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Chaninik Wind Group Multi-Village Wind Heat Smart Grids

Executive Summary

The Chaninik Wind Group serves the tribal communities of Kongiganak, Kwigillingok, Tuntutuliak and Kipnuk in southwest Alaska. The Chaninik Wind Group (CWG) was formed in 2005 by the electrical utility boards and managers of these villages. The managers of these utilities recognized the difficulties faced by small, stand-alone communities to operate, manage and improve energy services, as well as the barriers faced by small tribal utilities in building wind projects. Consequently, they formed a tribally based consortium with the first objective being working together to harness their local wind resources as a necessary step of preserving their communities in the face of rising fuel prices.

These communities are not connected by road or electrical intertie, but each community is similar in size, resources and cultural heritage. The Yup'ik communities are located within a 50 mile radius of each other on the Kuskokwim river delta in western Alaska. The total combined population of these four communities is less than 1,900. On average, 29% of the population live below the poverty level, with an average unemployment rate of 48%. The communities struggle greatly under the burden of overwhelming energy costs at \$.65 a kWh for electricity and up to \$9.00 a gallon for stove oil to heat homes.

Today, the group has built wind projects in Kwigillingok, Kongiganak, and Tuntutuliak. A fourth project is underway in Kipnuk to build an entirely new wind-diesel power system. This is expected to be completed by 2016. The wind heat portion of the smart grid will be installed in Kipnuk at that time. The CWG Board of Directors has led this development and been actively involved in determining the direction of their organization and working toward closer cooperation of their combined power systems. Over the last 8 years, the managers of CWG have learned that sustainable communities can only be built by local individuals working together on issues only they understand.

The CWG has established as its mission to become “the heartbeat of the region.” For the Board, this translates into building stronger, healthy and more self-reliant communities. The CWG’s idea is to start by building more effective and efficient energy systems that use less fuel, are lower cost to operate, and make use of local resources while increasing human capacity. Stable energy costs for their region are the groundwork for improving many other contributors to their overall quality of life. The Wind Heat Smart Grids are a logical and necessary extension of CWG’s mission.

This report covers the three year project to implement the Wind Heat Smart Grids for the CWG communities. The first wind heat system began operation in Kongiganak in November of 2012. This was the initial commissioning of the

USDoE Tribal Energy Program Wind Heat Smart Grids under this award. The Kong system has been in continuous operation since November 2012. A second system was commissioned in Tuntutuliak in December 2012, and the third system in Kwigillingok began operation in June 2013.

It was originally scheduled to have these projects on line by summer 2012. However, due to circumstances not related to the USDoE Tribal Energy portion of the project the project commissioning was delayed. The USDoE portion of the project required all other system components to be installed and operating before the Wind Heat technology could be implemented. Delays outside the control of this grant included: slow funding from other agencies or the communities for installation of related system components (wind turbines, diesel engines, controls, etc.) and the unpredictability that comes with working in remote communities under, often harsh, weather conditions. These delays did not affect the final completion of scope of the grant requirements.

This project could not have been possible without the support of the USDoE Tribal Energy Program. No other program support was available to provide the tools needed to knit the various components of the village wind systems together across a group of villages. The ability to implement this kind of solution is having and will continue to have a significant impact on improving the economics of wind-diesel systems for tribal communities. It has also provided a much needed method for individual tribal members to lower the cost of residential home heating and decrease fossil fuel use.

Project Overview

The project consists of implementing a Multi-Village Wind Heat Smart Grid in the diesel microgrids of four remote communities in southwest Alaska. Three projects in Kongiganak (Kong), Kwigillingok (Kwig) and Tuntutuliak (Tunt) have been completed as of June 2013. Each of these projects are high penetration wind-diesel projects with wind capacity in excess of 200% of the peak load. The excess wind capacity is able to displace significant amounts of diesel fuel used for power generation at low wind speeds, while at higher wind speeds the excess wind power is diverted to electric thermal storage (ETS) units distributed in residences throughout the community. The main objectives are to optimize the displacement of diesel fuel at the utility with wind energy, increase the number of kilowatt-hours sold by the utility and provide a lower cost source of home heat to residential customers.

The fourth project in Kipnuk is awaiting final construction funding to build an entirely new powerplant. The metering system has been implemented in Kipnuk, and the same system architecture will be used in all projects. The Kong, Kwig and Tunt projects have a common design. The Kipnuk project will be somewhat larger

and will benefit from the experience of the preceding projects. Kipnuk is planned for a completely new Wind Heat Smart Grid system to be completed Summer 2016.

Each of the first three projects (Kong, Kwig, and Tunt) consist of five 95 kW Windmatic 17s wind turbines equipped with power electronics to improve weak grid integration. Other system integration equipment consists of load controlled heat recovery boilers to manage system energy balance, and electronically fuel injected diesel generators to provide real energy support. The overall control of each of these systems is provided by an on-site wind-diesel supervisory system master control. The USDoE program provided support for the implementation of fast acting controllers on the ETS units, integration of distributed load control with wind-diesel system master control, installation of ETS units, and supply of multi-community automated meter reading systems for accounting and control.

A Wind Heat Smart Grid is a stand-alone, community diesel power grid with intentionally installed excess wind capacity. In these systems, light winds displace diesel fuel used for generation of electricity at the diesel power plant, while modest to high winds produce excess wind energy that is captured in ETS devices to heat homes. The wind energy used for heat is controlled, metered and provided to tribal members at a 50% discount to their current heating fuel cost. The result of this system is significant fuel savings at the utility and significant fuel and cost savings for homeowners, as well as increased revenue to the utility for excess wind sales.

