

DOE OFFICE OF INDIAN ENERGY

# EERE Technologies for Alaska

## Day 1

Bethel, Dillingham & Juneau

March 23 to April 1, 2015



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Indian Energy

A photograph of three wind turbines on a mountain ridge. The turbines are white with three blades each. The mountain is covered in green grass, and a thick layer of white fog or mist is rolling over the ridge, partially obscuring the base of the turbines. The sky is a clear, light blue. The overall scene is serene and emphasizes clean energy.

# EERE TECHNOLOGY SUMMARY



## Technology Videos

DOE's Energy Efficiency and Renewable Energy (EERE) Technology Videos:

EERE video library:

[http://energy.gov/eere/videos.](http://energy.gov/eere/videos)

A photograph of three wind turbines on a mountain peak. The turbines are silhouetted against a bright blue sky. The mountain is covered in green grass, and there is a thick layer of white mist or clouds at the base of the turbines. A dark blue banner with white text is overlaid at the bottom of the image.

**ENERGY EFFICIENCY FIRST**

# Community-Scale Consumption and Savings Potential

- Homes and commercial buildings consume 41% of U.S. energy
- The average Alaskan Native Village spends \$5,500 annually on energy costs, 10 to 20% of which is wasted from air leakage and outdated heating, ventilating, and air-conditioning (HVAC)
- The product of COMFORT in addition to monetary savings makes energy efficiency a valuable product

Data source: U.S. Department of Energy

# Energy Efficient Technologies

- Deep energy retrofits
- Net Zero Energy Ready Homes
- Air Source Heat Pump
- Water heating
  - On demand tankless
  - Heat pump hot water
- Appliances
- Retro-commissioning
- Building energy modeling tools
- Lighting

## ■ Deep Energy Retrofits

- Building performance whole-house approach
  - Residential, Facility and Commercial
- Insulation and air sealing
- Heating & cooling upgrades
- Natural & Healthy Ventilation
- Efficient building controls
- Lighting and daylighting upgrades
- Savings of 30% or more

# The Tightest Home

- 28 inch thick walls
- Almost zero air leakage
  - .05 ACH 50
- Heat Recovery Ventilator
- 

- Only incoming energy is for hot water, air source heat pump, appliances and lighting
- Majority of heat comes from internal byproducts of lighting, appliances, body heat, passive solar gain.
- Other heat comes from a rarely used electric heat pump (35 gallons of heating oil/year)





# Net Zero Energy Ready Home – Dillingham AK

	Electricity	Heating Fuel	Total
Average house in Dillingham	\$1,200 or 5,930 kWh	\$4,200 or 700 gallons of diesel oil	\$5,400
Net Zero Energy Ready	\$770 or 3,200kWh	Zero	\$770



# Ductless Mini-split Heat Pump (Air Source Heat Pump)



# Air Source Heat Pump

See Efficiency Vermont for approved cold climate units:

[https://www.energycorner.vermont.gov/docs/for\\_my\\_home/cold\\_climate\\_heat\\_pumps/evt-cchp-distr.pdf](https://www.energycorner.vermont.gov/docs/for_my_home/cold_climate_heat_pumps/evt-cchp-distr.pdf)



## Energy Recovery Ventilators (ERVs)

- Exchange stale indoor air with fresh outdoor air, recovering heat and moisture from the exhaust air and transferring it to supply air.
- More popular in cold climates, only recover heat from exhaust air and thus dry out the indoor air.
- ERVs could help improve indoor air quality by adding moisture to the air.

# Zero Energy Ready Homes

- 1,055 square foot home
- Six inch structural insulated panels (SIP) walls
- 10 inch SIP roof
- Insulated concrete forms (ICF) foundation walls with R-20 high-density rigid EPS foam under the slab
- Ductless heat pump heats and cools the home
- Passive solar
- Triple-pane windows
- Exhaust fan provides ventilation by drawing in tempered outside air through a 100 foot “earth tube” buried two feet underground
- \$144 per square foot (L48 price)



Source: DOE:

[http://www.energy.gov/sites/prod/files/2014/09/f18/DOE\\_ZEH\\_TCLegendCedarwood\\_09-20-14\\_0.pdf](http://www.energy.gov/sites/prod/files/2014/09/f18/DOE_ZEH_TCLegendCedarwood_09-20-14_0.pdf)

# Appliances

- Clothes washers – ENERGY STAR brands
  - Use 15 gallons of water per load compared to 23 gallons used by a standard machine.
  - 20% more efficient than non Energy Star washers, and only use 270 kWh of electricity annually
- Dishwashers – Older than 1994? Per cycle you will use an extra \$35/year and wastes more than 10 gallons of water per cycle.

# ENERGY STAR Rated Refrigerators

Refrigerator and freezer replacement are often overlooked as big money savers

- Can save an estimated \$150 annually by replacing one 10 years old or older
- ENERGY STAR refrigerators are 9-10% more efficient than non-ENERGY STAR brands
- Newer refrigerators can save \$35 to \$300 on energy costs over it's lifetime
- More than 60 million refrigerators are over 10 years old, costing consumers \$4.7 billion a year in energy costs
- Use the ENERGY STAR savings calculator to find out exactly how much money you will save by replacing your refrigerator:  
[https://www.energystar.gov/index.cfm?fuseaction=refrig\\_calculator](https://www.energystar.gov/index.cfm?fuseaction=refrig_calculator)

## Lighting

- Replace T-12 with T-5 electronic ballasts
- CFLs save 75% over a traditional incandescent lightbulb
- LED lighting saves 90% over a traditional incandescent lightbulb, but lasts much longer.

<i>All bulbs deliver equivalent brightness</i>	Single bulb wattage	Wattage used for whole house
<b>Incandescent bulbs</b>	60 watts	2,820 watts
<b>CFL bulbs</b>	14 watts	658 watts
<b>LED bulbs</b>	9.5 watts	446.5 watts



## ■ Lighting using kilowatt price of 12 cents

- **Monthly Cost of Using Incandescent Light Bulbs**

$$2.820 \times \$0.1188 \times 150 \text{ hours} = \$50.25$$

- **Monthly Cost of Using CFL Bulbs**

$$0.658 \times \$0.1188 \times 150 \text{ hours} = \$11.73$$

- **Monthly Cost of Using LED Bulbs**

$$0.447 \times \$0.1188 \times 150 \text{ hours} = \$7.97$$

# Retro-Commissioning a Building

- Retro-commissioning (RCx)
  - Identifies and improves less than-optimal energy performance in a large building's equipment and control systems.
  - The intent is for existing systems to work as efficiently as designed.
  - Evaluation and fine-tuning of heating and lighting systems can be implemented as a one-time intervention, frequent “re-tuning,” or ongoing “continuous commissioning,” to ensure that the energy savings persist.
- Native Alaskan Tribes can use RCx as a lead component of facilities' energy efficiency projects
- Retro-commissioning for public buildings is **a low-cost way to reduce energy costs by 10% to 20%** and can free up funds for other uses.

# Retro-Commissioning Guidelines

- Retro-commissioning is one part of an effective buildings energy efficiency policy suite, and an organization-wide energy management program.
- Retro-commissioning should be accompanied by benchmarking, rating, and disclosure policies so that building owners are more motivated to undertake RCx and so buildings can clearly demonstrate improved energy performance to the market.
- Retro-commissioning should not be a one-time effort, it should be followed-up with regular performance feedback, continuous improvement efforts, support for in-depth technical analysis of major equipment investment opportunities, technical assistance, and financial incentives.

# ■ Financing Retro-Commissioning

- Energy Service Company (ESCO)
- Loans
- Utility Incentives
- Small Business Initiatives Programs
- Train facility managers how to benchmark their buildings to determine RCxing opportunity
- Average Cost - \$0.03 To \$3.86 per square foot
- Average investment = \$33,696

# Scope of a Retro-commissioned Project

- Number and complexity of systems
- Size of the facility
- Equipment age and condition
- Commissioning service provider rates
- Level of on-site staff knowledge interfacing with the project
- Presence of an extensive operations & maintenance (O&M) program

## ■ ■ Non-energy Benefits to RCxing

- Improved environmental performance of building stock
- Increased thermal comfort and air quality in workspaces
- Increased employee productivity
- Increased O&M staff knowledge of their building and occupants
- Begin budgeting for future energy upgrades

# Retro-Commissioning Key Points

- Retro-commissioning is a process for “tuning up” a building’s equipment to make it work as efficiently as possible without major capital investment.
- Retro-commissioning for public buildings is a low-cost way to reduce energy costs by 10% to 20% and can free up public funds for other uses.
- Successful retro-commissioning policies go beyond a one-time effort, encouraging building owners to follow-up with regular feedback to ensure continued performance.

# EE Case Study: Nunamiut Village Corporation

Energy Upgrades	Project description
Energy education	Five Community Buildings in Anaktuvuk Pass, AK: Manager's dwelling, corporation office, hotel, restaurant, and village store.
Heating system replacements	<b>RESULTS:</b>
Door and window replacements	<b>\$313,478 cost of upgrades</b>
Insulation and air sealing	<b>\$55,000 annual energy savings</b>
On demand hot water installed	<b>5 year payback</b>
Upgrade chillers, freezers for key commercial sites	Project Background: Yukon Watershed Council environmental cleanup to "Once again drink clean water directly from the Yukon River as our ancestors did for thousands of years before us."
Lighting: Replaced T-12 with T-8 electronic ballasts. 132 LED bulbs replaced	The energy efficiency project contributed to the environmental cleanup planned since 1977.



The image shows three wind turbines on a mountain peak. The turbines are white with three blades each. The mountain is covered in green vegetation, and there is a thick layer of white mist or fog at the base of the turbines. The sky is a clear, bright blue. A large, semi-transparent blue rectangular box is overlaid on the lower portion of the image, containing the text 'BUILDING HEAT AND HOT WATER' in white, bold, sans-serif capital letters.

# BUILDING HEAT AND HOT WATER

# Solar Vent Preheat (SVP)

- A preheating air system
- Sunlight strikes south facing vertical box wall.
- South-facing wall surface is best
  - 45° of south gives 80%



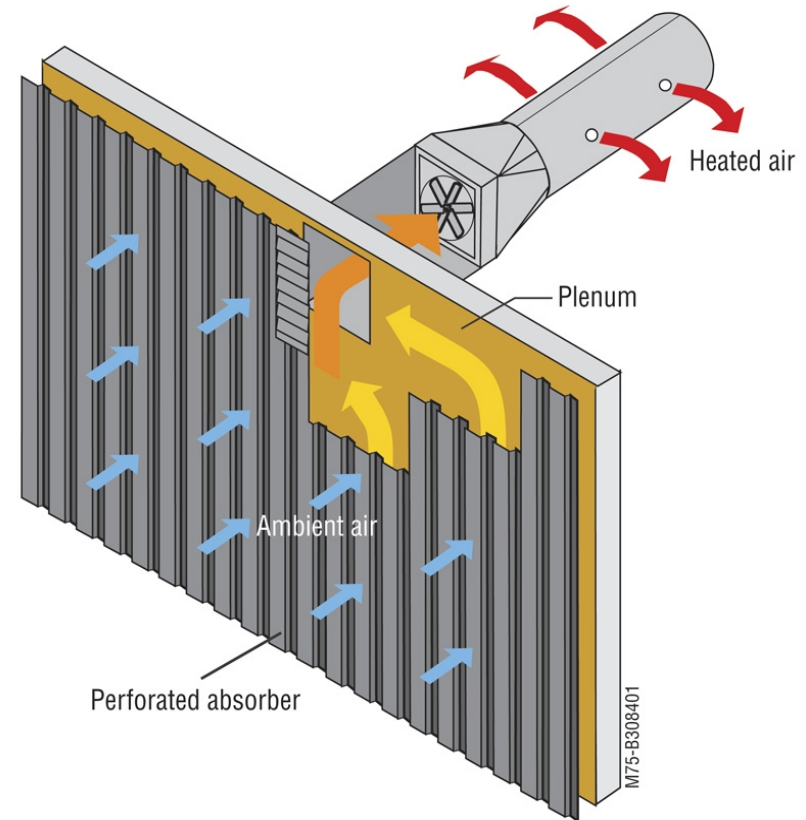
NREL/PIX 09173



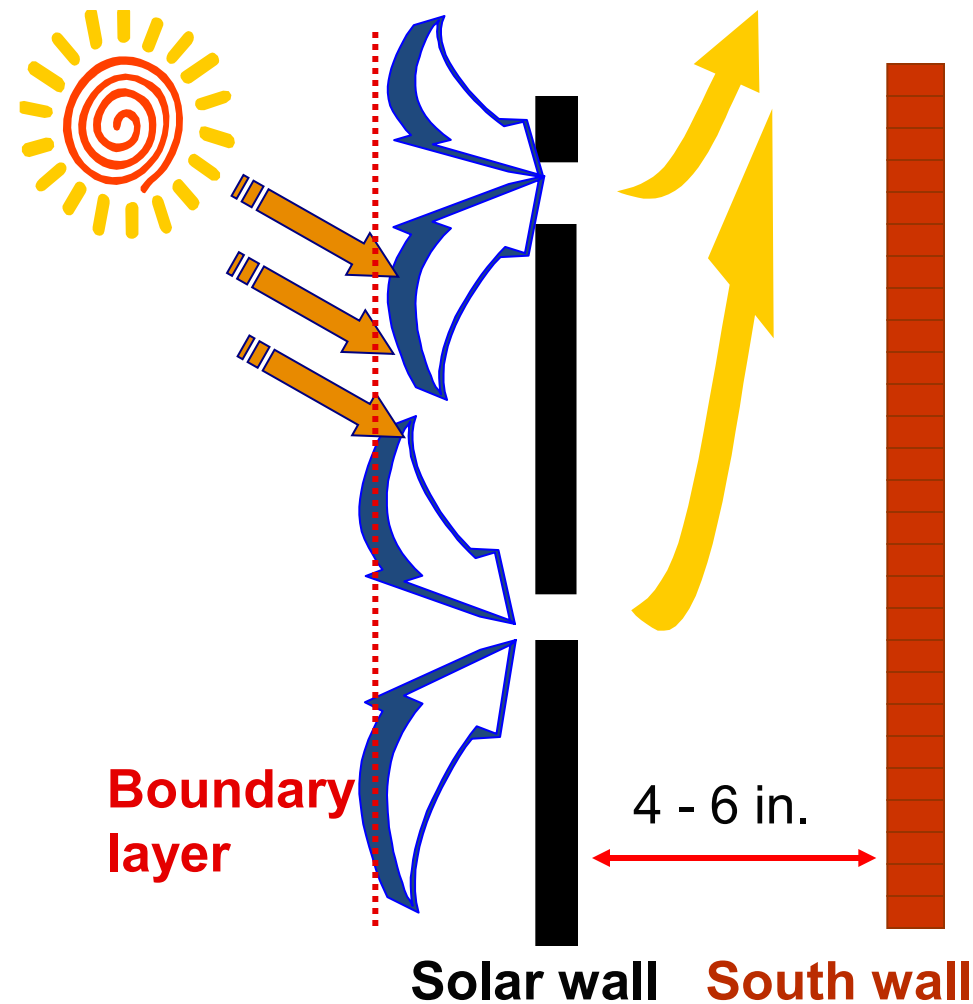
NREL/PIX 09355

# System Components

- Transpired solar collector
  - Perforated sheet of corrugated metal
- Air distribution
  - Ductwork, fan, and bypass damper
- Controls
  - Temperature and time clock or Energy Management Control System (EMCS)



