AEA Emerging Energy Technology Grant Application AEA-12-047

Project Title: **Dynamic Modeling of High-Penetration Wind-Diesel System and Deployment of a Lithium Ion Energy Storage System**

Applicant Contact Information: **NANA Regional Corporation**
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Project Partners: **WH Pacific**
Sustainable Power Systems LLC

Total Project Cost: $814,000
Grant Funds Requested: $784,000
Match Committed: $30,000

Previous REF or EETF Grants: None

Previous EETF Abstracts Submitted: **Dual Fuel Micro-CHP Development with the Infinia CHP System; Underground Coal Gasification**

Abstract

Project Summary

Project Description:
Low-penetration wind-diesel systems have long proved to be a commercially viable technology both within and outside the State of Alaska. However, the economic benefit of a lower penetration system is still questionable when compared to the greater diesel offset found in high-penetration systems. Through modeling it is apparent that high penetration systems offer far better economic benefits to isolated remote grids due to that fact that the excess wind has the potential to meet both electrical and thermal energy requirements. While there are numerous successful high-penetration wind-diesel systems throughout the world, this technology is still new to Alaska. The few installations that do exist are not currently seen as success stories, but this has more to do with failures of project management than failures of technology. The potential to address thermal energy requirements using excess wind in a high-penetration wind-diesel system is huge and should not be ignored by relevant stakeholders.

One of the challenges with implementation of a high-penetration diesel hybrid system is the ability to stabilize power with the highly variable wind resource given a small and fluctuating village load. Energy storage options have been discussed and implemented in Alaska yet while there are successful installations to point to, it is still considered an emerging technology. Use of energy storage must be done in an intelligent manner if energy losses, due to system inefficiencies, are to be kept at a minimum.

A high-penetration diesel hybrid system has numerous necessary ancillary components, in addition to an energy storage system. This project's objective is threefold: 1)Develop a proficiency with Dynamic Modeling tools to ensure that system designs are based on performance not only economics; 2) Develop a Battery Management System which includes lithium-ion batteries that can rapidly respond to the demands of the grid; and 3) Demonstrate a high-penetration diesel hybrid system in remote Alaska. These three items are intended to create a promising energy storage solution for diesel hybrid systems, create a successful deployment of a high penetration wind-diesel system in Alaska, and increase the confidence levels in wind-diesel stakeholders that this is viable option for investment of state, federal, and private dollars.

Sustainable Power Systems will team up with NANA Regional Corporation and WHPacific to successfully study, develop, analyze, and deploy a high-penetration wind-diesel system using a Lithium-Ion Energy Storage System.

Project Eligibility: The proposed technology qualifies as an emerging energy technology specifically because: 1) Currently dynamic modeling is not generally used to evaluate diesel hybrid system stability and power quality 2) High-penetration systems are not funded by the HB152 Renewable Energy Fund; and 3) Lithium-Ion Batteries have not been used in a diesel-hybrid system. Therefore the proposed project meets all of the EETF's eligibility criteria:

- It tests an emerging energy technology.
- It improves existing energy technologies (energy storage systems, wind turbines, power electronics, and controllers).
- It tests a technology that has never been deployed on an Alaskan village power system

The Lithium Ion Energy Storage System is based on well-proven power converter hardware, well-established digital control methodologies, and demonstrated energy storage devices. We estimate the current technology readiness level at TRL 5.

Project Innovation:
High-penetration wind-diesel systems require a high level of system integration, technology complexity, and advanced control, which increases the project cost, however the potential for reduced fuel consumption and diesel engine operation significantly. Dynamic modeling will be a large asset in gaining better understanding of system performance and prevention of costly commissioning delays. The modeling will include analysis of secondary load management and source/load prioritization as well as energy storage management

Currently in Alaska, the use of HOMER has been the model of choice because it provides an economic evaluation of projects which helps a community determine what size and type of components are best suited for their project. To date that has been the only modeling required prior to seeking state funding. However, HOMER is only an economic tool and is does not provide the community or developer with information that is critical to the design of a hybrid power system in an isolated island grid system. There is large need, in our state and beyond, for dynamic modeling which takes into account the interactions of numerous machines over a period of time as determined by the data inputs and system components. In fact ,the need for having dynamic modeling prior to construction could soon become a necessity. The leading software tool for such modeling in called Powerfactory and is developed by DIgSILENT.

A need still exists for a high quality and modestly priced energy storage system exists. Large scale batteries for wind-diesel systems that could provide village utility grid stabilization and load shifting are currently being developed by several suppliers. If these batteries become commercial products at the price points currently being anticipated, they could provide significant diesel fuel savings in communities with wind resources.

Priority This project meets the following Prioritization Criteria:

1) NANA Regional Corporation is an Alaska Corporation.
2) This project has $30,000 of matching funds.
3) This project has the potential for deployment in the state.

Technology Validation and Research Methodology

Objectives: The objectives will be to demonstrate the economic and technical feasibility of high-penetration wind-diesel systems and to evaluate the effectiveness of a high-penetration wind-diesel system using a lithium ion energy storage system for power quality support and reduction in spinning reserve requirements.