The average electrical load in the communities of Kong, Kwig and Tunt is 150 to 200 kW. In each community 495 kW of wind power was installed. While a complete year of data is not available due to timeline of commissioning, to date system operations are continuously providing a 30% reduction in the use of fuel at the powerplant, and at least a 30% reduction in heating fuel used by the tribal residences installed with ETS devices.

The outcomes of the Wind Heat Smart Grid components of this project are significant in that they have demonstrated a scalable framework for enabling small communities to more cost effectively install and efficiently use highly variable wind energy to meet their community development objectives. USDoE Tribal Energy program support was vital to the accomplishment of this objective because of the flexibility of their funding opportunities.

Specifically, USDoE Tribal Energy resources were used to implement the integration platform and provide the training and technical assistance necessary to bring the diverse components of this project together to make it possible. This project has met many technical and community development objectives. However, one fundamental technical outcome is most important and has widespread significance for all tribal and off-grid communities. That outcome is that this project has removed the technical obstacles to the effective use of large amounts of

highly variable wind energy in small isolated grids. This achievement opens the door to larger and more cost effective wind system deployments allowing for greater displacement of costly diesel fuel. Greater diesel fuel displacements translate to energy savings for both the utility and customers, and at the same time enable the utility to increase its revenues through heat sales. Displacing expensive, imported diesel fuel with local wind energy preserves precious dollars in the community and helps build a more sustainable region.

While the USDoE Tribal Energy Program support did not pay for the installation of the wind turbines or the upgrades to the power system, it did provide funding for the installation and implementation of controls in the ETS devices, assistance to install the devices and smart metering to keep track of the energy sales. The USDoE support was instrumental in pulling both the diverse systems components and the geographically distributed communities together to make the system functional and economical. The technical objectives demonstrated by the Wind Heat Smart Grid have enabled the CWG to create wind technician jobs, increase the wages of the local utility personnel and help make the local economy more resilient. Since the CWG communities are working collaboratively, the benefits of this work have been extended to multiple communities.

Project Objectives

The fundamental objective of this project has been the implementation of methods for using excess wind power to heat homes. This involves not only capturing the excess wind when it is available and doing so in a manner that maintains the stability of the power system, but also implementing a system that allows each community to account for the sale of wind heat separately from that of diesel generated electricity. These objectives have clearly been met and through this project the CWG communities are able to use wind energy to displace fuel used by the local utility for power generation, but also fuel used to heat homes within the community. Currently, in the CWG communities of Kong, Kwig, and Tunt, ETS devices operate in a complementary manner to the availability of wind energy. That wind energy is metered and sold to residential customers at a saving of over 50% of the comparable cost of heating fuel.

The results and progress of this project have been reported by the CWG President, William Igkurak and Intelligent Energy Systems Principal, Dennis Meiners at the Tribal Energy Conferences in Denver in each year of the project.

Funds were not available for full scale deployment of an ETS device in each residence across the entirety of all villages. 21 ETS units were installed in Kongiganak, 27 were installed in Kwigillingok, and 30 were installed in Tuntutuliak. These systems are expected to be expanded to 50 ETS units per community in the near future. The outcomes of these projects have significance for

all stand-alone tribal communities with respect to the shared goals of displacing diesel fuel use, lowering energy costs, and fostering local economic development.

With the exception of the number of ETS units installed, each of the power systems in Kong, Kwig and Tunt are, in all important respects, similar. A typical system is described below.

Project Performance and Activities

Typical System: Kongiganak Case

The Puvurna Power Company serves the community of Kongiganak, a traditional Yup'ik Eskimo village of 439 permanent residents. Kongiganak is located on the west shore of Kuskokwim Bay, 70 miles southwest of Bethel, and 450 miles west of Anchorage. The community includes a school, washeteria, community center, clinic, lighted 2500-foot runway, a bulk fuel storage facility, two small local stores, and 135 residences. The economy is based primarily on a fishing and subsistence lifestyle. Local employment includes work at the school, limited commercial fishing and seasonal construction.

The population and electrical load are increasing each year. Recent oil price volatility has resulted in a tripling of fuel prices since 2007. The electric utility (Puvurna Power Company) is tribally owned and buys diesel fuel in bulk for \$4.50 to \$5.00 per gallon. The Village Tribal corporation purchases fuel in bulk for a similar price and resells residential heating oil for approximately \$6.50 to \$7.00 per gallon depending on availability. Since the community is entirely dependent on diesel fuel for heating and power generation, reducing dependency on diesel fuel is vital for the economic stability of the community. In the lower Kuskokwim region, there is an abundant wind resource. Wind-diesel systems hold promise for lowering power costs and reducing diesel fuel use for this and many communities in rural Alaska.

The addition of 495 kW of wind capacity to the Puvurna (Kongiganak) diesel power grid created a high penetration wind-diesel system with excess wind turbine capacity installed. The intention was to generate electricity in excess of the power generation needs and use this energy to displace heating fuel.

In order to absorb all of the excess wind energy, a “Smart Grid” system is necessary. A graphic depicting the general conceptual design is presented below (Figure 1: System Architecture). It provides an overall perspective of the components of the wind-diesel power system and how they relate to the individual residential customer, now and in the future.