# Solar Vent Preheat Principle



- Sun warms the collector surface
- Heat conducts from collector surface to thermal boundary layer of air (1 millimeter [mm] thick)
- Boundary layer is drawn into perforation by fan pressure before heat can escape by convection

# Advantages of Solar Vent Preheat

- Relatively low cost for on-site renewable energy utilization
- Reliability of equipment and system
  - Only moving part is the fan
  - Operates at ambient temperature
- Very low maintenance
- High efficiency
- No storage



NREL 17424



NREL 178254

# Generic LCOE -Cost Example

Building Occupancy	Daytime/7 days/week
Collector Area	30 feet (ft) x 60 ft
Energy Savings	150 kilowatt British thermal unit (kBtu)/square feet (ft <sub>2</sub> ) x 1800 ft <sub>2</sub> = 270 one million British thermal units (MMBtu)
Collector Cost	\$19,800
State Tax Credit	\$6,534 (33%)
Federal Tax Credit	10% = \$1,980
Accelerated Depreciation	Varies 10% up to \$2,000
Net Cost	\$10,000
Simple Payback	4 years
Heating Efficiency	70%



NREL 00957

Solar Vent Preheat

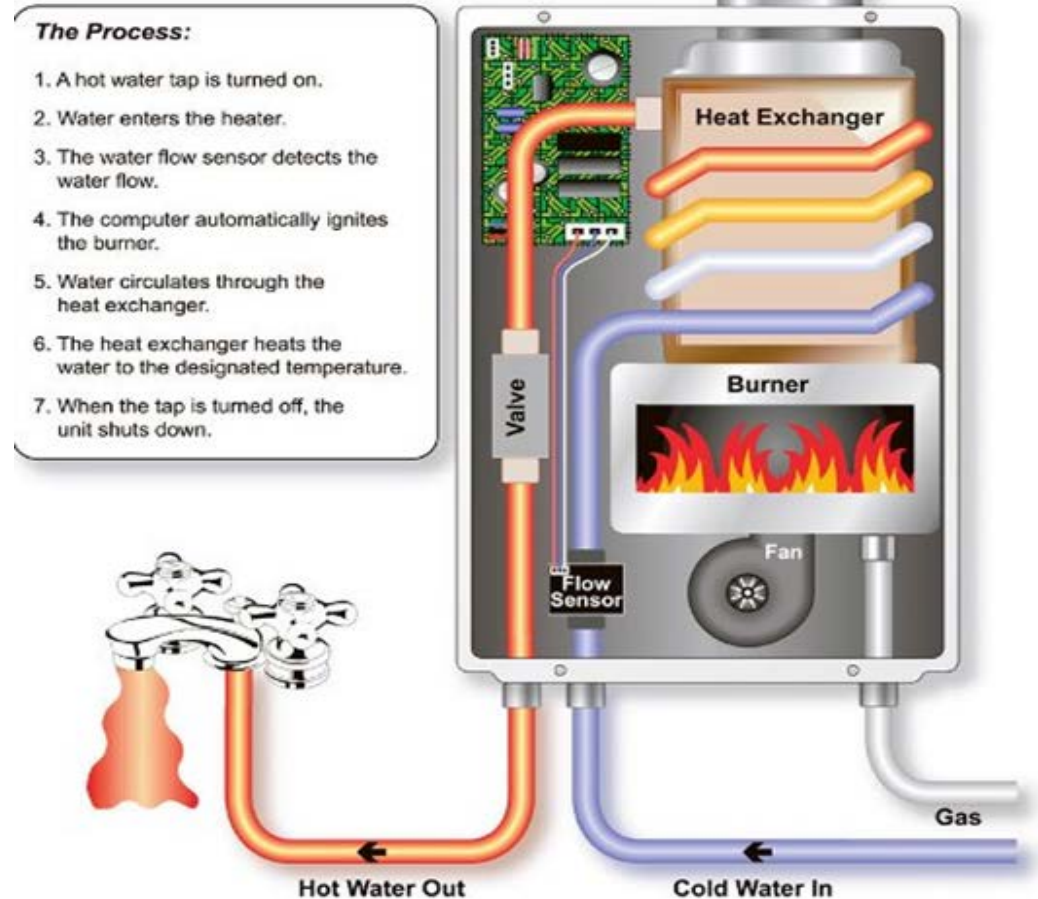


Photo from Rapid City, South Dakota, Recreation Center

# Tankless Hot Water Heat

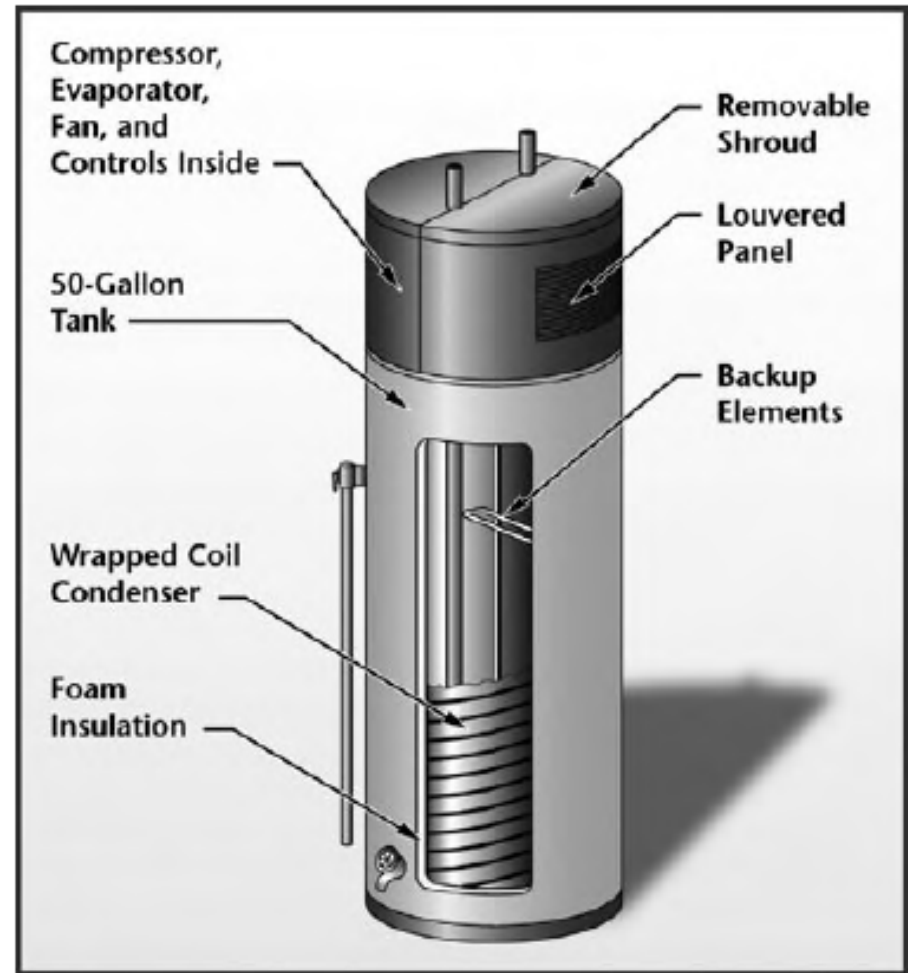
- On demand (tank less or instantaneous) water heaters provide hot water only as needed
- Eliminate standby energy losses associated with hot water storage tanks
- On demand DHW characteristics:
  - Typical hot water flow rate of 2 – 9 gallon/minute
  - Can serve 1 to 3 bathrooms
  - Equipment lifetime  $\geq 20$  years
- Typical annual energy savings range from 8% to 25%

## How Does a Tankless Water Heater Work?

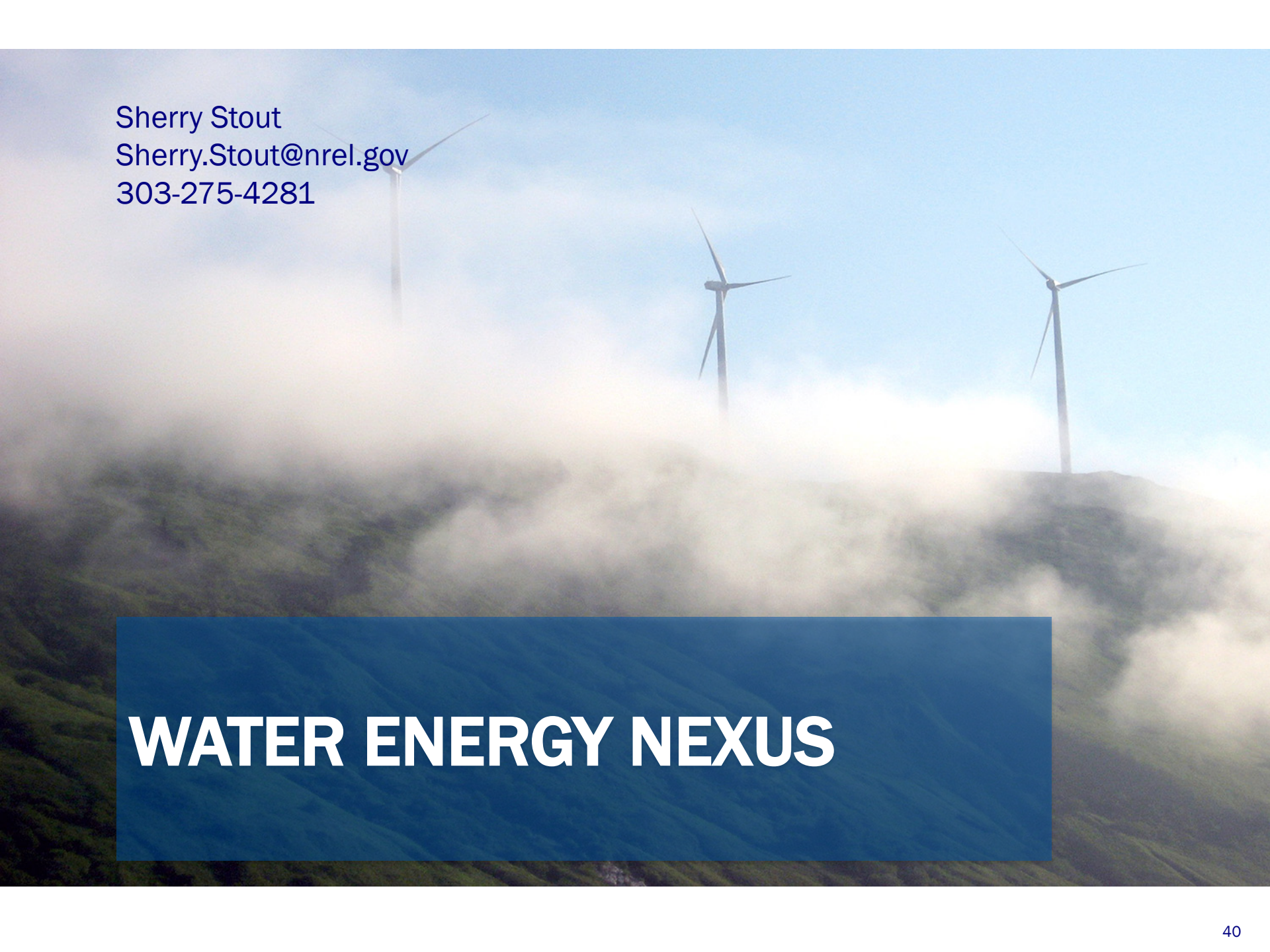


# Heat Pump Hot Water Heat

- Average energy savings over electric resistance heater is 40% to 60%
  - Depending on hours/year electric resistance back up heating element has to be used
- Typical payback periods are less than 3 years





The background of the slide is a photograph of three wind turbines situated on a mountain ridge. The turbines are white with three blades each. The sky is a clear, bright blue, and there are soft, white clouds or mist around the base of the turbines and the mountain. The overall scene is clean and modern, representing renewable energy.

Sherry Stout  
Sherry.Stout@nrel.gov  
303-275-4281

# WATER ENERGY NEXUS

# Water/Wastewater Systems



Wastewater lagoon Goodnews Bay  
Photo Source: ANTHC

- Water/wastewater systems require heating to prevent freezing
  - Both the pumping and heating are significant energy loads
  - Villages planning to add wastewater systems need to plan these loads into their electrical systems
  - The addition of water/wastewater systems will increase village electrical demand by 20-30%

## Water/Wastewater Systems Continued

- With appropriate storage, water/wastewater treatment systems can be ramped up and down to correspond to peak output from RE systems
  - These systems can act as a sort of demand-response system on isolated grids to balance loads

# Wastewater Treatment

- Wastewater heating
  - Open (evaporation) lagoons often freeze in the winter and can have sub-optimal temperatures even in the summer
  - Additional heating of the lagoon (beyond the natural metabolic heat produced by microorganisms) can quicken the degradation process rendering the waste safer in a shorter amount of time
    - RE systems can be used as energy source for heating needs
- Anaerobic Digestion
  - Takes advantage of the same processes found in the open lagoons but concentrates the waste and microorganisms
  - With a large enough feedstock, AD can produce methane gas in recoverable quantities
  - In Alaska, systems need to be insulated and/or placed in heated buildings to maintain appropriate heat levels
  - Thermally efficient systems can reach temperatures high enough (125-135 degrees F) to kill 99.99% of pathogens

# Water Treatment



**UV Reactors** - After membrane filtration, the water is further disinfected using high intensity ultraviolet (UV) light. Each UV reactor contains seven high intensity UV bulbs which "shine" on the water as it passes through the reactor.

Photo Source: City of Thornton, CO

- UV Water Treatment
  - Can be used to disinfect water without chlorine
  - Slightly more energy intensive than chlorine treatment
    - Can be paired with renewable energy sources (wind, solar)
      - Treatment systems can be ramped up and down to correspond with peak RE output
  - No need to ship and store chlorine

# Water and Renewables

- Renewable energy sources such as solar and wind are intermittent and require either energy storage or backup generators to supply constant power.
- Common energy storage includes batteries or ceramic thermal storage
- Hot water loops can also be used to store power in the form of thermal energy
- RE produced hot water can be used to heat water/wastewater systems and other large thermal loads (e.g. schools, clinics, etc.)



Photo Source: Ian Baring-Gould / NREL

A photograph of three wind turbines standing on a mountain ridge. The turbines are partially obscured by a thick layer of white mist or fog that fills the valley and clings to the slopes. The sky above is a clear, pale blue. The overall scene is serene and emphasizes clean energy in a natural setting.

