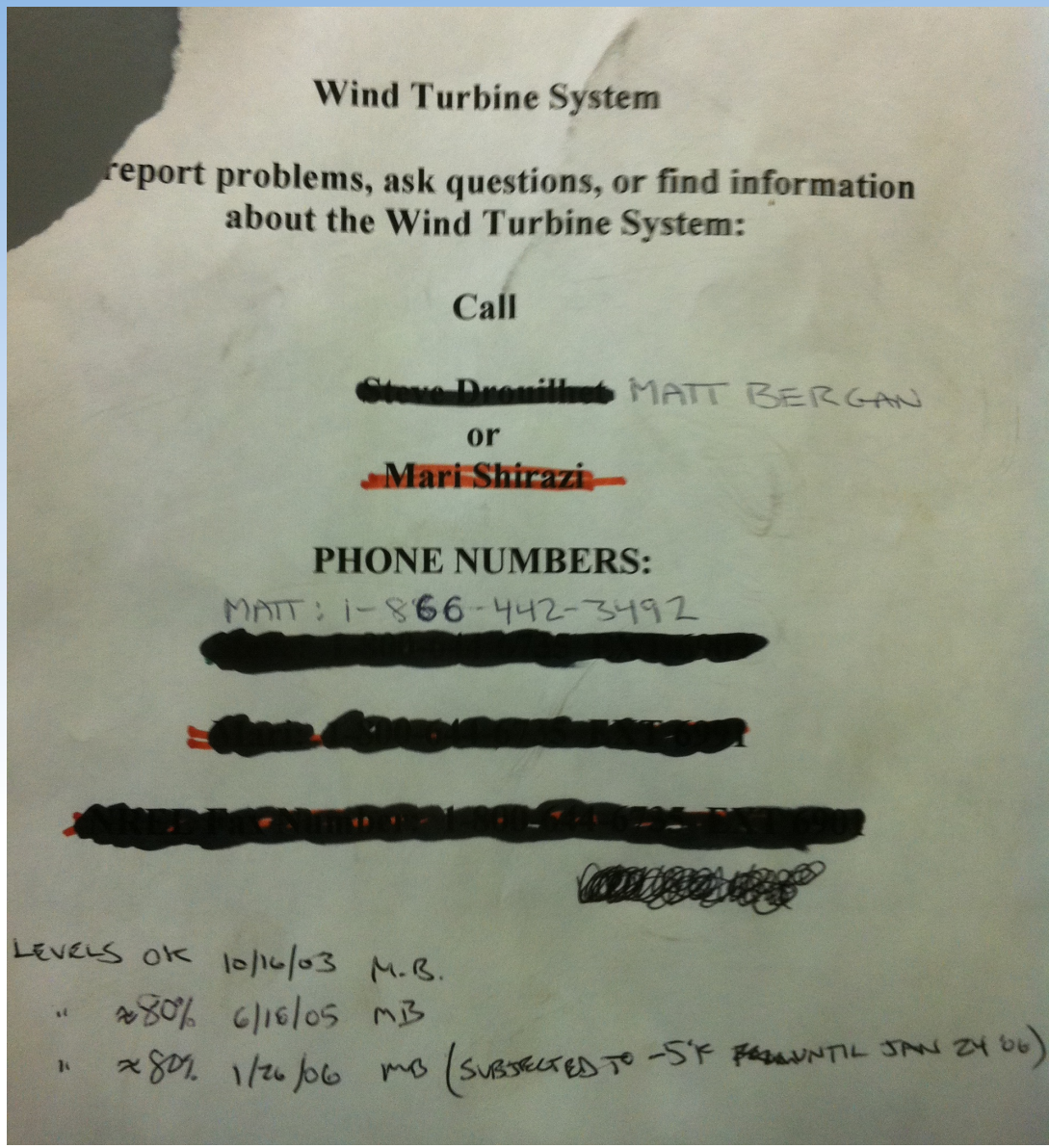
Deployment Challenges

- Quality wind resources are often away from the community so there is an increased cost to construct distribution lines.



Deployment Challenges

- Project champions and key personnel can leave during project implementation causing delays.



Wind Turbine System

report problems, ask questions, or find information about the Wind Turbine System:

Call

~~Steve Drouillard~~ MATT BERGAN

or

~~Mari Shirazi~~

PHONE NUMBERS:

MATT: 1-866-442-3492

[redacted]

LEVELS OK 10/16/03 M.B.

" ≈80% 6/16/05 MB

" ≈80% 1/26/06 MB (SUBJECTED TO -5°F UNTIL JAN 24 06)

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Deployment Challenges

- Lack of internet bandwidth needed for communication for data collection and health monitoring.
- No local cranes for install or ongoing maintenance.
- Cold climate makes winter maintenance and turbine operation more challenging.