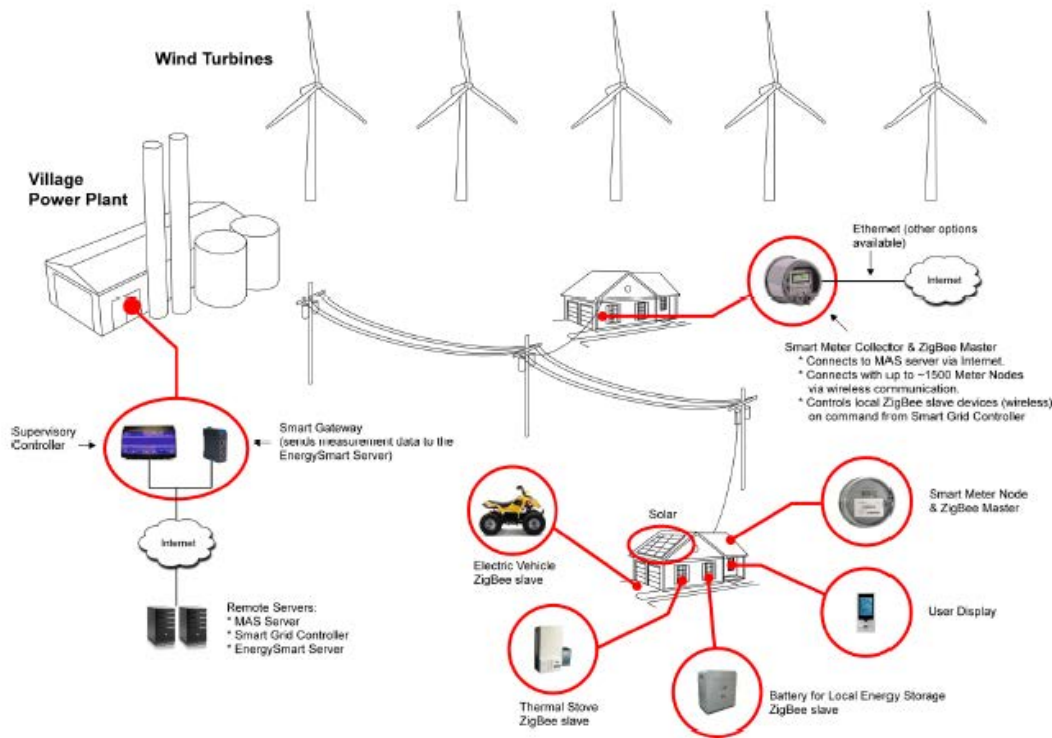


Figure 1: System Architecture

The system components are as follows:

1. Two electronically fuel injected diesel generator sets, rated at 260 kW.
2. 5 Windmatic 17-S wind turbines, remanufactured (each 95 kW nominal) - 600kW expected winter peak.
3. Load controlled, electric boiler connected into the power system heating loop.
4. 21 residential electric thermal storage (ETS) devices distributed across the community. Each unit has a 6 KW peak charge with energy storage capacity of 31 kWhr.
5. Modifications to the system master controls to manage distributed ETS devices.
6. Modifications to residential ETS devices to provide low frequency protection, two way communications and resolution of load control.
7. A smart metering system to link all systems, within each community and between the communities, together.

In support of implementing smart grid objectives, several years of historical weather data for Kongiganak and Bethel area were collected and analyzed. Consulting meteorologists were asked to examine aerial photographs and maps, suggest potential wind sites, and estimate wind turbine output. One year of monitoring data was collected and several models were run to estimate the potential fuel savings.

Wind for Heat

One of the first tasks in designing a wind-diesel system for a remote community, like Kongiganak, was to analyze the amount of fuel available for displacement and correlate that information with the potential for wind generation (see Figure 2: Wind Production and Penetration by Month). Survey information indicated that, because electrical rates were being subsidized, the greatest need for energy cost relief was for fuel used for home heating. It is estimated that the average homeowner consumes 766 gallons of heating fuel at a cost of over \$6.24 per gallon. In some circumstances, this makes up more than 60% of a household budget. The decision was then made to implement a wind system sufficiently large enough to generate excess wind energy. It was estimated that that excess wind energy could be sold for \$.10 to \$.15/kWhr. This would represent a significant cost savings to the average consumer while increasing revenues to the local utility.

There are multiple locations for wind energy to displace heating fuel throughout the village of Kongiganak and throughout the rest of rural Alaska and other isolated grid environments. The implementation of the advanced control and metering system to make the Wind Heat Smart Grid possible required additional funding. The CWG Board asked Intelligent Energy Systems to assist them with the development of these systems and to help seek assistance from the Tribal Energy Program at USDoE.

