AEA Emerging Energy Technology Grant Application AEA-12-047

Project Title: **Dynamic Grid Balance for Isolated Diesel Power Grid**

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

Total Project Cost: $500,000
Grant Funds Requested: $430,000
Match Committed: $70,000

Previous REF or EETF Grants: None

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

Project Summary

Project Description: Most isolated village power grids suffer a significant degree of 3-phase load imbalance, which is primarily caused by the unequal allocation of single phase loads on the three phase distribution system. In some cases, load balancing is difficult or impossible because the distribution system consists of single phase radial feeders, and there is only one option as to which phase a particular customer load is placed on. Even when there is a three phase distribution system, it is generally impossible to keep the load balanced at all times, because single phase loads come and go over the course of the day.

Load imbalances create a number of problems for power systems. The most heavily loaded phase will dictate the amount of generation capacity required. Consequently, a larger generator must be run to meet a given total load if the load is unbalanced than if the load were equal on all three phases. The larger generator will operate less efficiency and consume more fuel. Second, because diesel generators cannot independently control the voltage on each phase, unequal loading of the three phases causes unequal phase voltages. Three-phase motors and generators are very sensitive to voltage imbalance and will operate hotter and less efficiently in the presence of unequal voltages. Three phase pumps (such as may be used in village water and sewer infrastructure, for example) may fail prematurely. Similarly, three phase wind turbines connected to the village distribution system are also at risk for reduced life.

Sustainable Power Systems has been developing a prototype design of a Dynamic Grid Balancer (DGB) to address the phase imbalance problem on village power grids. Using power electronics and active filtering technology, the DGB continually monitors the load imbalance on the power plant bus and shifts load from one phase to another such that the diesel generators always see a perfectly balanced load. The benefits are that the total village load may be met with smaller diesel gen-sets operating more efficiently and more equal phase voltages throughout the village distribution system. The proposed project will be to complete the development of a commercial prototype, to test the prototype in the ACEP Hybrid Application Laboratory at UAF, and to deploy the unit in a village power plant in the NANA region. Concurrently, WHPacific will conduct quantitative grid imbalance studies and market assessment for the villages in its region.

Project Eligibility: The proposed technology qualifies as an emerging energy technology, because it increases the efficiency hydrocarbon (diesel fuel) use, and it increases the efficiency and longevity of renewable energy equipment. The proposed project meets all of the EETF's eligibility criteria:

- It tests an emerging energy technology.
- It improves existing energy technologies (diesel generators and wind turbine generators).
- It tests a technology that has never been deployed on an Alaskan village power system (nor on any diesel power grid worldwide, to the best of our knowledge).

The prototype DGB is based on well-proven power converter hardware and well-established digital control methodologies. We estimate the current technology readiness level at TRL 5.

Project Innovation: All prior attempts to address the load imbalance problem inherent to isolated power grids have focused on physically relocating individual consumer loads to different distribution feeder phases and/or upgrading single phase feeders to three phase. While these measures are helpful, they are time-consuming, costly, and only partially effective. Our approach offers the possibility to perfectly balance the load (from the perspective of the diesel plant) dynamically and cost-effectively.

Priority

Distribution imbalance is a common challenge to overcome in remote power systems of Alaska and successful implementation of this technology will enable lower overall energy costs associated with providing power. NANA Regional Corp. will work with the Alaska Center for Energy and Power to verify the performance of the

Grid Balancer. There is currently an estimated commitment, between Sustainable Power Systems and NANA Regional Corporation of $70,000 in cost share for this project which equates to 16% of the project budget.

Technology Validation and Research Methodology

Objectives: The objectives will be to demonstrate the feasibility and evaluate the effectiveness of balancing the three-phase load on an actual Alaskan village power system.

Methodology: The Dynamic Grid Balancer will be tested both in Sustainable Power Systems' in-house development lab and at the ACEP Wind-Diesel Application Center to verify proper function in response to various levels of phase imbalance. Village testing will document the performance of the diesel power system with and without the dynamic grid balancer. Measurements will include the following:

- Individual phase loads on the power plant over a one-week period.
- Diesel operating strategy (diesel rating online versus time)
- Diesel fuel consumption versus load
- Individual phase voltages at the plant bus versus time
- Individual phase voltages at selected points around the village versus time
- Power consumption of the dynamic grid balancer

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. Between NRC and Sustainable Power Systems We have estimated our match at $70,000 at this time.

Task Code	Task Description	Total Cost	SPS Match Funds	NRC Match Funds	Grant Request
100	Procurement of Dynamic Grid Balancer	$ 310,000	$ 10,000	$ -	$ 300,000
200	Characterization of Typical Grid Imbalance (3 communities)	$ 30,000	$ 5,000	$ 4,500	$ 20,500
300	Market Assessment	$ 10,000	$ -	$ 1,500	$ 8,500
400	Prototype Testing at ACEP/WiDAC	$ 25,000	$ 10,000	$ -	$ 15,000
500	Shipping and Installation in Host Village	$ 10,000	$ -	$ -	$ 10,000
600	DGB Field Commissioning and Preliminary Testing	$ 30,000	$ 20,000	$ 1,250	$ 8,750
700	Extended Testing and Data Analysis	$ 65,000	$ 5,000	$ 9,750	$ 50,250
800	Final Report	$ 20,000	$ -	$ 3,000	$ 17,000
	Total Cost	$ 500,000	$ 50,000	$ 20,000	$ 430,000

Project Schedule

This project is scheduled to run 18 months with the first six months focused on development, the second six months will highlight prototype testing at the Alaska Center for Energy and Power's Hybrid Application Laboratory, and the last six months will focus on extended testing, data collection, and data analysis.

	Months After Contract Award																	
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Procurement of Dynamic Grid Balancer																		
Characterization of Typical Grid Imbalance (3 communities)																		
Market Assessment																		
Prototype Testing at ACEP/WiDAC																		
Shipping and Installation in Host Village																		
DGB Field Commissioning and Preliminary Testing																		
Extended Testing and Data Analysis																		
Final Report																		

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

Northwest Arctic Borough The Northwest Arctic Borough covers approximately 36,000 square miles in Northwest Alaska. It is the second largest Borough in Alaska and is roughly the size of the state of Indiana. Its current population is roughly 7,300. Its landmass encompasses the drainages of five major rivers: Wulik, Noatak, Kobuk, Selawik, and Buckland. The Energy Division, headed up by Ingemar Mathiasson, has been working to reduce energy costs to its communities.

Discussion of Commercialization of Funded Technology

This grant will expedite the commercial development of dynamic grid balancer technology in Alaska and beyond. A successful field test of the technology will demonstrate its potential to increase efficiency and reduce operating costs in isolated diesel power systems, whether or not they include renewable energy generation. In Alaska alone, there are several hundred potential applications. Worldwide, there are many thousands of isolated diesel power grids that could benefit from this technology. At the conclusion of the proposed project, Sustainable Power Systems and WH Pacific will move aggressively to capture this market.

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.

Lance Miller
Vice President, Resources
NANA Regional Corporation

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