# SOLAR PHOTOVOLTAICS (PV)



# Photovoltaics System (Grid Connected)

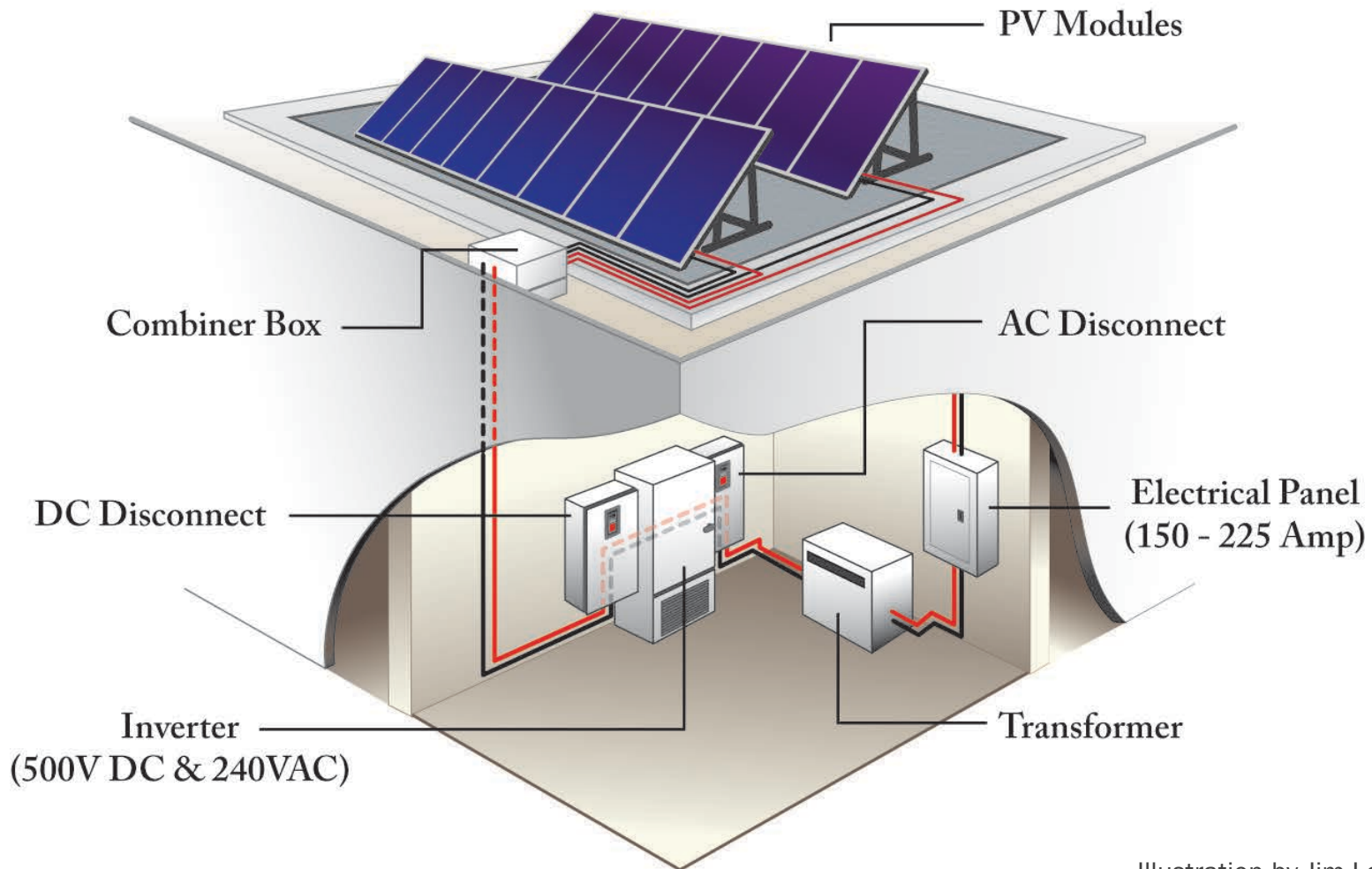
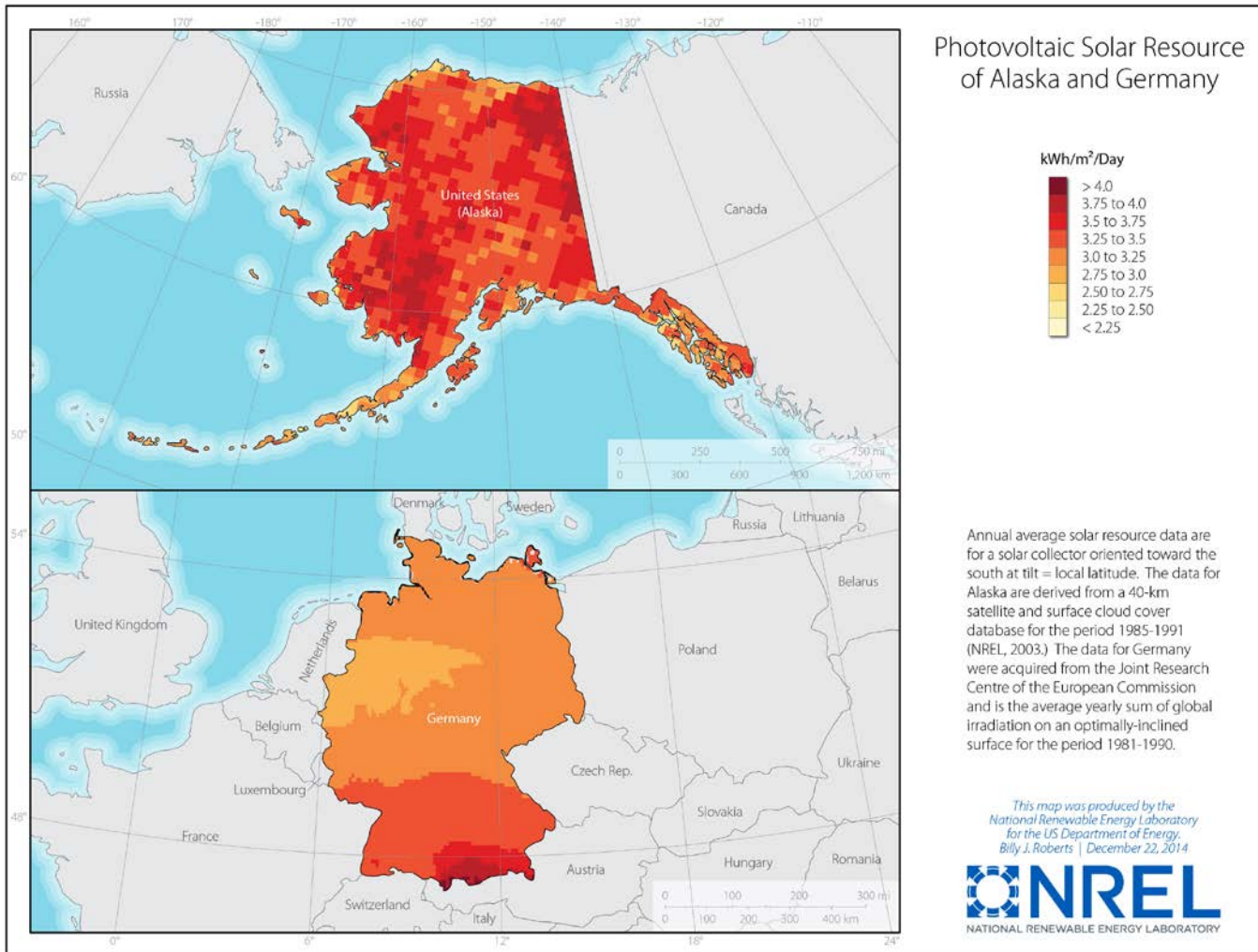


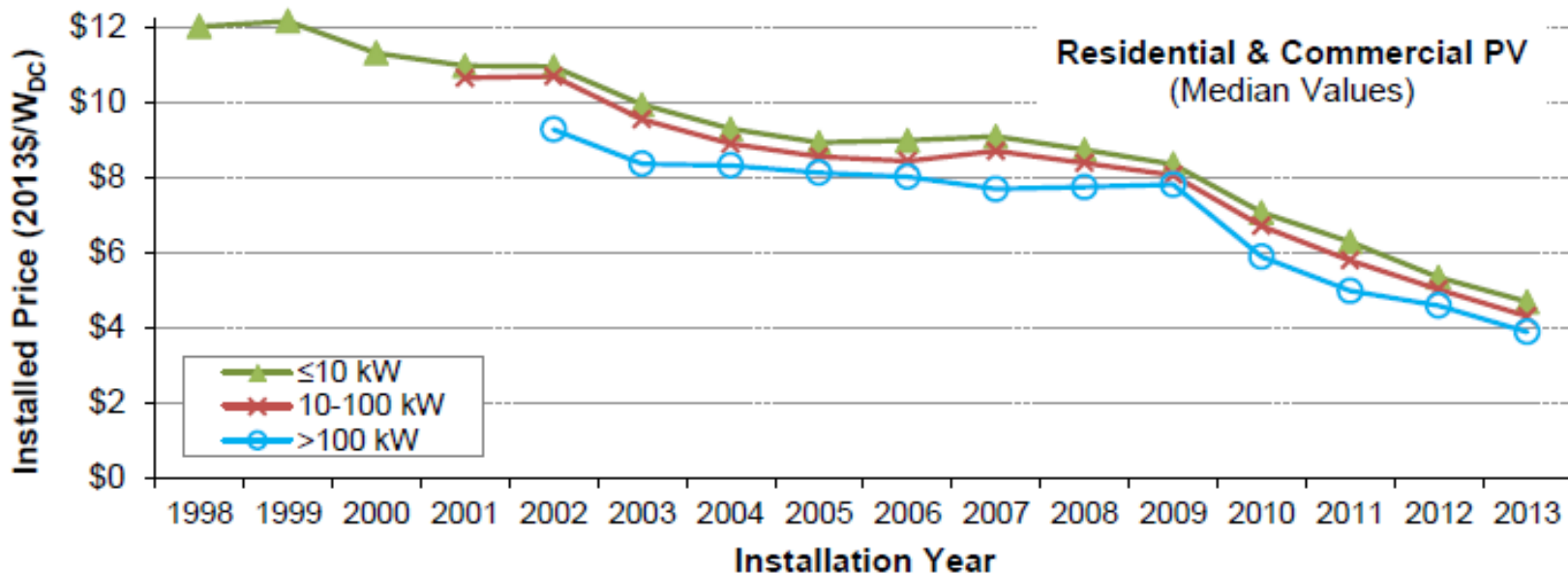
Illustration by Jim Leyshon, NREL



# Alaska has a significant solar potential



# Installed Price of Residential and Commercial PV Over Time



Notes: See Table 1 and Table B-2 for residential and commercial PV sample sizes by installation year. Median installed prices are shown only if 15 or more observations are available for the individual size range.

**Figure 6. Installed Price of Residential & Commercial PV over Time**

Source: EIA 2005 data

Source: Lawrence Berkeley National Laboratory, "Tracking the Sun VI". <http://emp.lbl.gov/sites/all/files/lbni-6350e.pdf>

# Solar PV in Nome, Alaska

- Bering Straits Native Corporation (BSNC) installed a 16.8 kW solar PV system on the headquarters office building in 2008
- The PV array produces approximately 16,000 kWh of electricity per year, offsetting approximately 1,000 gallons of diesel fuel annually
- BSNC also installed solar hot water heaters on two corporation-owned apartment buildings.

Learn more:

<http://alaskarenewableenergy.org/why-renewable-energy-is-important/alaskas-renewable-energy-projects/#sthash.EaCjnh9.dpuf>



Photo courtesy of The Bering Straits Native Corporation

# Kaltag Produces Small Scale Solar PV on the Yukon River

- Projects were carefully developed, designed, constructed and operated
- As pilot projects, they demonstrate that solar energy can be successfully harnessed to save fossil fuel in Alaska
- The first year of operation produced approximately 8,200 kWh, which yields a fuel cost savings of \$1,797 for the Alaska Village Electric Cooperative (AVEC)'s FY13 reported efficiency of 13 kWh/gallon
- With an estimated savings of \$2,000, this was essentially accurately predicted performance.



# Northwest Arctic Borough Solar PV to Power Water and Sewer Plants

- All 11 villages will receive the solar systems by 2014
- Ambler Village exceeded expectations in March of 2013, sometimes running entirely on solar
- Peak performance in Spring due to increased day light
- Solar reflection provides up to 30% in output due to solar reflection off the snow
- Savings for each plant is between \$6,000 and \$8,000/year.



Photo courtesy of Northwest Arctic Borough

# Useful Solar Resources for PV

## PROJECT DEVELOPMENT & FINANCE “GENERAL”

- For General Project Development & Finance:  
[http://www.nrel.gov/applying\\_technologies/financing.html](http://www.nrel.gov/applying_technologies/financing.html)
- *Tribal Business Structure Handbook* (Nilles, Kathleen, NAFOA):  
[www.nafoa.org](http://www.nafoa.org)
- *Renewable Energy Handbook in Indian Country*: (Douglas C. MacCourt and Ater Wynn, Indian Law Practice  
(<http://www.nrel.gov/docs/fy10osti/48078.pdf>)

## PROJECT DEVELOPMENT “RESOURCES”

- NREL Learning About Renewables:  
[http://www.nrel.gov/learning/re\\_photovoltaics.html](http://www.nrel.gov/learning/re_photovoltaics.html)
- Renewable Energy Atlas: [http://maps.nrel.gov/re\\_atlas](http://maps.nrel.gov/re_atlas)
- PVWatts: <http://www.nrel.gov/rredc/pvwatts/>
- RETScreen: <http://www.etscreen.net/ang/home.php>

## PROJECT DEVELOPMENT “OFF-TAKE”

- Power Purchase Agreement Checklist:  
<http://www.nrel.gov/docs/fy10osti/46668.pdf>
- Renewable Portfolio Standards:  
[http://apps1.eere.energy.gov/states/maps/renewable\\_portfolio\\_states.cfm](http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm)

The image shows three wind turbines on a mountain ridge. The turbines are positioned at different heights and angles. The background is a clear blue sky with some light clouds. The foreground is a green, hilly landscape. A large blue rectangular box is overlaid on the bottom left of the image, containing the text 'WIND POWER' in white, bold, uppercase letters.