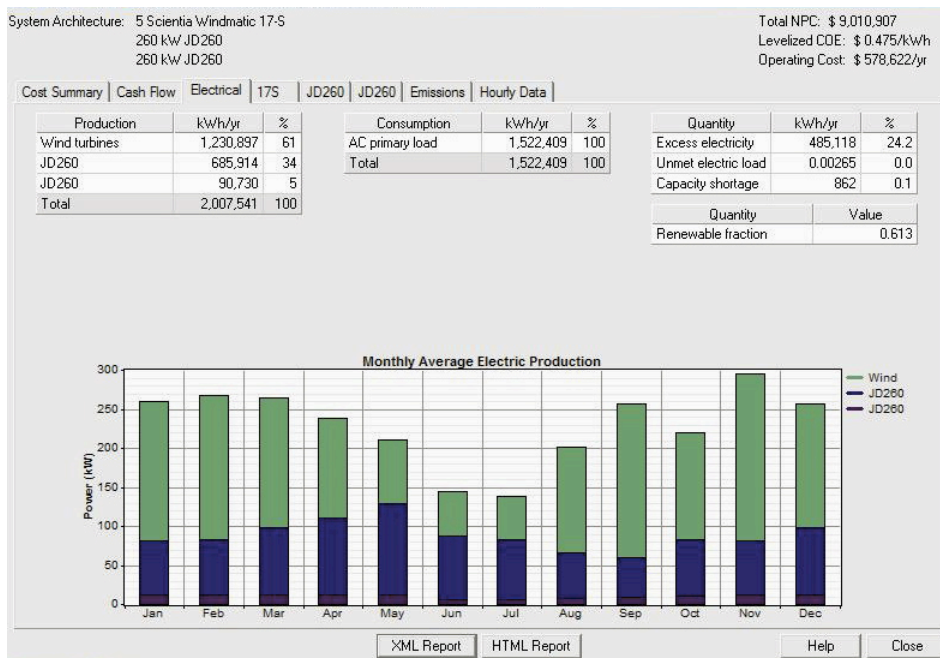


Figure 2: Wind Production and Penetration by Month

Initial wind-diesel designs envisioned achieving very high wind energy contribution through the use of fast acting energy storage systems (i.e. a flywheel or battery storage) to regulate energy flows on the grid as the wind power fluctuated. Funds were not available for an advanced flywheel or battery system, so a lower cost

solution was proposed. This approach required closer integration with the wind turbine and diesel generator outputs and specialized controls and control scenarios that prioritized the use of ETS devices distributed across the community for load balancing. Keeping track of the excess wind energy separately from the diesel generated electricity was necessary because each residential customer is eligible for subsidy for the first 500 kWhrs of residential consumption from the State of Alaska Power Cost Equalization program.

The system configuration that was proposed for assistance is described below in Figure 3.

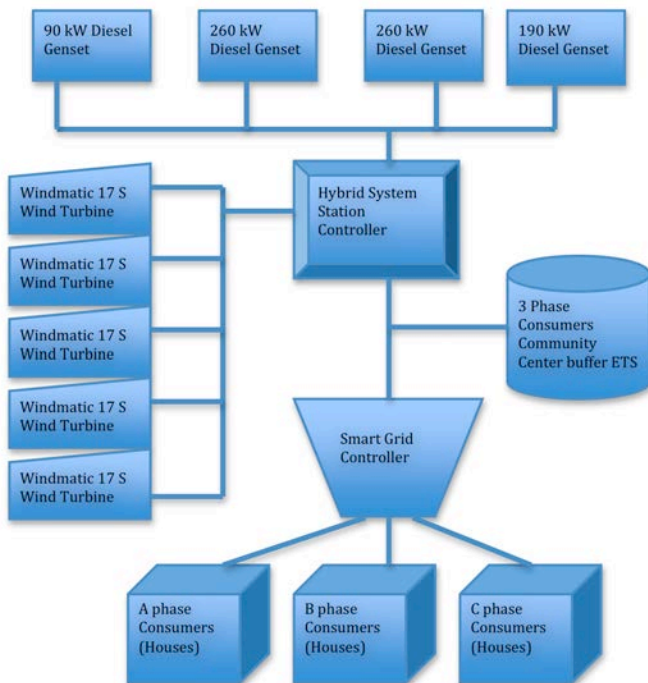


Figure 3: Principle Wind-Diesel System Components

Two diesel gensets, both capable of prolonged efficient operation at low load, were installed in the Puvurna power system. Wind turbines were installed in 2009. However, the wind turbine supplier was unable to provide a control system for the turbines and the program was delayed as a new wind turbine controller was built. The metering system and ETS units were installed in the winter of 2011, in anticipation of commissioning wind turbines in July 2012. A first phase wind turbine was installed in Kong in August 2011, and work was begun to make improvements to that controller and advance the design. A second version of the wind turbine control was implemented in the summer of 2012, along with installation of the wind-diesel supervisory control and load balancing boiler. The ETS gateways and control were implemented in October 2012 in Kongiganak. Two weeks were required to provide onsite commissioning. The entire wind heat system became active in automated mode in late November 2012 and has been successfully

operational since that time. An advanced data collection system is expected to be implemented within the next year to provide additional data collection and analysis capabilities.

The diesel generators were interfaced with the wind turbines and an electric boiler was employed to buffer the wind variations. The electric boiler is connected into the power plant’s heat recovery system to provide heat to the community washeteria.

Community Heating

In the CWG communities, there is a good match between the available wind resource and the heating needs of the communities. The five 17S Windmatic (95 kW) machines were installed to intentionally generate excess wind energy over and above that required to meet the community electrical load. As configured, in light wind speeds (10 to 20 mph), the wind turbine output reduces the need for diesel power generation. In modest to high wind speeds (> 20 mph), excess wind power is generated and stored in the ETS units. The ETS units capture electrical energy by heating ceramic bricks that can be accessed later for room heat, thus displacing heating fuel. Special metering was added to the ETS device controllers to calculate energy consumption on the ETS unit.

Fuel and Cost Savings: Available wind and electric load data were analyzed using HOMER modeling software to provide general guidance in estimating the amount of excess wind energy that would potentially be available for heating. A base year of 2015 was used in which the load is expected to be 1,500,000 kWhrs. The HOMER model is an energy flow model which estimates energy production for each hour of the year, and sums these to provide a general estimate of power production of each turbine. The HOMER model does not take into consideration the stability of the power balance in the system.

