Alaska Energy Authority

Emerging Energy Technology Grant Fund Application

March 9, 2012

Project Title: **Self Regulated Wind Diesel Grid Using Electric Thermal Storage Units**

Applicant: **Intelligent Energy Systems, LLC**

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Partners: **Steffes Corporation, Tom Steffes**
Tuntutuliak Community Services Association Electrical Services
Richard Wies, Phd. University of Alaska Fairbanks
Ginny Faye, Assistant Professor University of Alaska Anchorage/ISER
Albert Sakata, Sakata Engineering

Total Project Cost: **$485,634**
Grant Funds Requested: $ 465,634
Match Committed: $ 20,000

Previous Grants: **Tuntutuliak Wind Farm Construction – REF #2195457**

Previous Abstracts: **None**

Abstract

1. Project Summary

a. **Project Description**

Villages are almost entirely dependent on diesel fuel for power generation and heating. The use of wind or hydroelectric power to displace diesel fuel is economically and environmentally desirable. However, due to rapidly fluctuating energy output from wind turbines, varying village loads, and limited system energy reserves, wind penetration is usually limited to 30% of power generation. The inability to efficiently absorb and balance large power flows on small isolated grids, limits the capacity and economics of wind, solar and hydro address the high cost of energy in villages. This project employs distributed intelligent load control as a low cost, effective method of increasing renewable penetration on isolated grids. Rather than dump excess wind or hydro power, or curtail output, deferrable consumer loads, such as electric thermal storage (ETS) units, hot water heaters, freezers, and electric heaters, can be brought on and off line autonomously using advanced on board grid sensing switches.

In this application, electric thermal storage units (ETS) will be used to regulate the frequency of a village wind diesel grid. Each ETS unit would be equipped with an advanced on board micro controller. Software embedded in the controllers measures the frequency and voltage of the power system and uses this information to switch internal elements on and off to stabilize the grid.

ETS heating units are specially designed resistance heaters with electrical elements encased in ceramic bricks. The bricks are housed in insulated cabinets and are able to store electricity as heat for long periods of time. ETS units are designed for residential or commercial heating applications and equipped with thermostats and fans to dispense stored heat. Each individual ETS unit would be equipped with an advanced controller that independently and rapidly controls elements to shed load to prevent outages and absorb excess wind power as required to maintain grid stability. The excess wind power provides a lower cost alternative to diesel fuel for space heating.

The Tuntutuliak power system is designed with sufficient wind power to displace high heating needs as well as the electric load. ETS units with advanced controllers would be installed in 30 homes on the Tuntutuliak wind diesel grid. A separate 3-phase ETS unit would be installed in the community washeteria. The population of ETS equipped with advanced controllers acting together across the community grid will be used to provide complete stabilization of the wind diesel power grid, without the need for separate communication method or specific coordination. The ETS heating units will smooth power fluctuations and provide consistent heat output for the user.

This control method can be adapted for use in other devices, such as hot water heaters, heat pumps, hydrogen generators, and household appliances to balance the load on a grid. This technology will increase the economics of village wind and hydroelectric systems by enabling more cost effective larger installations, increasing local energy sales, lowering home heating costs and providing a simplified method of grid stability.

b. **Project Eligibility :**

1. This project meets the requirements of AS 42.45.375, which includes the improvement to an existing energy technology reasonable expectation of commercial viability within five years. High heating oil prices make wind heat an attractive alternative. This technology has a readiness level of 8. This demonstration will lead to rapid deployment across all grids in Alaska.

c. **Project Innovation**

On a power grid, the system frequency is a measure of the balance between load and generation. Wind energy is a highly variable source of energy. Installing sufficient wind capacity has broad applicability for displacing diesel fuel in villages. When the amount of wind energy exceeds the load on a system the system frequency rises and if not managed will result in power outages. Using wind and hydropower for heating in villages often improves the economics of installing renewable energy systems, with multiple benefits of lowering village heating costs, and increasing local energy sales which improve the financial sustainability of the community.