# WIND POWER





# **WIND ENERGY RESOURCE**

## **WIND OVERVIEW**

## **ALASKA WIND ENERGY POTENTIAL**

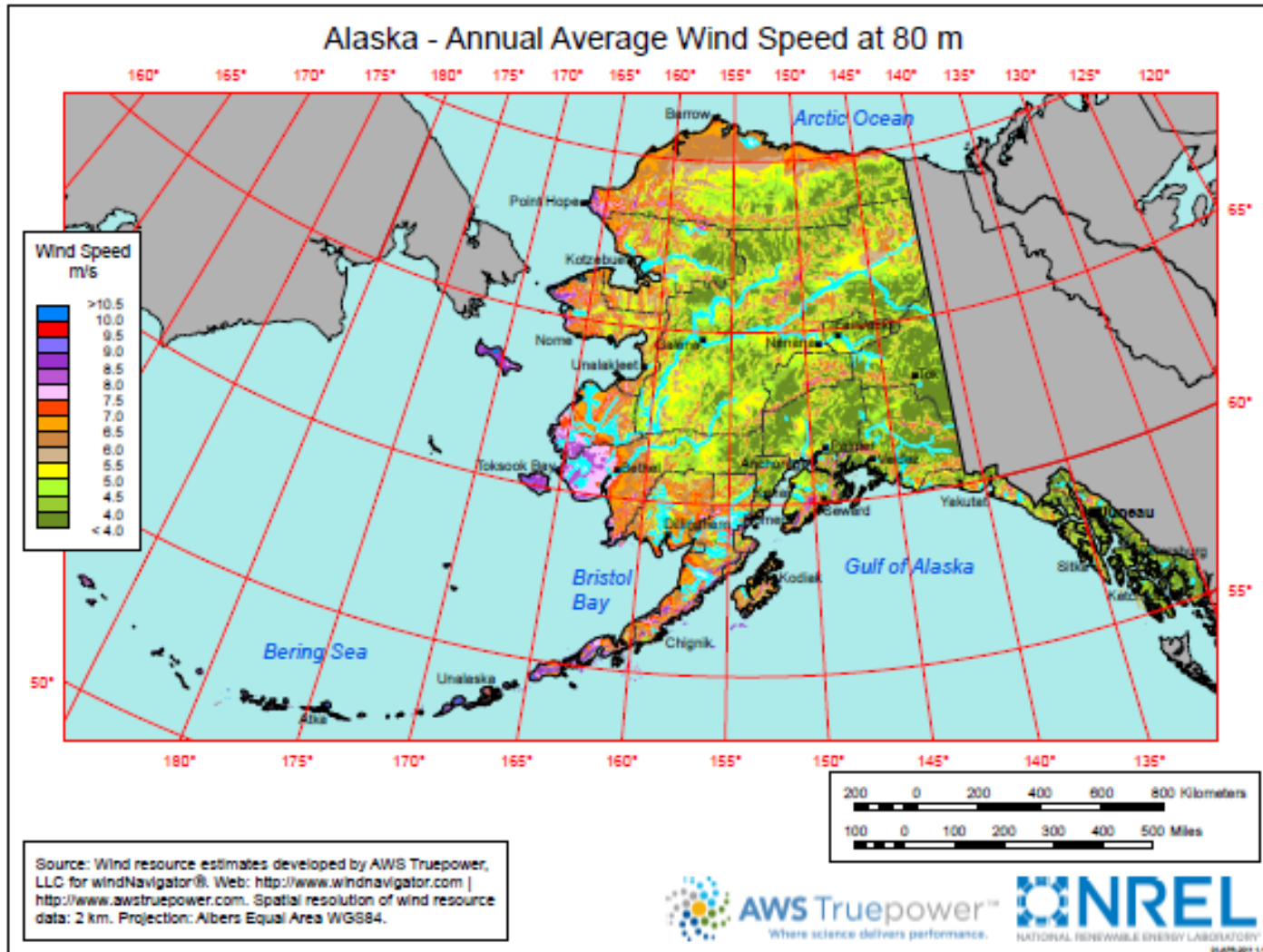
## **WIND PROSPECTOR**

## **CASE STUDIES**

## **WIND ENERGY TAKEAWAYS**

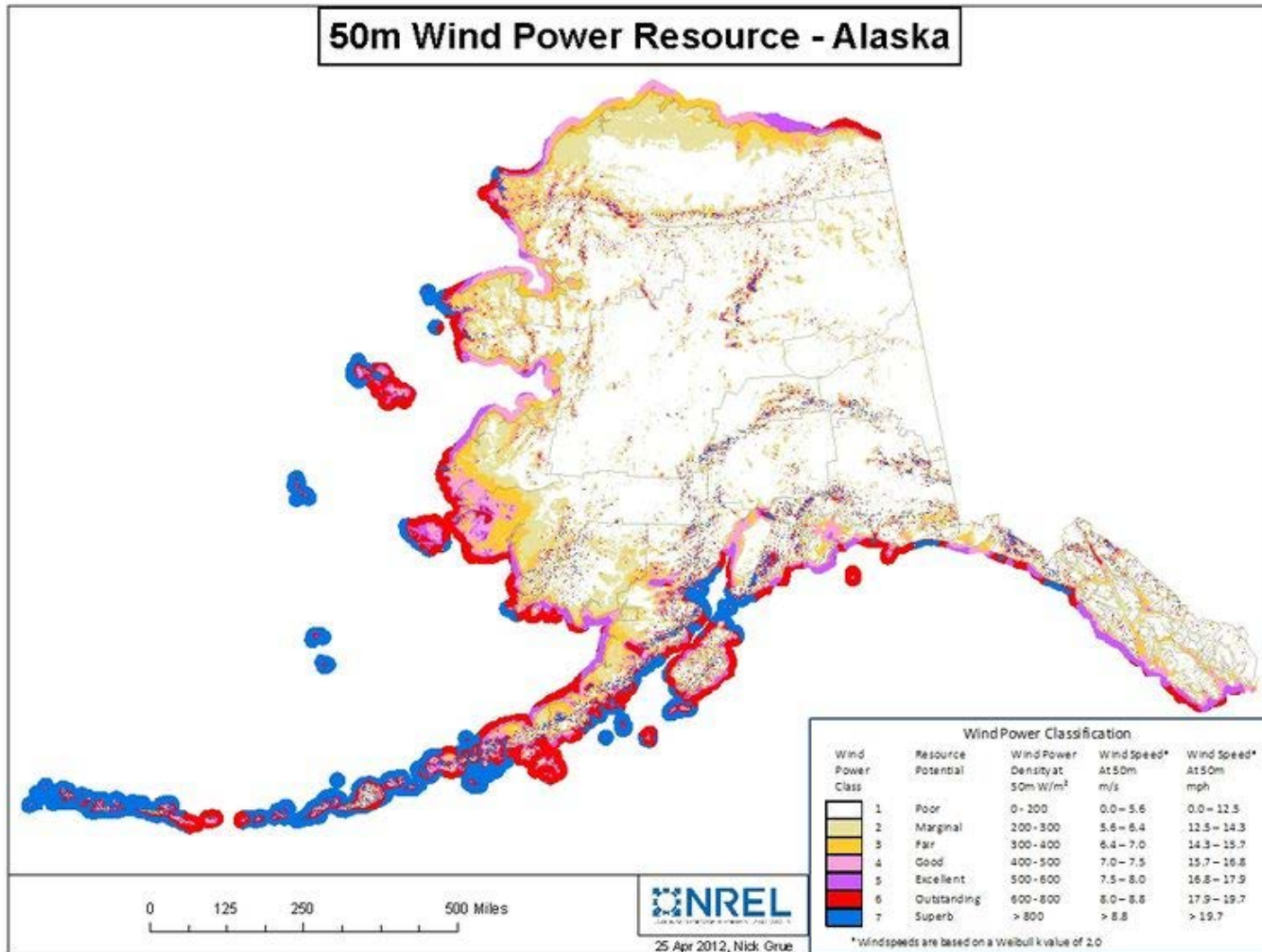


# Alaska Wind Resource Map



Source: [http://apps2.eere.energy.gov/wind/windexchange/wind\\_resource\\_maps.asp](http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp)

# Wind Resources and Opportunity on Tribal Lands



# Sizes and Applications



Photo from Bergey Windpower Co. Inc., NREL 02102

## Small ( $\leq 100$ kW)

Homes  
Farms  
Remote applications (e.g.,  
water pumping, telecom sites,  
ice making)