Table 1 – Projected Fuel Savings in Kongiganak 2015

System Description	Overall System		Power Plant		Heating Fuel Estimated	
	Fuel Consumption (gal/yr)	Fuel Savings (%)	Fuel Consumption (gal/yr)	Fuel Savings (%)	Fuel Consumption (gal/yr)	Fuel Savings (%) per household
Diesel Only	135,750	n/a	90,750	n/a	45,000	n/a
Wind-diesel			54,690	39.7		20.0
Fuel Displacement target	45,000		36,060		9,000	

Windmatic Wind Turbines

The CWG community leaders reviewed, with IES, several wind turbine types and selected the Windmatic 17S. Their reasoning was based on their many years of living in rural Alaska, and their experience with running power systems. Based on this experience, their primary selection criteria were that the turbines must be of proven design and made up of individual mechanical components that local technicians could understand and be trained to work on. Their secondary criteria was redundancy. They wanted as many wind turbines with as much capacity as they could get for their investment.

The Windmatic is of classic Danish design and has been proven to be a reliable workhorse, wherever it has been installed. The Windmatic 17S (17 meter rotor diameter) wind turbine is a three bladed, stall regulated, upwind wind turbine with a nominal rating of 95 kW. These turbines use induction generators that require excitation from the power line to generate power and consequently operate at the line voltage and frequency. Considerable work was required to adapt the control of these turbines to weak grid applications. Design, development and testing of an appropriate control system for these turbines resulted in project delays of 18 months.

The Windmatic operates between 4 m/s and 25 m/s, achieving rated power at 15 m/s. Above rated wind speed and during periods of cold dense air, the wind turbine's power could easily exceed the rated power for short periods without causing the wind turbine to cut out. The Windmatic turbine can operate from 0 to 125% of full rated load (95kW). The gust power of the turbine is estimated to be 120 kW and has been observed in other locations. The maximum gust power of 5 machines defined the total capacity required for all thermal storage banks.

The Role of the Tribal Energy Program: Need for Smarter Controls and Metering

The CWG Board settled on the five turbine configuration for each community. Since the wind regimes are similar across the regions, each system is estimated to produce over 480,000 kWhrs of excess electricity, equivalent to 14,700 gallons of heating fuel (13,690 Btu/gal in an 80% efficient appliance). Electric thermal storage (ETS) stoves will be used to capture and store this energy. In the Kongiganak wind-diesel system there are three types of thermal energy storage capacity:

- The power plant heating loop
- Community facilities which include the community center and head start classrooms.
- Residential heating

While the actual savings resulting from the use of excess wind energy will depend on several variables, such as the availability of the wind, customer decisions and price, electricity sold for \$.09 to \$.12/kWhr would be equivalent to \$3.00 per gallon heating fuel. Since current heating fuel prices exceed \$6.00 per gallon, this excess

wind energy represents a potential fuel savings of 50% saving. Annual average residential fuel usage is 760 gallons per household. The target for this project would be to displace 200 gallons of heating fuel in each of the 21 homes fitted with the an ETS unit in Kongiganak.

Making this design work required three elements:

1. Modifications of wind-diesel supervisory controls to incorporate the distributed ETS devices into the grid stabilization plan.
2. Modification of ETS controls to communicate and react to control signals from the supervisory controls with sufficient speed and resolution to follow changes in the wind output.
3. Purchase and install a metering system that would enable the utilities to charge different rates for excess wind energy used for heating from the normal electrical charges.

In addition to providing support to purchase and install controls and metering systems, USDoE funds were used to pay local operators to install the metering systems and the electric thermal storage devices. The managers of each local utility (Kwig, Kong, Tunt and Kipnuk) coordinated their local work teams to complete this work. The utilities required a metering system with remote reading and remote disconnect/reconnection as a financial management feature for utility operations and collections.

Table 1: Heating Fuel Comparison used by communities for establishing excess wind energy rates into ETS devices.

Diesel #2	Gallon Cost	Cost/MMBTU	Appliance Conversion Efficiency:	Actual Cost/MMBTU
138,690 BTU/gallon			78%	
	\$3.00	21.63		27.73
	\$4.00	28.84		36.98
	\$5.00	36.05		46.22
	\$6.00	43.96		55.46
	\$6.24	44.99		57.68
	\$7.00	50.47		64.71
	\$8.00	57.68		73.95
Electricity	Cost per KW/hr	Cost/MMBTU	Avg App Conversion Efficiency	Actual Cost/MMBTU
3,412 BTW/KW			98%	
	0.05	\$14.65		\$14.65

	0.075	\$21.96		\$22.43
	0.08	\$23.45		\$23.93
	0.09	\$26.38		\$26.92
	0.1	\$29.31		\$29.91
	0.125	\$36.64		\$37.38
	0.15	\$43.96		\$44.86
	0.175	\$51.29		\$52.39
	0.2	\$58.62		\$67.29

The Wind Heat Smart Grid Control System

A critical part of the Puvuruaq wind-diesel system is the automated power system control. High penetration wind-diesel systems require sophisticated control systems to dispatch the generation resources reliably and to maintain system voltage and frequency during periods of wind operation. The control system is designed to optimize and balance the heating and electrical loads against the available wind power and the diesel generator output. In general, the diesel power plant supervisory controller is integrated with the wind turbine and demand managed device control to create a hybrid System Master Controller (SMC). The SMC automates the combined operation of the wind-diesel system package and features high-resolution data recording, full remote control operation and redundant levels of control to assure reliable power system operation. In addition to the supervisory control, a Smart Grid Controller manages the use of electric thermal storage units and metering of the excess wind energy through the individual meters in the homes. The primary subcomponent controllers are the diesel generator or genset controllers, the wind turbine controllers, and demand managed or thermal device controllers. The control system is broken down into several levels of operation.