The project innovation is the use of distributed intelligent load control to increase wind penetration, reduce diesel fuel usage and stabilize a village wind diesel grid.

This project validates the performance of advanced self-regulating load control of ETS devices to provide an improved, more energy efficient frequency control solution for high penetration wind diesel grids. The project demonstrates the use of an advanced microprocessor controlled ETS units in Tuntutuliak that enable each individual ETS device to automatically shed or increase load in a complementary manner with the available wind. This advanced controller will demonstrate the use of a simple to deploy, robust, cost effective means of grid self-stabilization using distributed deferrable loads.

The Chaninik Wind Group is using electric thermal storage (ETS) units to capture excess wind and store it for residential heating. These ETS devices are equipped with a controller that requires set point signals from the powerhouse SCADA to absorb excess wind. This current ETS controller also has an onboard low frequency relay that disconnects the device from the grid when the system frequency drops below a set limit. This feature prevents outages when there is a power deficiency in the system. Currently the ETS devices are only enabled through a radio signal broadcast from the powerhouse SCADA system. The advanced controller proposed in this project provides autonomous self-regulation.

The performance of the system will be evaluated in all operating modes, both low and high penetration, and from fully controlled through the SCADA to autonomous self regulation of ETS units. The SCADA is able to collect data and adjust system component configurations to fully optimize the wind and ETS potential, including minimizing diesel generator loading.

A resource allocation model of the Wind-Diesel system will be used to evaluate the self-tuning algorithms for the ETS devices. On board measurement devices and special control boards will be fitted to the ETS units. These will be polled to validate the control performance. The controllers can be remotely tuned by modifying input membership functions. The controllers continuously monitor their performance and will be tuned where necessary. The project will demonstrate the suitability for commercial application of the ETS units for the displacement of heating fuel with wind, and the large-scale integration of renewable energy in standalone and grid connected power systems. The advanced control system will be evaluated for adaption to other deferrable loads such as hot water heaters, hydrogen generators, ice makers, pumps, freezers and plug in vehicle controllers to provide an easy to deploy, low cost and robust method of grid stabilization.

d. **Priority**

This application meets all four of the stated priority considerations outlined in AS 42.45.375(d) and the Alaska Energy Authority's Request For Applications (RFA sec. 4.3):

1. **Alaska residents, associations, organizations, or institutions** – This project will serve the community of Tuntutuliak. The project will provide the utility and customers with a scalable

solution for energy cost savings from which other communities can benefit. The project is proposed by an Alaskan business.

2. **Projects that demonstrate partnership with the University of Alaska or another Alaska postsecondary institution** – Ginny Fay Assistant professor of energy economics of The UAA Institute of Social and Economic Research and Dr. Rich Wies, Phd. Asst. Professor of Electrical Engineering at UAF are participants. They will provide analysis of energy system performance.
3. **Projects supported by matching funds or in-kind partnerships** – IES commits to support this project with $25,000.00 in in-kind services during the operational support phase of this project.
4. **Projects with potential for widespread deployment in the state** – The successful implementation of the self regulated grid is an extremely flexible low cost tool for increasing renewable energy usage.

2. Technology Validation and Research Methodology

Steffes ETS devices will be deployed on the Tuntutuliak Wind Diesel grid. Dynamic control simulation will be compared with actual performance of the ETS units using power monitors. Actual high speed and power quality data will be collected from the wind diesel SCADA system, and used to validate control settings and response requirements. One year of data will be collected analyzing ETS energy storage, and associated control modes to assure stable plant operation. Each ETS controller comes equipped to sub-meter energy usage and receive a radio signal to provide a set point. Home owners, who host the ETS devices will be interviewed to determine user satisfaction and annual savings. This will provide the opportunity to verify and build upon the findings of economic models developed by the Institute for Social and Economic Research for the Chaninik Wind Group operating plan. Rich Wies from the University of Alaska will serve as an independent evaluator and consultant on this project. Dr. Wies will review data and proposed operating scenarios for control system assessment, system validation and performance enhancements. The impact of forecasting the accuracy for load and renewable energy penetration will be evaluated.