Photo from Tjaden Farms, NREL 13764

## Mid-scale (100–1,000 kW)

Village power  
Hybrid systems  
Distributed power



Photo from Native Energy Inc.,  
NREL 7593

## Large, land-based (1–3 MW)

Utility-scale wind farms  
Large distributed power



Photo from HC Sorensen, NREL  
17855

## Large, offshore (3–7 MW)

Utility-scale wind farms,  
shallow coastal waters  
No U.S. installations

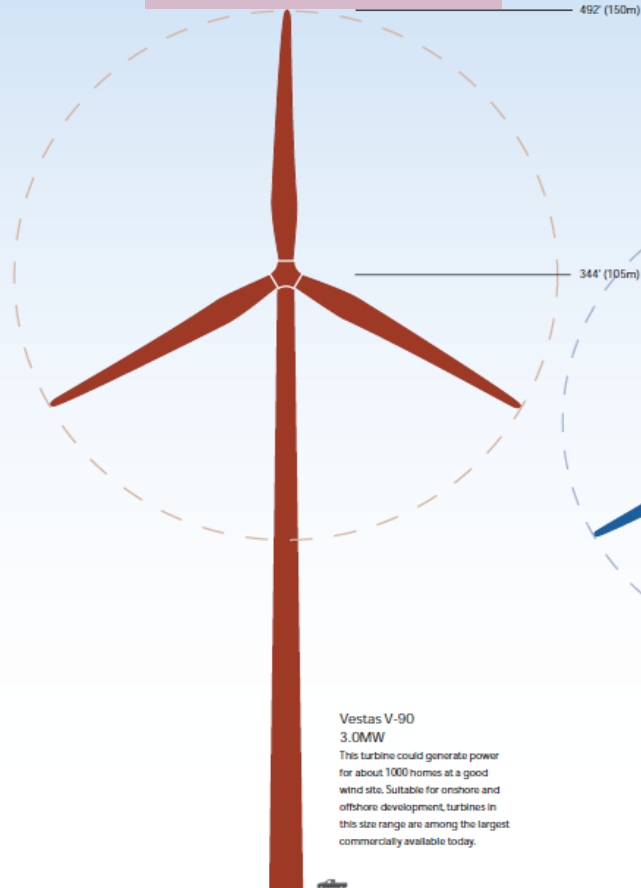


# Turbine – Sized to Economic Project Goals

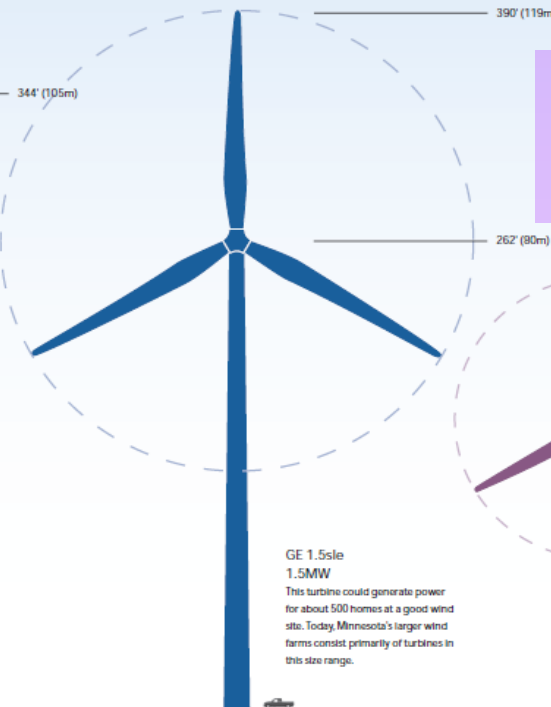


## THE SCALE OF WIND POWER

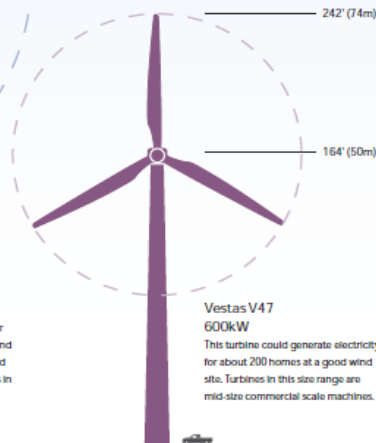
Vestas V-90  
3MW  
~ 1,000 homes



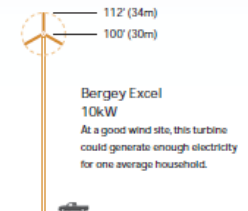
GE 1.5sle  
1.5MW  
~ 500 homes



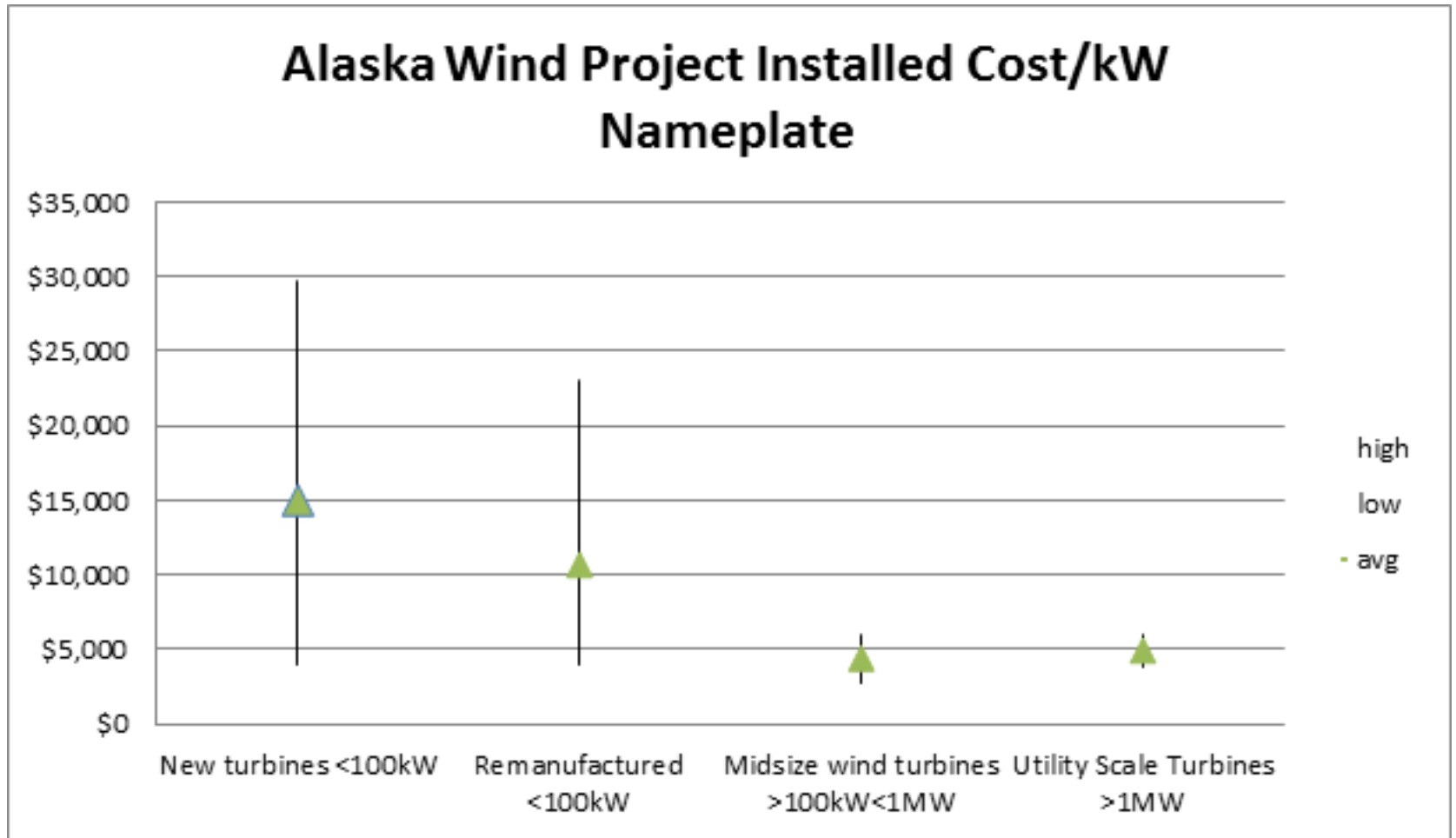
Vestas V47  
600kW  
~ 200 homes



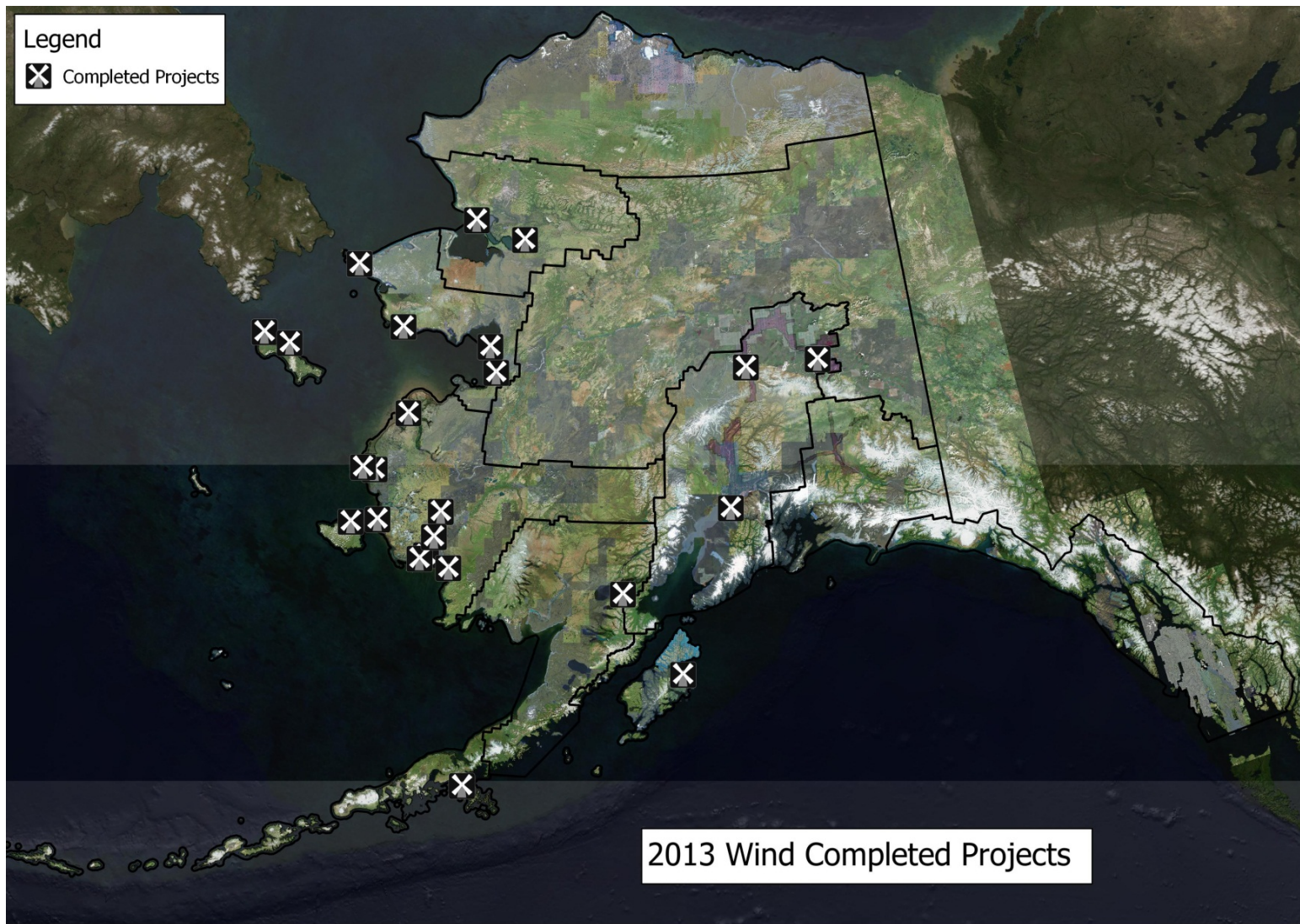
Bergey Excel  
10kW  
~ 1 home



# LCOE for Alaska Wind Energy



# Wind Energy Projects in Alaska



Source: <http://www.akenergyauthority.org/programwindanalysisdata.html>

# Wind Diesel Construction Costs

## Summary of Average Cost of Alaska Wind Projects per Installed kW

	Average Total Cost	Cost /Installed kW
Small Rural	\$2,917,900	\$10,200
All Rural	\$4,290,000	\$9,600

Sources: Denali Commission; Alaska Energy Authority; project developer data. Prepared by Ginny Fay, Tobias Schwörer; Institute of Social and Economic Research; University of Alaska Anchorage. Report: Alaska Isolated Wind-Diesel Systems: Performance and Economic Analysis

Source: University of Alaska Anchorage

# Toksook Bay, Alaska

Power system that supplies the ~800 people of the communities of Toksook Bay and Nightmute in coastal Southwest Alaska

- Power system operated by the Alaska Village Electric Cooperative
- Average load just under 370 kW (both Toksook and Nightmute)
- 3 NW100-kW turbines and resistive community heating loads
- Installed in the fall and winter of 2006
- 24.2% average wind contribution with much higher instantaneous contribution
- Almost 700 MWh generated by wind last year, saving almost 46,000 gal (174,239 l) of fuel
- First year turbine availability of 92.4% - currently under warranty
- Average net capacity factor of 26.0% from Aug '07 to July '08



Photo Credit: Northern Power Systems



Photo Credit: Northern Power Systems



# Kodiak, Alaska

- Endeavor to produce 95% of energy sales with cost effective renewable power solutions by the year 2020. KEA Board Feb 2007
- Isolated island electric grid
  - About 12,000 people
  - Peak Load – 25 MW, Minimum Load – 11 MW
- Power Generation
  - 2 x 10 MW Hydroelectric Units
  - 6 x GE 1.5 MW Wind Turbines
  - 7 MW Diesel Fired Combined Cycle Plant
  - 7 Diesels totaling 25 MW's
- Wind Project (first 3 turbines inst. 2008)
  - Cost ~ \$21.4 million
  - Annual Production of 12.2 million kWh
  - Annual fuel savings of 800,000 gallons
  - Some limited integration issues
  - Operating above expectations
- 3 more turbine installed in 2013 with a balancing battery bank



# Key Takeaways

- Wind energy is a mature, yet evolving technology
- Wind energy comes in many sizes, including community scale
- Wind turbine project development (from 5 kW to 200 MW) has clear impacts to neighbors/neighboring communities that are both positive and negative and therefore requires active stakeholder engagement



In the Village of Tuntutuliak the use of wind and smart-grid technology has fundamentally changed the energy landscape of rural Alaska. Photo courtesy of: Center for American Progress

# Wind Resources

## RESOURCE

- <http://apps2.eere.energy.gov/wind/windexchange/>
- [Guide to Tribal Clean Energy Development](#)
- <http://www.akenergyauthority.org/>
- [Guide to Tribal Clean Energy Development](#)

## TECHNOLOGY

- <http://www.nrel.gov/wind/>
- <http://www.smallwindcertification.org/>

## POLICY

- [www.dsireusa.org](http://www.dsireusa.org)



The image shows three wind turbines on a hillside. The turbines are positioned across the top half of the frame, with the leftmost one being the tallest and the rightmost one being the shortest. The hillside is covered in green grass and is partially obscured by a thick layer of white mist or fog. The sky is a clear, bright blue. A dark blue rectangular box is overlaid on the bottom left of the image, containing white text.

# **DIESEL EFFICIENCY -JED DROLET OF AEA**

# Alaska Energy Authority: Diesel Efficiency

- Importance of Training
- Diesel Genset Efficiency
- Powerhouse efficiency
- Distribution efficiency
- Fuel considerations
- Takeaways

# ■ Importance of Training

Training can help avoid these scenarios:

- Fluid leaks that result in damage to equipment and operator risk
- Running a genset that is too large, which wastes fuel
- Delayed maintenance which causes engines to wear prematurely and waste fuel
- Inefficiency and accelerated wear due to too hot or too cold engine operating temperatures

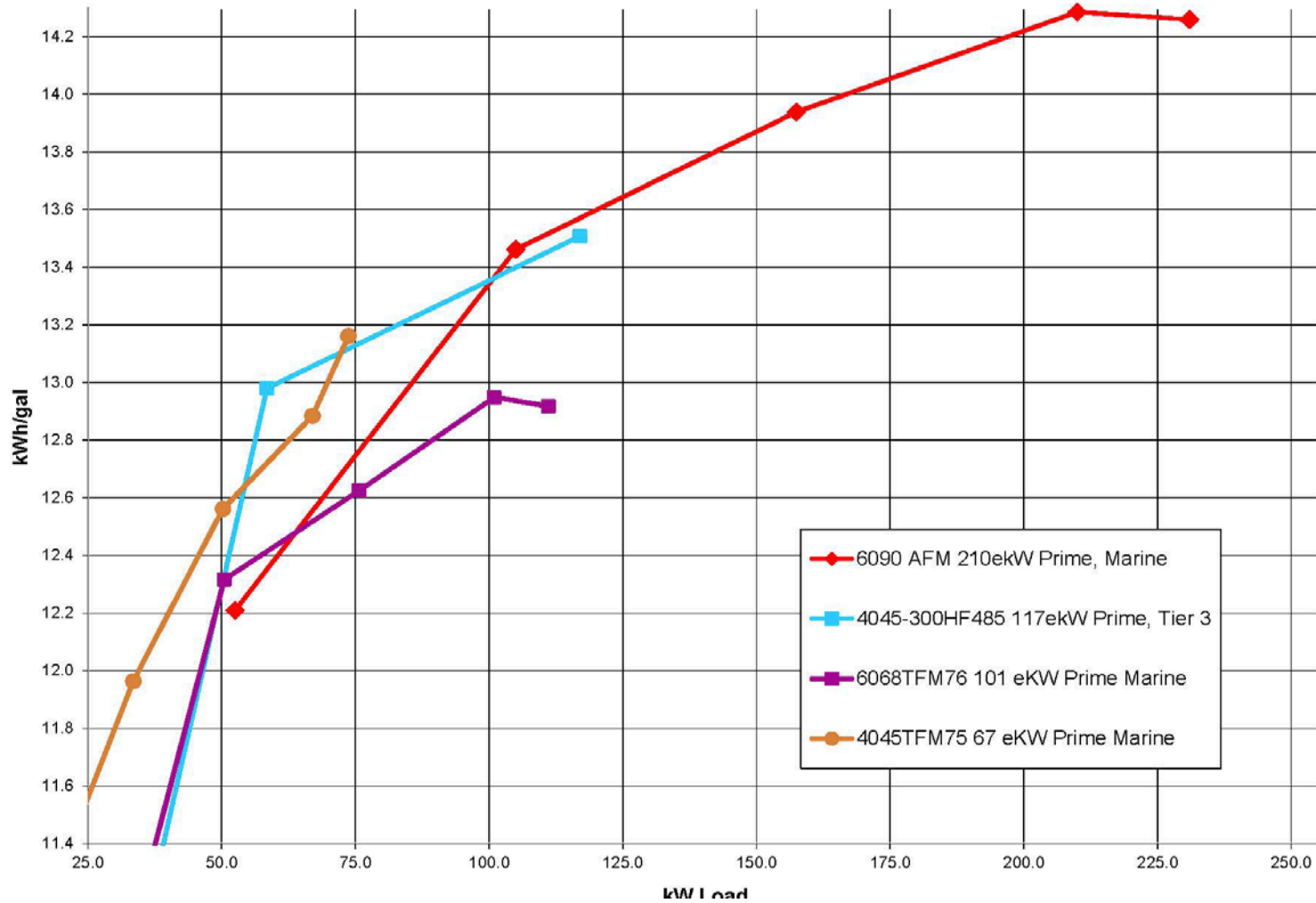
AEA provides Power Plant and Advanced Power Plant Operator Training. See our website ([akenergyauthority.org](http://akenergyauthority.org))