The control system is a structured hierarchy providing a high degree of resiliency for power control with minimal loss of power in the event that an individual component or controller fails. Each diesel generator has its own controller independent of the SMC. The failure of one generator controller does not affect the operation of any other generator controller, or the operation of the station controller. The protection functions and the load sharing functions of the remaining generator controllers will function as normal and the SMC will simply modify its scheduling table to take into account the missing generator. This control architecture insures that the diesel plant stays on line. The electric thermal storage devices have their own separate controller that include a low frequency cut off, radio communications, and sub metering. Each electric thermal storage device has an individual controller that monitors outdoor temperature, state of charge and responds to automatic pricing signals and manual control.

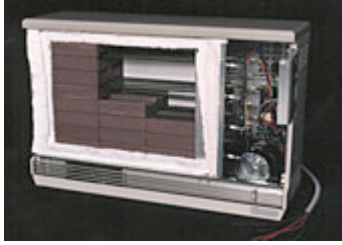
Electric Thermal Storage

An average home in Kongiganak uses over 760 gallons of heating fuel annually. During a windy week in the winter, a single home can consume an entire 55 gallon drum of heating fuel. This project proposed to capture the wind and use it to heat homes throughout the year using Electric Thermal Storage (ETS). ETS is the method of capturing excess wind generated electricity as heat and storing it for use at a later time. An ETS unit is an insulated metal box, about the same size as a Toyo Stove, containing electric heating elements that lie within special, high-density ceramic bricks. These bricks are capable of storing vast amounts of heat for extended periods of time. During periods of excess wind energy, a signal from the power plant SMC is sent to the metering system. The meters then enable the relays, which turn on elements that heat the bricks. Operation of the system is completely automatic. A sensor monitors the outdoor temperature to regulate the amount of heat the system stores in the bricks. A thermostat regulates the delivery of the heat to the room. Each unit has a built in microprocessor that allows the owner to configure the operation for their needs. There are over 100,000 of these units in operation in the mid-west states and off-peak heating is common in Europe. The system provides a lower cost, low maintenance method of home heating.

For the wind-diesel application to be effective the ETS units will be charged on dynamic schedules, charging in periods of high wind. The residential ETS units are sized to provide a maximum heat production of 30,000 Btu/hr. Heating surveys indicate that average hourly living room heat for a residence in Kongiganak is 14,000 Btu/hr. Each thermal storage unit can both produce and store up enough energy depending on the charge schedule to output 20,000 Btu/ per hour per unit, 24 hours a day. This is similar in size and energy output to a Toyo Stove. The pictures below present an exterior and interior view of a room unit. The dimensions are 58 inches in length, 24.5 inches in height, and 10.5 inches in depth, and when filled with heat charge bricks each unit weighs 650 lbs.



The room units (shown above and below) are non-ducted and are designed to heat the room or area where they are placed. These heaters can be used in new construction applications or as a retrofit or supplement to an existing heating system and only require an electrical connection to operate.



A fan inside the unit circulates stored heat evenly and quietly as the room thermostat calls for heat. Individual units are easy to operate and require very little maintenance. The amount of heat stored in the brick core of the heater is regulated (either manually or automatically) according to seasonal weather conditions using an outdoor temperature sensor and an onboard microprocessor.

Signals from the wind-diesel System Master Control enables the ETS to charge and calculates energy usage of each ETS device. This information is then compared with energy usage data from the Smart Metering system. This allows the utility clerk to allocate electrical usage charges differently between excess wind and diesel only generation.

The Smart Metering system working with control signals from the diesel plant insures that customers are only charged the reduced excess wind rate for heating.

ETS units with modified control features include:

1. Under frequency detection and disconnection relay
2. Submetering of heating elements
3. Individual element control for 100 watt resolution per device
4. Two way communications between each ETS device and the powerhouse SMC