Methodology: This project will develop a dynamic model of a potential high-penetration wind-diesel system using Powerfactory software, review existing market survey and do further research as needed to determine which lithium battery is best suited to a remote location, procure the battery and incorporate the battery management system into the existing Sustainable Power Systems supervisory controller. After development and testing at the University of Alaska's Hybrid Application Laboratory the energy storage system will be installed in a community in the NANA region which already has funding for wind-diesel construction. The exact community will be selected and described upon request for a full proposal. This project will leverage work that has been done through a previous Emerging Energy Technology Fund Award 'High-penetration power electronics' and funding allocated for development in the communities of Buckland, Noorvik, and Deering. There will be an intense focus on data collection and analysis so that other communities can benefit from the process.

Summary of Project Schedule and Project Budget

Project Budget
The type of in-kind staff support will include planning, resource assessment, community coordination, meeting time for project management, and other aspects involved with project execution. NRC staff members will come

from the village economic development and resource divisions of NRC. NRC has estimated our match at $30,000 at this time.

Task Code	Task Description	Total Cost	NRC Match Funds	Grant Request
100	**Dynamic Modeling of High-Penetration Wind-Diesel**	$ 50,000	$ 9,000	$ 41,000
200	**Modeling of Lithium Ion Battery ESS**	$ 10,000	$ 1,500	$ 8,500
300	**Review & Market Assessment of Village Scale ESS**	$ 6,000	$ 900	$ 5,100
400	**Procurement of ESS and Development of Battery**	$ 600,000	$ -	$ 600,000
500	**Testing at ACEP's Hybrid Application Laboratory**	$ 25,000	$ -	$ 25,000
600	**ESS Field Commissioning and Preliminary Testing**	$ 30,000	$ 4,500	$ 25,500
700	**Extended Testing and Data Collection**	$ 65,000	$ 9,750	$ 55,250
800	**Final Report and Data Analysis**	$ 28,000	$ 4,350	$ 23,650
	Total Cost	$ 814,000	$ 30,000	$ 784,000

Project Schedule

The first phase of the project will use dynamic modeling techniques using Powerfactory software. The dynamic modeling will analyze various possibilities for high-penetration system scenarios. Simultaneously market analysis and procurement of a lithium ion supplier will be found and development of the battery management system and interface to the supervisory controller will be developed. The destination community will be modeled dynamically prior to equipment installation to forecast possible power quality issues. After the energy storage system is tested at ACEP's hybrid application laboratory, and after passing testing requirements, the system will be delivered to a pilot project community for data collection long term and analysis. This project will be closed out in two years.

	Months After Contract Award																	
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-24
Dynamic Modeling of High-Penetration Wind-Diesel	■	■	■															
Modeling of Lithium Ion Battery ESS			■	■														
Review & Market Assessment of Village Scale ESS			■	■														
Procurement of ESS and Development of Battery Management System					■	■	■	■	■	■	■							
Testing at ACEP's Hybrid Application Laboratory												■						
ESS Field Commissioning and Preliminary Testing													■	■				
Extended Testing and Data Collection															■	■	■	■
Final Report and Data Analysis																		■

Project Qualifications

NANA Regional Corporation- Applicant. NRC (www.nana.com/regional/) has significant experience in resource development, rural development, and deploying appropriate technologies in rural Alaska. As the parent corporation of over 40 subsidiaries, many of them working in the technology arena, NRC understands and has experience in deploying appropriate technology. Please refer to our proof of eligibility attached.

WHPacific- Engineering and Project Management. WHPacific (www.whpacific.com/) is a multi-disciplined architecture and engineering company, with specialties in energy, building engineering, and architecture. Jay Hermanson, Energy Manager, and Distributed Energy Specialist, Katherine Keith, will provide the project management and engineering support. WHPacific's specialty is remote and rural infrastructure and rural energy. WHPacific's experience as a technology integrator can be leveraged with our

operations in NW Alaska.

Sustainable Power Systems LLC. Stephen Drouilhet, Managing Director of Sustainable Power Systems, has a 16 year history of developing hybrid power system components for the Alaskan village power market, first as a Senior Engineer at the NREL National Wind Technology Center and later as President of Sustainable Automation, Inc. In late 2011, the latter company was reorganized as Sustainable Power Systems, with a renewed focus on green power systems technology. The company's engineering staff has expertise in the following areas:

- Wind-diesel hybrid power systems
- Power converter design
- Power systems dynamic modeling
- High speed digital control
- Data acquisition, logging, and reporting

Discussion of Commercialization of Funded Technology
This grant will expedite the commercial development of high-penetration wind-diesel systems in Alaska and beyond. A successful field test of the technology will demonstrate its potential to increase system efficiency, reduce energy costs, and stabilize power quality in isolated diesel power systems.

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.

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Lance Miller
Vice President, Resources
NANA Regional Corporation

Appendices Include: Team Resumes, Letter of Support, and Proof of Eligibility