# Saint George Powerhouse



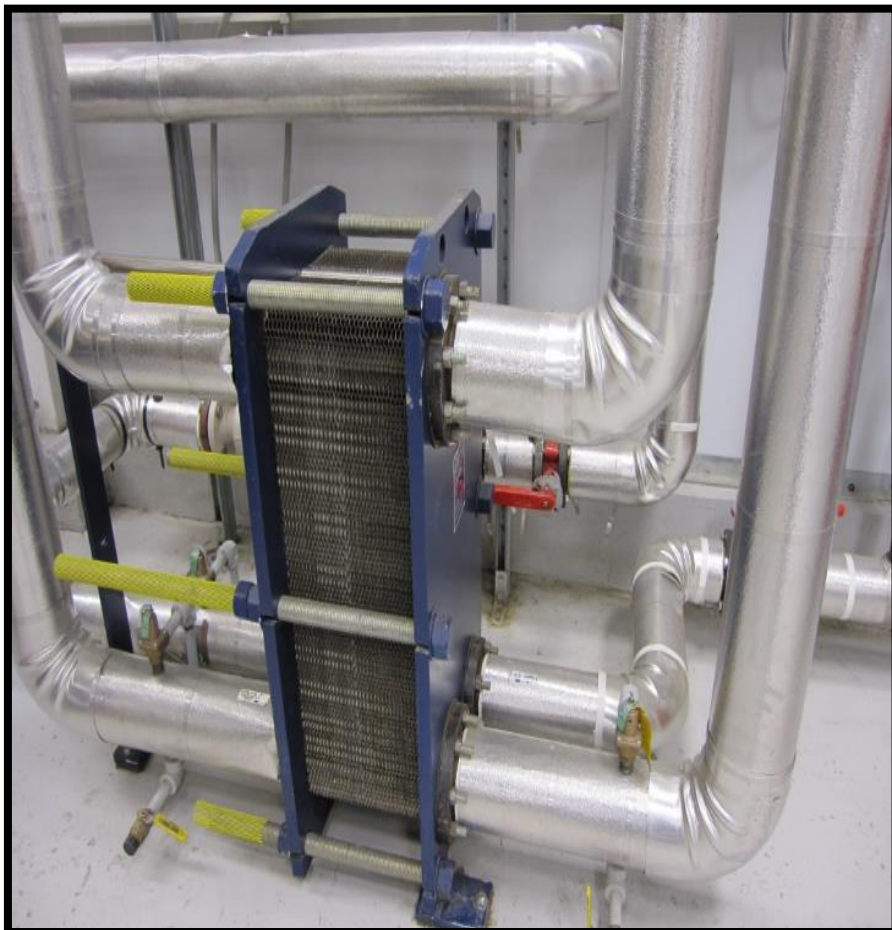
# Saint George Engine Options

St. George Engine Options





# Heat Recovery



Power Plant Heat Exchanger



Boiler Room Heat Exchanger

# Electrical Distribution in Chignik and Napakiak



## Distribution Efficiency (ask an electrical engineer)

- Optimize transformers
- Optimize line voltage
- Power factor correction

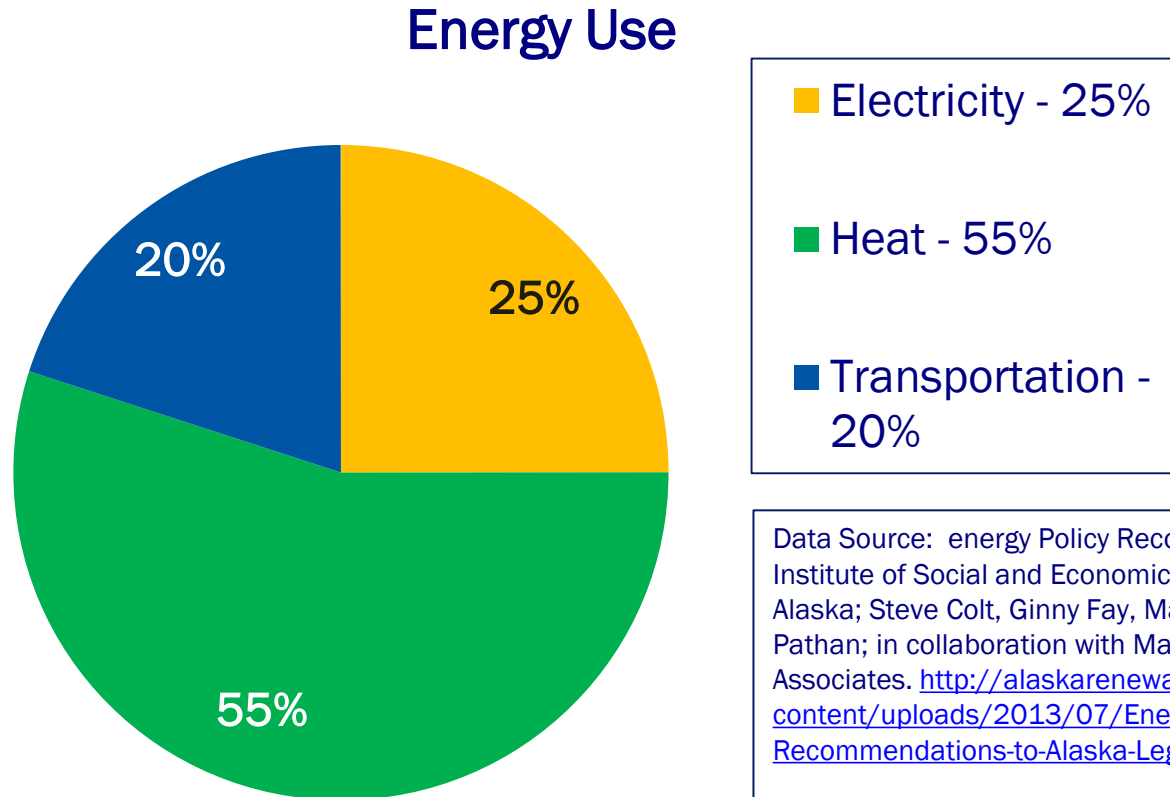




## ■ AEA Takeaways

- Train your operators
- Check with the Alaska Energy Authority before replacing gensets, particularly regarding EPA regulatory compliance

# Typical Alaska Village Energy Consumption



Because of high heat demand in Alaska villages, it is important to capture “rejected” or waste heat from diesel gensets. This substantially increases energy efficiency on the supply side.

# Diesel Generation of Power Production in Alaska

- Generated diesel accounts for 94% of power production in the 181 rural communities that receive power cost equalization (PCE) assistance from the Alaska Energy Authority (AEA).
- Diesel efficiency can almost immediately reduce the energy cost burden on rural, grid-isolated, Alaskan communities while renewable and alternative energy resources are developed.

Source: Alaska Rural Energy Plan and the 2009 AEA Guide for Alaskan Communities to Utilize Local Energy Resources

# Diesel Gensets

- Diesel engine technology is over 100 years old; a mature technology that has been incrementally improved on for years
- Diesel engines are coupled with generators to produce electricity—or a “Diesel Genset”
- To reduce diesel fuel costs, many Alaska villages are looking at wind and solar energy to produce electricity. This electricity must be integrated into the existing diesel genset.



**A diesel genset and aboveground storage tank combines a diesel to electricity generator and an engine mounted together to form a single piece of equipment known as an engine-generator set or “Genset”.**

NREL photo # 24487

# Diesel Engine Power Generation

- Recent advances have improved diesel efficiency by more than 50%:
  - Engine efficiency
  - Automated generator controls
  - Waste Heat recovery
  - Continuous operations and maintenance techniques
- Deployment of modern diesel technology in rural community diesel powerhouses has been documented to increase the usable electrical energy generated from a gallon of diesel fuel by 20% - 30%
- Installation of monitored [heat recovery](#) systems from both traditional water jacket systems and new exhaust stack waste heat recovery systems can increase the fuel conversion efficiency of diesel powerhouses by another 20% - 35%.

# Combined Heat and Power

- **Water Jacket Heat Recovery**

- Waste heat recovery for space heating is a common, proven design. Modern high-efficiency heat exchangers, super-insulated heat piping, high efficiency electric pumps, modern electronic BTU meters, and variable speed radiator fan motor controllers maximize the utilization of heat available from diesel engines. The associated design and maintenance procedures are well understood in the Alaskan power industry. For this reason, water jacket heat recovery for space heating is considered a mature technology in Alaska.

- **Exhaust Stack Heat Recovery.**

- Heat recovery from diesel engine exhaust stack is a proven and cost-effective technology. Recent technological improvements have made exhaust stack heat recovery from diesel engines feasible and economical in midsize engines, which are used in rural Alaska. These advances in exhaust stack heat recovery have boosted recovered heat.



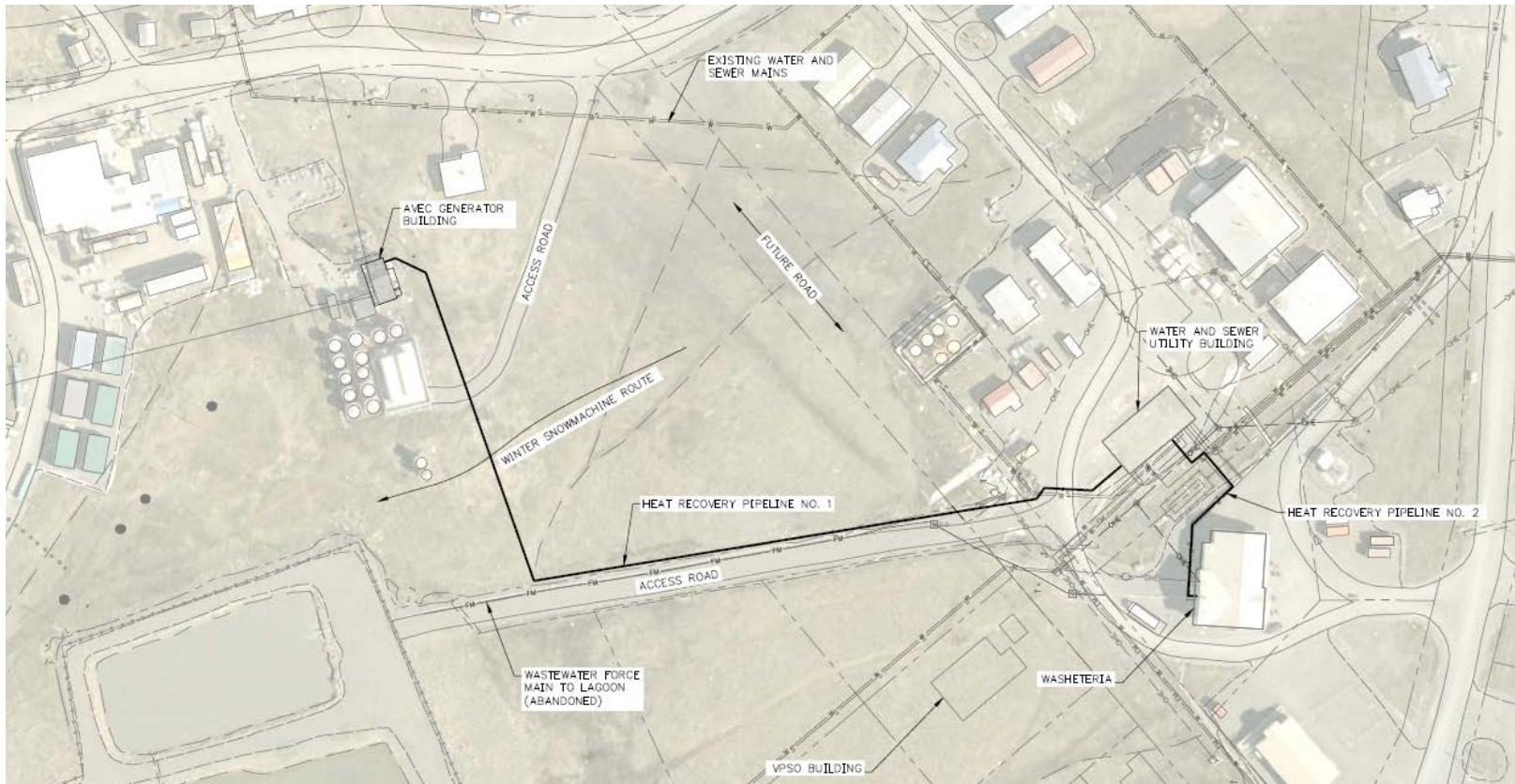
## Savings from ANTHC Heat Recovery Projects

Community	Energy Savings (Annual Gallons of Fuel)	Annual Cost Savings (DCCED Fuel Price Report, 2012)	Present Value of Lifetime Savings (20 Years, 3.5% Real Cost Increase of Fuel)
Minto	11,000	\$ 55,550	\$ 1,698,000
Allakaket	7,300	\$ 45,041	\$ 1,370,000
Kwigillingok	4,500	\$ 29,025	\$ 858,200
Goodnews Bay	5,000	\$ 26,500	\$ 1,732,900
McGrath	6,000	\$ 44,820	\$ 1,319,200
Savoonga	9,000	\$ 50,490	\$ 1,477,200
Selawik	11,875	\$ 73,268	\$ 2,157,000
Shungnak	10,400	\$ 64,168	\$ 1,889,400
Ambler	10,300	\$ 63,551	\$ 1,871,200
Sleetmute	2,068	\$ 15,199	\$ 450,000
Russian Mission	2,200	\$ 12,650	\$ 375,500
<b>Totals</b>	<b>81,843 Gallons</b>	<b>\$ 491,058</b>	<b>\$ 15,198,700</b>

# Case Study: Quinhagak Heat Recovery System

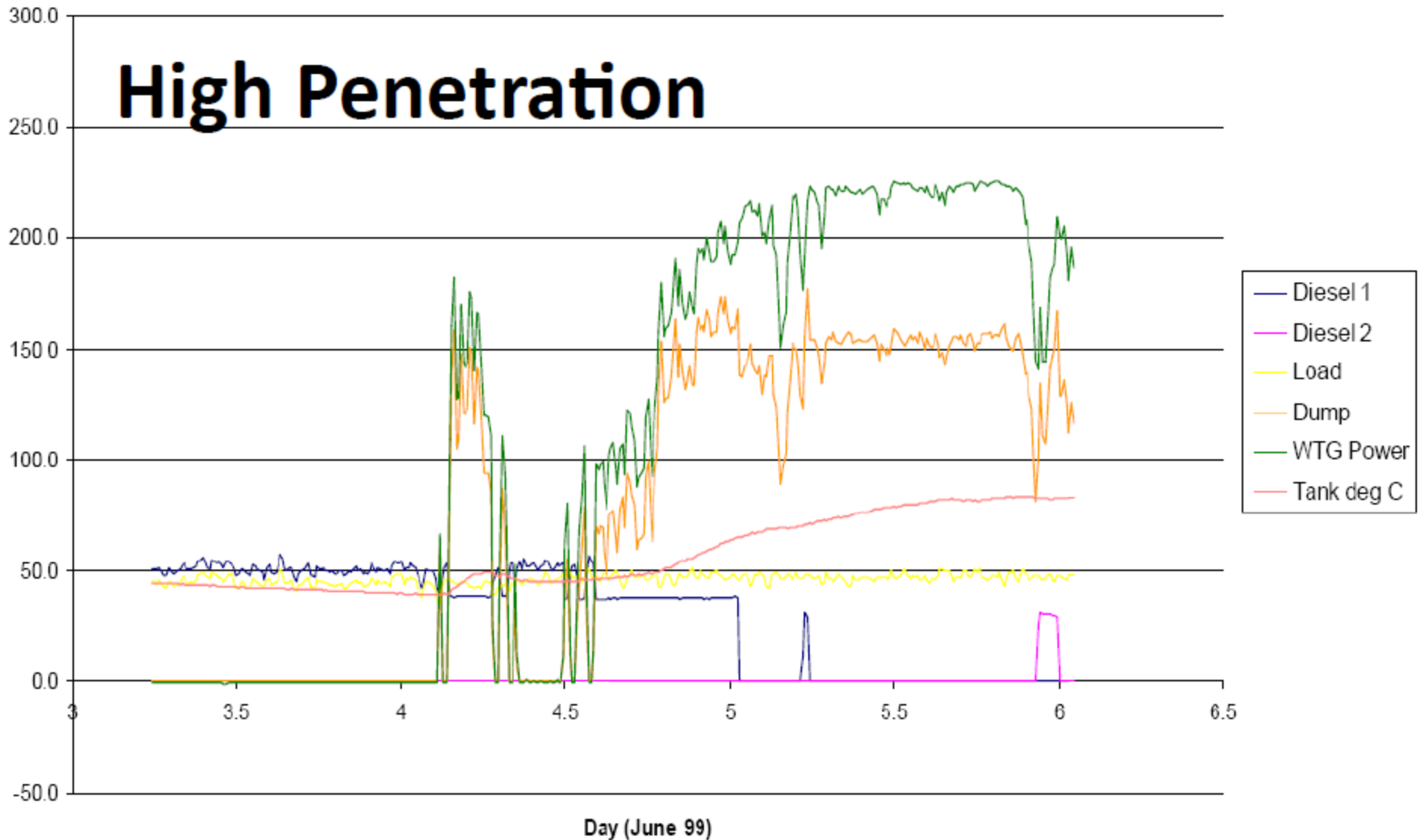
This project will capture waste heat from the existing AVEC power plant and send it to the washeteria and combined utility building. Heat is transferred from the power plant to the two community facilities through circulating glycol lines. Recovered heat, measured and metered in BTUs, is sold by the power utility to the community at 30% of the cost of fuel oil.

Once the system is fully operational, Quinhagak is expected to reduce their annual heating fuel usage by 14,200 gallons, for a fuel savings of almost \$64,000 per year. Net savings after recovered heat sales cost is expected to be \$45,000 per year. Design and construction costs are estimated at \$820,000.



10-Minute Data, NPS Hybrid Wind/Diesel Power System  
TDX Corp., St. Paul Island, AK, USA

# High Penetration



Source: NREL, Ian Baring-Gould

# Case Study: Inside Passage Electric Cooperative in Hoonah (Juneau Region)

- Constructed a heat recovery project in 2011 to recover available marine jacket water heat from IPEC-Hoonah diesel generator that is currently being rejected to the atmosphere via radiators. Provides heating for:
  - Local school
  - Pool
  - Gymnasium
  - Police station
  - Fire hall
- Will reduce diesel heating fuel consumption of nearby community buildings by over 55,000-gallons/year.