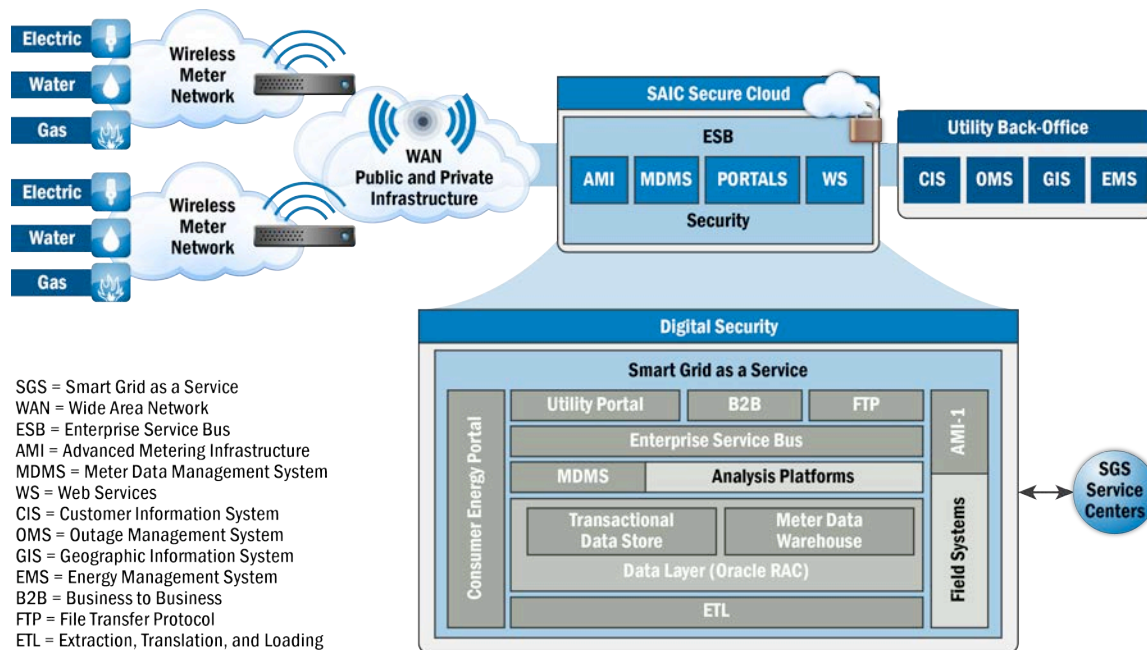


Technician Wassilie Lupie installs an ETS device in a home in Tuntutuliak, AK.

Smart Metering

One of the objectives of the program that was the most difficult to achieve was the full integration of a Smart Meter based Smart Grid on such a small scale. Smart Metering programs are expensive, not necessarily because of the hardware, but because of all the software features that must be implemented to make the systems effective. Besides being financially out of reach of small communities, most if not all smart grid/smart metering systems require a full time information technology staff to maintain and operate the systems. As part of this project, much time and effort was spent determining what metering options and features were practical and available. This is still an emerging market. The following major vendors were investigated and quotes and scope of services were obtained. GE, Itron, Sensus, Landis and Gyr, and Elster meters, as well as many other suppliers were reviewed. SAIC Smart Grid as a Service (SGS) using Elster metering systems were selected and implemented. Below are three figures describing the existing SAIC system.

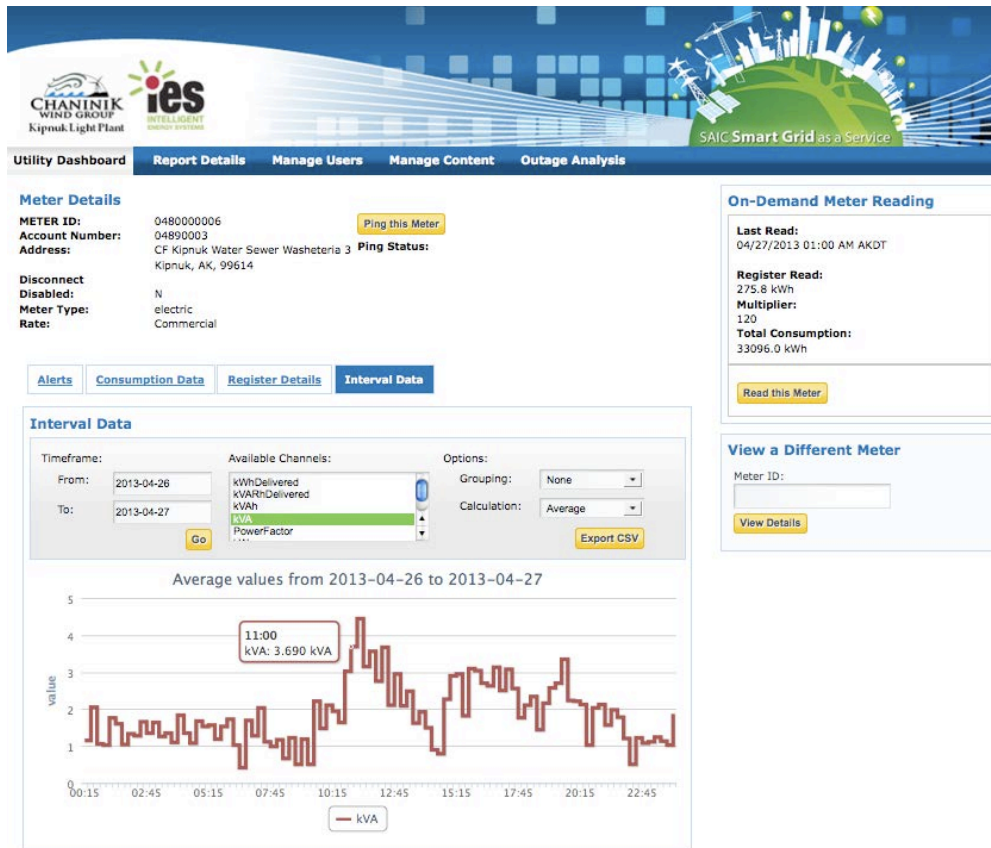
The following figure describes the range of services available to the communities through the SGS backbone.



The following figure provides a screen shot of the outage management module for the community of Kipnuk, as shown through their Utility Management Portal. While the metering system has many features, the Outage Analysis Module has been most helpful in improving the reliability of local power grids. Prior to the installation of the metering system, many of the problems within each community grid were practically undiagnosable.