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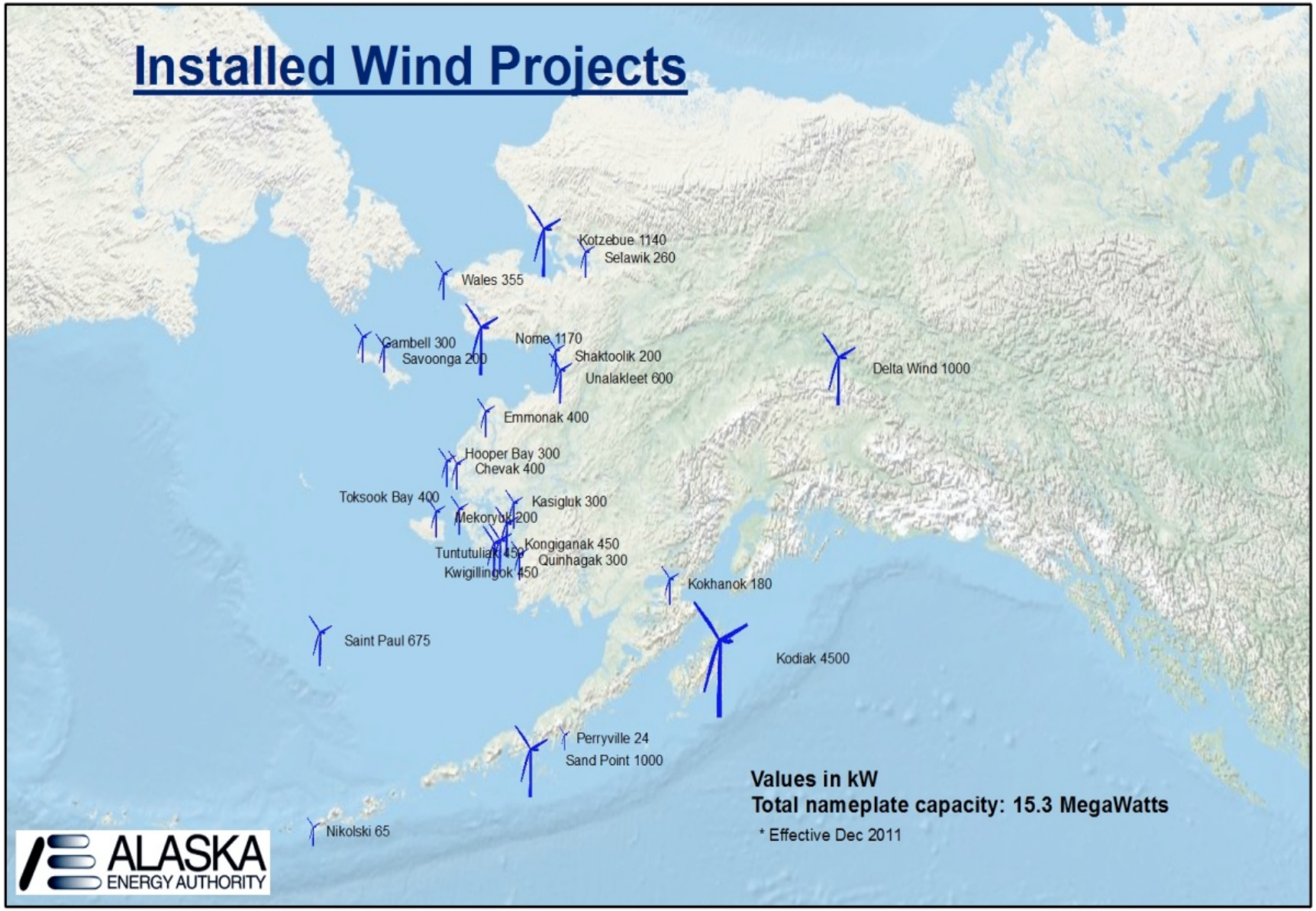
Deployment Challenges

- Technology Barriers
  - VAR support (reactive power) is needed for induction motors.
  - Real and reactive power need to be balanced at all times.
  - Need appropriate and reliable energy storage
  - Capital cost of ancillary equipment is high.

Installed Wind Projects



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Alaska Innovation

http://www.armyparatrooper.org/dropzone/showthread.php/22477-The-Many-uses-of-Duct-Tape-in-Alaska

What Will It Take?

- Demand-side management with wireless load monitoring and control.
- Advances in diesel technology to allow for low loading of the diesel gen-sets.
- Cost effective foundation design and shipping methodologies.
- Training programs to build up knowledge base and workforce.
- Dynamic modeling for optimization and design support

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Alaska Workforce Development

Kid Wind Challenge (Wind for Schools)

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