Learn more: <http://alaskarenewableenergy.org/why-renewable-energy-is-important/alaskas-renewable-energy-projects/>

## Integrating Renewable Energy & Diesel

- Diesel gensets operate all the time (24/7)
- Wind and solar are “intermittent” renewable energy resources; they are only available when the wind blows or the sun shines

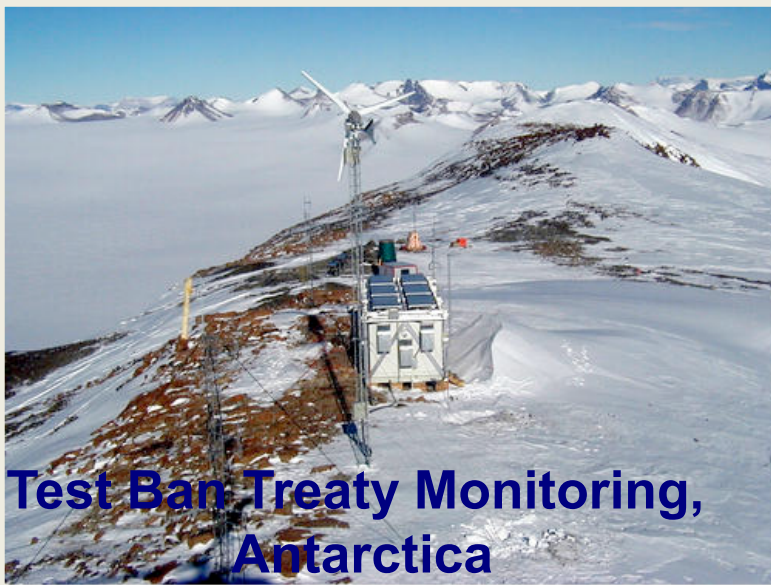
### HYBRID SYSTEMS

When wind or solar energy is connected into a village electric grid, the diesel gensets must increase or decrease production in response to the wind or solar output at any (and every) moment in time.

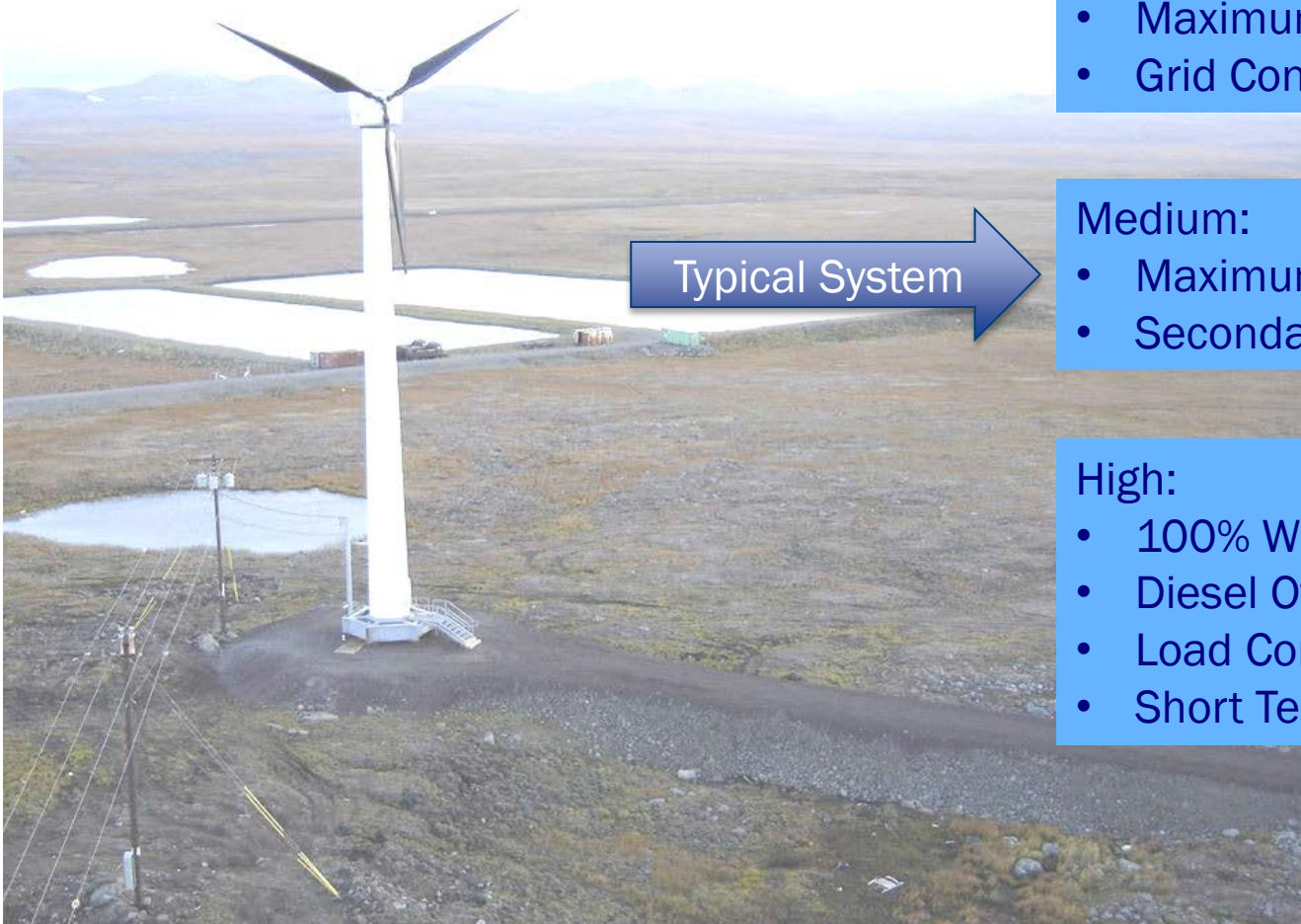


NREL Photo #07406

# Hybrid Power Systems are Widespread



# Wind and Diesel Penetration Levels



## Low:

- Maximum 30% Wind
- Grid Connected

## Medium:

- Maximum 80% Wind
- Secondary Load Control

## High:

- 100% Wind
- Diesel Off
- Load Control
- Short Term Storage

# Hybrid Power System Classifications and Considerations

Penetration Class	Operating Characteristics	Instantaneous Penetration	Average Penetration
LOW	<ul style="list-style-type: none"> <li>• Diesel runs full-time</li> <li>• Wind power reduces net load on diesel</li> <li>• All wind energy goes to primary load</li> <li>• No supervisory control system</li> </ul>	< 50%	< 20%
MEDIUM	<ul style="list-style-type: none"> <li>• Diesel runs full-time</li> <li>• At high wind power levels, secondary loads are dispatched to insure sufficient diesel loading or wind generation is curtailed</li> <li>• Requires relatively simple control system</li> </ul>	50%–100%	20%–50%
HIGH	<ul style="list-style-type: none"> <li>• Diesels may be shut down during high wind availability</li> <li>• Auxiliary components are required to regulate voltage and frequency</li> <li>• Requires sophisticated control system</li> </ul>	100%–400%	50%–150%

- Note: any system with the capability to have instantaneous penetrations above 50% will require specialized load controls and other grid integration measures
- Consider penetrations when system is at minimum load (at night, high winds, etc.)



# Key Takeaways for Diesel Efficiency and Renewables

- Diesel engines are coupled with generators to produce electricity, or “Diesel Genset”
- Diesel gensets remain as the backbone of energy systems for conversion and backup and must be integrated into renewables for rural villages
- Diesel has a 30% to 35% conversion efficiency from diesel to electricity
- A 10% to 25% improvement of the original 30% to 35% for electricity
- CHP heat recovery systems (combined heat and power) have a 30% to 40% conversion of the original diesel fuel into useful waste heat energy.
- **Continuous maintenance and operations contributes to diesel efficiency at 20% to 30%.**

The image shows three wind turbines on a mountain ridge. The turbines are positioned across the top of the frame. A thick layer of white mist or clouds fills the middle ground, partially obscuring the base of the turbines and the mountain. The sky is a clear, bright blue. In the foreground, a dark blue rectangular box with a subtle wavy pattern is overlaid on the image. The word "BIOMASS" is written in large, white, bold, sans-serif capital letters within this box.

# BIOMASS



# JUNEAU: UAF Cooperative Extension Service Biomass Resource

[www.AlaskaWoodHeating.com](http://www.AlaskaWoodHeating.com)

- Offers FREE pre feasibility studies for biomass –easy application.
- Biomass cost calculator
- Additional resources
  - Stove examples
  - Health and safety guidelines

# Biomass Siting Factors

Project feasibility depends on:

- Availability and cost of each type of biomass (chips, pellets, or logs)
- Competing fuel cost (e.g., fuel oil, natural gas, etc.)
- Peak and annual thermal load
- Building size and type
- Space availability
- Operation and maintenance staff availability and experience
- Local emissions regulations



Dried paper mill sludge is fed into the hopper at a biorefinery plant.

NREL Photo #07713

## Biomass Waste to Heat CHP

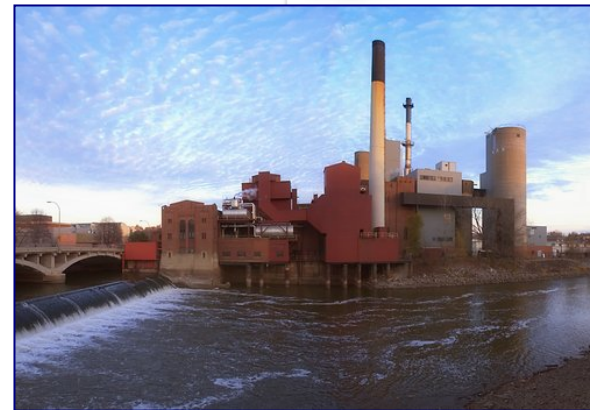
- Small scale units can heat if several homes share a battery bank.
- Manufacturers Video of CHP waste to heat:
  - [https://www.youtube.com/watch?feature=player\\_embedded&v=pmTJtJbCoB4](https://www.youtube.com/watch?feature=player_embedded&v=pmTJtJbCoB4)
  - Owned by an Alaskan Tribal Regional Corporation.

# Types of Biomass Heating Equipment

- Residential stoves or boilers use chips, pellets, or logs
- Commercial or institutional heating boilers
- Industrial



NREL 06656



NREL 19255

# Wood Pellet Stoves

- New York State's Energy Research & Development Authority (NYSERDA) has one of the most extensive list of tested wood pellet stoves and appliances  
<http://www.nyserda.ny.gov/All-Programs/Programs/Residential-Wood-Pellet-Stove>
- <http://www.nyserda.ny.gov/All-Programs/Programs/Residential-Wood-Pellet-Stove/Residential-Pellet-Stove-Program-FAQ>
- Make sure a lengthy pellet supply exists before investment.

# Biomass Energy Projects

## Model Neighborhood Project

Subsidizing the cost to transition from oil heating systems to advanced wood pellet boilers for homeowners in Berlin, New Hampshire, and Farmington and Wilton, Maine

[http://www.northernforest.org/model\\_neighborhood\\_project.html](http://www.northernforest.org/model_neighborhood_project.html)

## The Wood to Energy Project

Two primary objectives:

1. Provide a complete literature review on the state of the science
2. Develop database of wood-to-energy related industries in the United States and Canada

Learn more: <http://www.wood2energy.org/>



# Helpful Links

## U.S. Forest Service Woody Biomass Utilization Site

The Woody Biomass Utilization Team is an interdisciplinary team that promotes and facilitates the planning and delivery of an integrated, interdisciplinary approach to the recovery and utilization of woody biomass from ecological restoration and hazardous fuels reduction work. <http://www.fs.fed.us/woodybiomass/>

## Biomass Energy Resource Center (BERC)

BERC assists communities, colleges and universities, state and local governments, businesses, utilities, schools, and others in making the most of their local biomass energy resources.

<http://www.biomasscenter.org/>

## Biomass Thermal Energy Council (BTEC)

BTEC is an association of biomass fuel producers, appliance manufacturers and distributors, supply chain companies and non-profit organizations that view biomass thermal energy as a renewable, responsible, clean and energy-efficient pathway to meeting America's energy needs. BTEC engages in research, education, and public advocacy for the fast growing biomass thermal energy industry.

<http://www.biomassthermal.org/>

## Pellet Fuels Institute

The Pellet Fuels Institute is a non-profit association that serves the pellet industry. <http://pelletheat.org>

## ALASKA – Free feasibility study, cost calculator, equipment resources

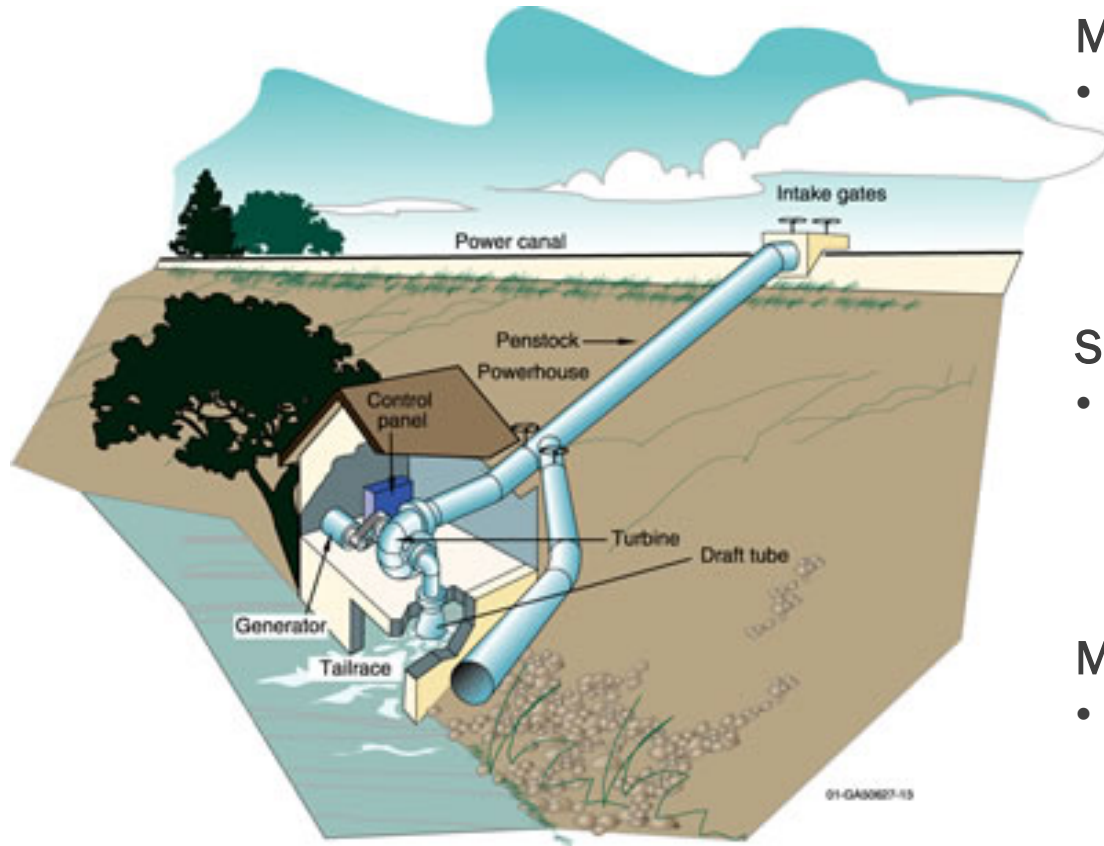
[www.AlaskaWoodHeating.com](http://www.AlaskaWoodHeating.com)

The image shows three wind turbines on a mountain peak. The turbines are white with three blades each. The mountain is covered in green grass and is partially shrouded in a thick layer of white mist or fog. The sky is a clear, bright blue. A large, semi-transparent blue rectangular box is overlaid on the bottom half of the image, containing the text 'HYDRO ELECTRICITY' in white, bold, uppercase letters.