3. Summary of Project Schedule and Summary of Project Budget

a. **Project Schedule:**

The ETS unit is a well tested electric thermal storage device. The advanced controller was developed by IES and Steffes and is available for Fall 2012 installations. Customer surveys will be conducted along with deployment in August /September 2012. Installations will take place in October and November of 2012, followed by operational commissioning, to be completed in December 2012. Data collection to begin December 2012.

Test data will be analyzed on an ongoing basis to validate performance.

b. **Project Budget:** The projected budget allocated by expenditure type is listed below:

Hardware/equipment	$289,884
Contractual	$195,750
Total Project Cost	$485,634

4. Project Team Qualifications

- Tom Steffes: is the chief project engineer at Steffes Corporation. Steffes is supplier of high quality electric thermal storage (ETS) heating units. Tom Steffes in charge of research development and testing of new ETS products, especially for smart grid and wind heat applications.
- Dennis Meiners, is the CEO of IES, an Anchorage based business. Mr. Meiners has over 10 years of involvement in village power wind diesel system integration, and is currently involved in three high penetration wind projects with the Chaninik Wind Group. The project will be assisted by staff of IES.

- Albert Sakata: Mr. Sakata is an registered electrical engineer, with more than 30 years of power and control system experience. Mr. Sakata has been a licensed and practicing electrical engineer for 25 years in Alaska.
- Ginny Faye: Ginny Faye is assistant professor of energy economics at the Institute of Social and Economic Research at the University of Alaska Anchorage. Professor Fayes area of expertise is in the economic assessment of wind diesel hybrid systems.
- Carl Andrew: Is the manager of the Tuntutuliak Community Electrical Utility. Carl will direct his staff to assist with this project, and to provide on site support.
- Dr. Richard Wies, Ph. D., P.E. University of Alaska Fairbanks, and Associate Professor of Eectrical and Computer Engineering at UAF, and registered electrical engineer in the state of Alaska. Dr. Wies has over 12 years of research experience focused on standalone hybrid systems.

5. Discussion of Commercialization of Funded Technology

a. **Potential Market:** This technology uses on board control to smooth out fluctuations in excess power, and provides consistent heat energy for users. The fundamental objectives of this project is to provide a simple robust, cost effect and easy to deploy method of increasing the use of renewable, particularly wind, energy integration in villages. This technology can be used deployed in various formats and in various markets. ETS units could be deployed a unit that can be plugged into the wall socket of cabin in a small village with a wind turbine and a series of these units would be added for grid stabilization. Similarly larger units could be deployed on the Anchorage Fairbanks intertie to improve the integration of wind. The device requires no communication with the utility, and can be adapted to many different appliances. The instate market is large, especially in wind diesel and hydro applications, such as those found in Southeast Alaska.

b. **Potential Public Benefit:**

Three primary benefits: improved the economics of village wind power, increased heating fuel saving, and provides a simple method of grid integration. A major problem for village power is low wind penetration. Installing a single wind turbine to reduce fuel used for power generation is expensive when considering the installed cost includes mobilization of equipment, crews, shipping, integration and distribution lines and connections. It is desirable to increase the capacity of village wind systems to increase penetration and to provide heat.

6. Signed Applicant Certification: By signature on this application, I certify that we are complying and will comply with the amount of matching funds being offered.

_____Dennis Meiners, Intelligent Energy Systems, LLC

Proof of Eligibility: Intelligent Energy Systems, LLC meets the eligibility requirement as a business holding an Alaska business license. Please see Attachment 1 (Alaska Business License – Intelligent Energy Systems, LLC).