Screenshot of Kipnuk Outage Analysis Module of SAIC’s Smart Metering System



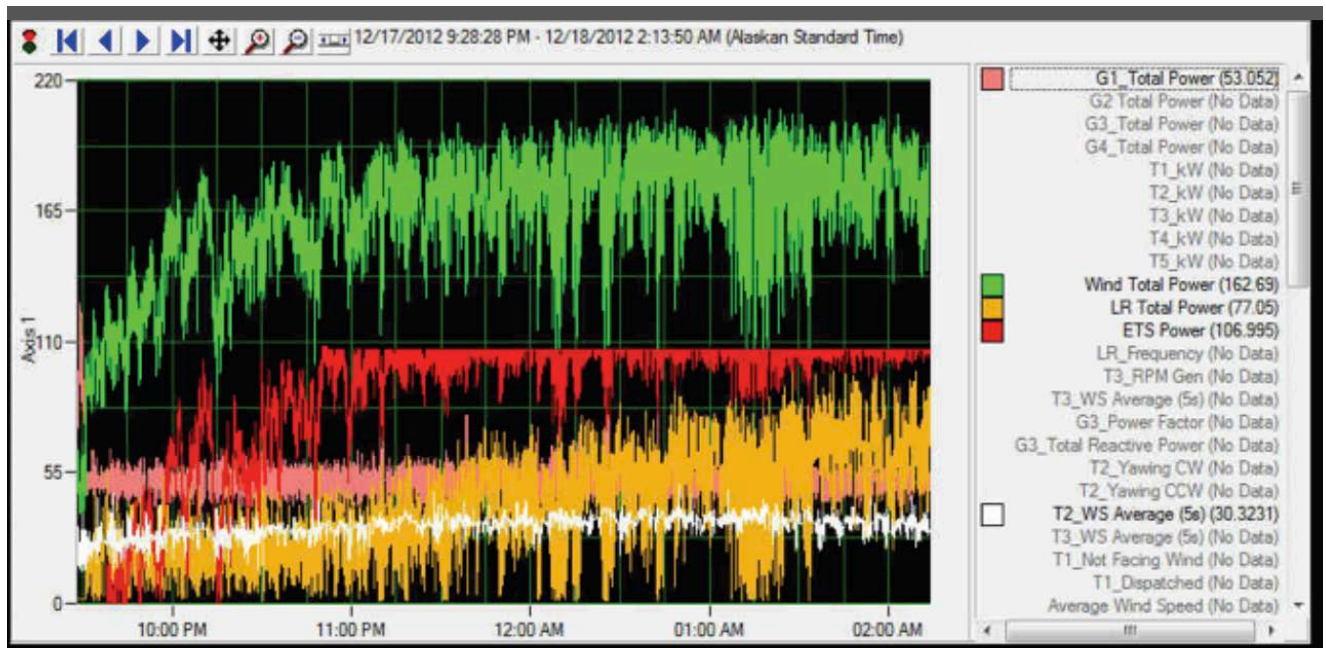
Screenshot of Smart Meter Profile for Washeteria in Kipnuk, AK

The Smart Meter utility and customer web portals allow a web interface for each customer and utility to manage their energy information and metering system. The utility uses the secure interface for managing the metering systems and providing data and reports for usage and reliability. Each customer has access to their consumption information through a web page that measures energy usage and provides an hourly usage report. Each commercial customer can read their energy usage in 15 minute averages.

System Performance

The figure below is a snapshot that captures system operation in Kongiganak during a 5 hour period on December 18, 2012. At that time only 3 wind turbines were on line, as well as 21 ETS units, running in parallel with a 250 kW generator. The total nighttime system load in the community was approximately 125 kW. The green trace in the figure shows the combined wind power in the system. The average wind speed at the time was approximately 25 mph, and average output from each wind turbine was 80 kW. The winds were gusty and wind power would vary +/- 30% over a few seconds. The green trace indicates that the wind is rising over time. The pink trace is the output from the diesel generator that is controlled

at a set point of 55 kW. The gold trace indicates the energy consumption of the load balancing boiler, and the red trace is the energy supply to the ETS devices. This data indicates that the 21 ETS units are actively following the wind load, and that after 5 hours the devices become full and have reduced their ability to absorb any more heat energy. This data indicates that in a modest wind, the ETS devices are completely charged in 5 hours. The system as configured is limited by the need to expand the thermal storage capability.



Kongiganak SCADA Snapshot

Conclusions and Lessons Learned

While data collection to substantiate performance is on-going, reception by the communities has been highly favorable. Requests from community members and Tribal leaders have been made to expand the system to every home, and to upgrade the electrical distribution system to accept more wind energy. Other nearby communities that have heard or seen the success of this system are also requesting assistance to install this capacity in their communities.

The data shown indicates the stability and effectiveness of this system to absorb wind energy using residential ETS devices. Homeowners with ETS devices are reporting a high level of satisfaction with the functionality of the ETS units, as well as home heating fuel use decreases in excess of 30%. A data collection program is underway to accurately quantify these benefits.

The results are shown in the following tribal member responses expressed on the Kongiganak Facebook page. As the sentiments from the Facebook page show, homeowners are able to turn off their diesel heaters and use wind energy to save fuel and money. Roderick Phillip, Board Chairman at Puvurna Power Company

took and posted these pictures. He and the other Chaninik Wind Group community members are excited and grateful for the support of the USDoE Tribal Energy Program in their efforts to bring low cost energy to their region.



Screenshot of Community Facebook Page for Kongiganak, AK – December 2012