# HYDRO ELECTRICITY



# Scale of Hydroelectric Power Plants



## Macro Hydropower

- Although definitions vary, DOE defines large hydropower as facilities that have a capacity of more than 30 MW.

## Small Hydropower

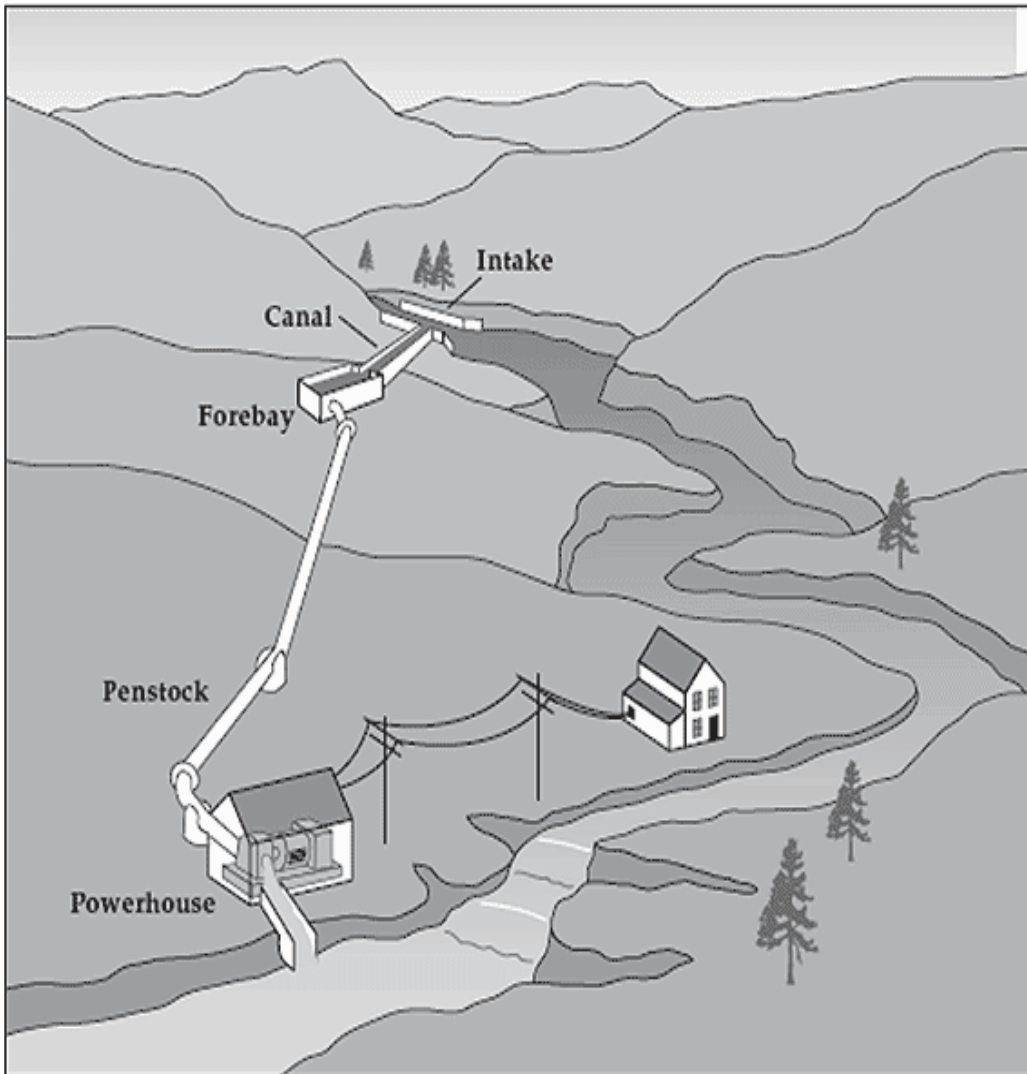
- Although definitions vary, DOE defines small hydropower as facilities that have a capacity of 100 kW to 30 MW.

## Micro Hydropower

- A micro hydropower plant has a capacity of up to 100 kW. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.

Source: [http://www1.eere.energy.gov/water/hydro\\_plant\\_types.html](http://www1.eere.energy.gov/water/hydro_plant_types.html)

# Community-Scale Hydroelectric Components



- Hydropower plants are composed of three basic components:
1. A water diversion or intake system,
  2. A pipeline or penstock to move the water, and
  3. A powerhouse..

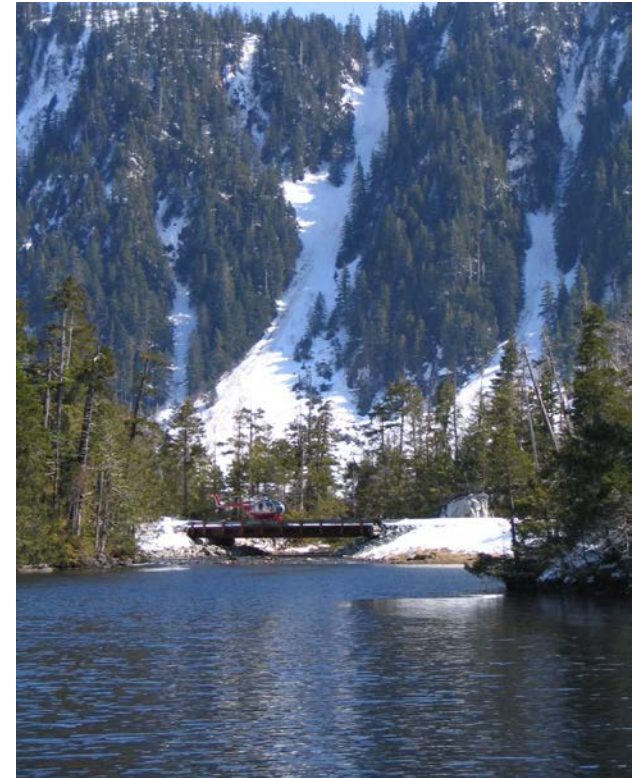
Source: NREL

# Alaska Hydroelectricity

Alaska currently generates about 21% of electricity from hydropower, much of it from projects in Southeast Alaska. Power generation numbers listed assume a 50% capacity factor.

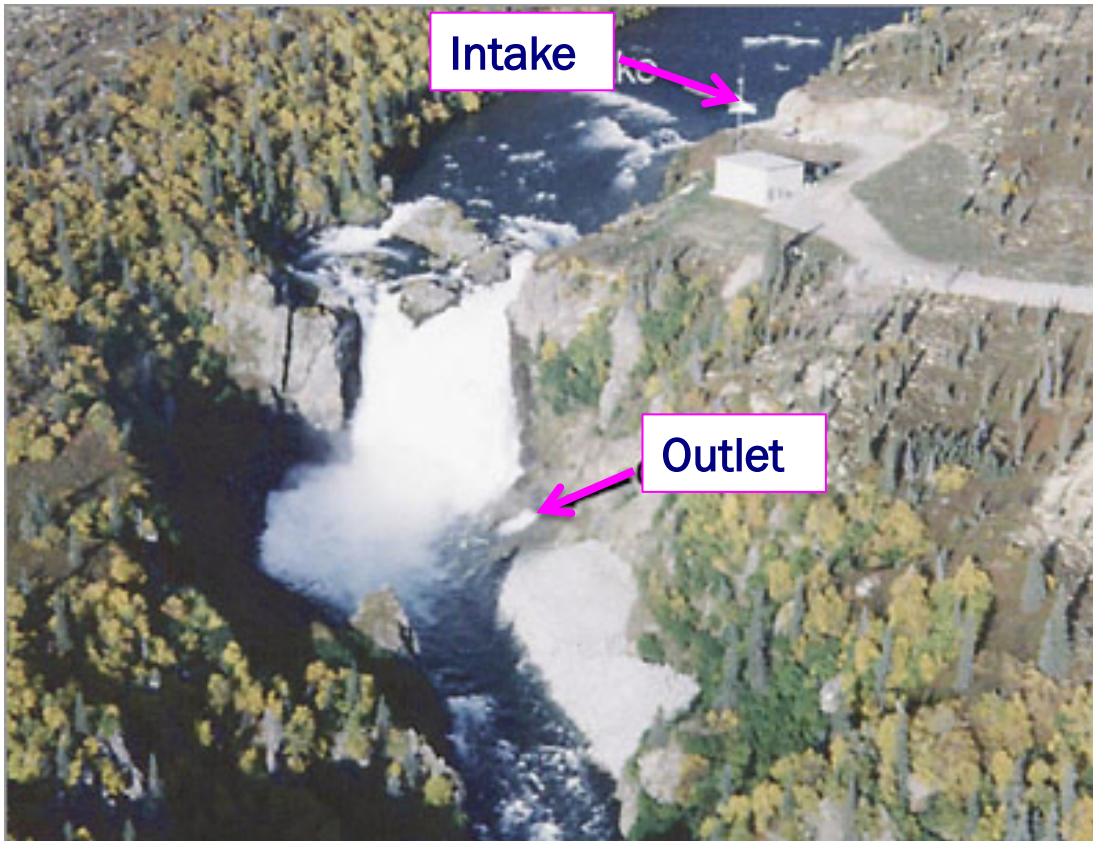


Hydro dam in Akutan produces 775 MWh/year and displaces approximately 39,000 gallons of diesel annually.



Haida Corporation's Reynolds Creek 2008 5-megawatt hydro project. Photo from NREL 25048

# Technology Overview and Siting – Diversion Hydro



- A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock
- It may not require the use of a dam

- Typically no storage opportunities as with impoundment, lower capital costs due to lack of dam
- Fewer concerns with fish and less land area impact than with impoundment

## Alaska Community-Scale Tidal Hydroelectricity

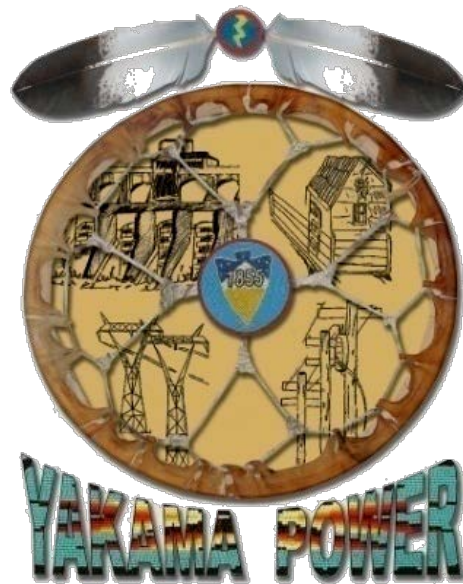
Cook Inlet- Ocean Renewable Power Company

- An array of four 150 kW TidGen Power Systems
- Rated capacity of 600 kW near (within 3 kilometers) of East Foreland, Alaska
- The devices will be installed in water depths of 60-190 feet
- Models have predicted peak velocities nearing 5 meters per second (~9 knots)
- Learn more: <http://alaskarenewableenergy.org/why-renewable-energy-is-important/alaskas-renewable-energy-projects/#sthash.0uAGykc2.I4IZWNu3.dpuf>

# Wapato Hydropower Project: Successful Example



Drop Site 2 Powerhouse



Source: Yakama Power



# Useful Resources

## RESOURCE

- [Guide to Tribal Clean Energy Development](#)

## TECHNOLOGY

- [Virtual Hydropower Prospector:](#)  
<http://hydropower.inl.gov/prospector/index.shtml>

## POLICY

- [www.dsireusa.org](http://www.dsireusa.org)



## More Resources & Maps

- NREL Geothermal:  
<http://www.nrel.gov/gis/geothermal.html>
- Guide to Tribal Clean Energy Development:  
<http://www1.eere.energy.gov/tribalenergy/guide/index.html>
- DOE Geothermal Technologies Program:  
<http://www1.eere.energy.gov/geothermal/faqs.html>
- Alaska Renewable Energy Maps  
<http://map.akenergyinventory.org/>
- Colorado Geo Energy & Heat Pump Association:  
<http://www.gogeonow.org/>

# NREL Tools Links

Data or Tool	Link
State & Local Energy Data (SLED)	<a href="http://apps1.eere.energy.gov/sled/#/">http://apps1.eere.energy.gov/sled/#/</a>
Interactive Mapping Tools	<a href="http://maps.nrel.gov">http://maps.nrel.gov</a>
MapSearch	<a href="http://www.nrel.gov/gis/mapsearch/">http://www.nrel.gov/gis/mapsearch/</a>
REAtlas	<a href="http://maps.nrel.gov/re_atlas">http://maps.nrel.gov/re_atlas</a>
PV Watts	<a href="http://pvwatts.nrel.gov/">http://pvwatts.nrel.gov/</a>
SAM (System Advisory Model)	<a href="http://sam.nrel.gov">http://sam.nrel.gov</a>
HyDRA	<a href="http://maps.nrel.gov/hydra">http://maps.nrel.gov/hydra</a>
Solar Prospector	<a href="http://maps.nrel.gov/prospector">http://maps.nrel.gov/prospector</a>
OpenPV	<a href="https://openpv.nrel.gov/gallery">https://openpv.nrel.gov/gallery</a>
PVDAQ	<a href="http://maps.nrel.gov/pvdaq">http://maps.nrel.gov/pvdaq</a>
LCOE Calculator	<a href="http://www.nrel.gov/analysis/tech_lcoe.html">http://www.nrel.gov/analysis/tech_lcoe.html</a>
REEDS (Regional Energy Deployment System)	<a href="http://www.nrel.gov/analysis/reeds/">http://www.nrel.gov/analysis/reeds/</a>
PV JEDI (Jobs and Economic Development Impact Models)	<a href="https://jedi.nrel.gov/index.php">https://jedi.nrel.gov/index.php</a>
OpenEI	<a href="http://openei.org">http://openei.org</a>
CREST(Cost of Renewable Energy Spreadsheet Tool)	<a href="https://financere.nrel.gov/finance/content/crest-cost-energy-models">https://financere.nrel.gov/finance/content/crest-cost-energy-models</a>
Smartgrid.gov	<a href="http://smartgrid.gov">http://smartgrid.gov</a>

# Resources for Technologies

## PROJECT DEVELOPMENT “PERMITTING”

- Federal Energy Management Program Environmental Siting Guide:  
[http://www1.eere.energy.gov/femp/technologies/derchp\\_envsiting.html](http://www1.eere.energy.gov/femp/technologies/derchp_envsiting.html)
- Guide to Tribal Energy Development:  
[http://www1.eere.energy.gov/tribalenergy/guide/permitting\\_licensing.html](http://www1.eere.energy.gov/tribalenergy/guide/permitting_licensing.html)  
[http://www1.eere.energy.gov/tribalenergy/guide/regulatory\\_agencies.html](http://www1.eere.energy.gov/tribalenergy/guide/regulatory_agencies.html)

## PROJECT DEVELOPMENT “TECHNOLOGY”

- Tribal Energy and Environmental Information Clearing House:  
<http://teeic.anl.gov/er/index.cfm>
- Renewable Energy Resource Assessment:  
[http://www1.eere.energy.gov/tribalenergy/guide/assessing\\_energy\\_resources.html](http://www1.eere.energy.gov/tribalenergy/guide/assessing_energy_resources.html).

## PROJECT DEVELOPMENT “CAPITAL”

- General Project Development & Finance:  
[http://www.nrel.gov/applying\\_technologies/financing.html](http://www.nrel.gov/applying_technologies/financing.html)

