Development of Electric Thermal Storage for Hybrid Energy Projects in Alaska

Applicant Contact Information

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Total Project Cost:	$1,298,750
Grant funds requested:	$1,175,766
Match committed:	$ 122,984

Previous project title(s) for abstracts submitted to the Emerging Energy Technology Fund

Development/Deployment of Supervisory Controller and Secondary Load Controller for Wind-Diesel Hybrid Systems

Development of Controls for Demand Management by Electric Thermal Storage and Data Collection on Existing Wind-Heat Sites

1. Project Summary

a. Project Description

Multiple studies have demonstrated that adding energy storage to a high penetration wind-diesel system can significantly increase wind energy extraction and the amount of displaced diesel fuel. Electrical batteries provide one well known energy storage option. Recent developments in Electric Thermal Storage (ETS) technologies have made the thermal option very attractive as well, especially for Alaska, where the energy need for domestic and commercial space heating is estimated at 55% of the energy consumed. Modern ETS systems electrically heat high-density ceramic bricks to temperatures of over 1000 F resulting in a thermal storage system capable of storing vast amounts of heat for extended periods of time.

The most obvious benefits of thermal storage for space heating are its simplicity and reliability since no energy conversion is needed. ETS can most effectively be integrated into a hybrid wind-diesel system by its use as a secondary load for grid frequency regulation. The high temperatures available within the ETS introduce the possibility of using the ETS to generate electricity by the incorporation of a thermoelectric generator or a Stirling engine, 5% to 15% of the stored energy being available at essentially 100% efficiency given that the "waste" heat still serves the primary purpose of space heating.

Marsh Creek, LLC is partnering with the UAF to:

- Develop an architecture and use cases for thermal energy storage best suited for hybrid energy projects typical for Alaska villages;
- Conduct design studies for the incorporation of thermoelectric generators and/or Stirling engines for the conversion of part of the stored thermal energy to electrical energy.
- Construct and experimentally test a prototype ETS incorporating electrical generation to collect research data and prove its projected performance and economics.
- Install an ETS unit with power generation into an existing rural wind-diesel site in Alaska and evaluate.

The use of ETS can significantly reduce the amount of fuel oil needed for space heating and the capacity of the electrical storage batteries needed (reducing capital costs) within the micro-grid of a typical Alaskan rural village.

b. Project Eligibility

The prototype ETS incorporating electrical generation will take 18 months to specify, design, construct and test. An additional 18 months will be required to modify (as required) and then install and evaluate it within the rural Alaskan village micro-grid. It will facilitate:

- Achieving full potential of renewable energy resources and reducing fossil fuel consumption by storing excess energy in thermal energy storage for later gradual controlled dispatch as space heating and supplemental electrical power.
- Reducing cost of operating the power system over its lifespan through improved reliability and optimized infrastructure;
- Creation of intellectual property relevant to Alaska thus supporting the state's manufacturing and construction industries.

c. Project Innovation

The project has a number of unique features and innovations improving energy utilization while minimizing cost and environmental impact. Innovations include:

- Demonstration of the integration of thermal energy storage in a complex hybrid energy plant;
- Development of control algorithms and implementation for the use of thermal energy storage integrated into hybrid energy plants;
- Development of architectures and use cases for the thermal energy storage, including the use of a Stirling engine and TE generators for maximizing energy production.
- Development of thermal energy storage as a packaged commercial product.

d. Project Priority Qualifications

The project satisfies qualification requirements of AS 42.45.375, in particular:

- The applicant is an Alaskan organization.
- The project demonstrates partnership with the University of Alaska Fairbanks.
- The project applicant provides matching funds.
- The project has a potential of wide deployment in the state.

2. Technology Validation and Research Methodology

a. Objectives

The project's major objectives are defined in the following progression:

a. Identify optimal architectures, control algorithms for storing and dispatch, and use cases for a typical for Alaska example of a hybrid energy plant;
b. Obtain data for decision regarding use of thermoelectric generators or a Stirling engine in combination with thermal energy storage;
c. Development of an experimental thermal energy storage prototype for trials and obtaining data proving its economic viability;
d. Development of thermal energy storage as a commercial product for use in Alaska or elsewhere.

b. Methodology

Industry proven combinations of theoretical analysis, computer modeling, and experimentation will be used to accomplish the project goals.

It is anticipated that the ACEP test-bed will be utilized for experimental model validations and testing of the thermal storage prototype.

3. Summary of Project Schedule and Summary of Project Budget

The project milestones for the first year will include identifying use cases and preferred architectures, computer modeling of the thermal storage in a preferred configuration and a yearend prototype demonstration and yearly progress report. Project milestones for the second year will include design and construction of a prototype on a test bed, prototype round 1 testing and yearend prototype demonstration and yearly progress report. Project milestones for the third year will include round one testing analysis, system design revision, prototype testing, prototype demonstration and project final report.

The estimated project schedule and labor cost budget timeline are presented in the table below:

Year		Project Tasks	Task Total	Year Total
Year 1	**1**	Project requirements definition	$ 84,641	
	2	Thermal storage modeling	$ 334,567	$ 419,209
Year 2	**3**	Storage system design and component research	$ 107,076	
	4	System integration and SCADA deployment	$ 103,887	
	5	Energy Storage Test Round 1	$ 243,858	$ 454,821
Year 3	**6**	Design revision and energy storage tests	$ 238,875	
	7	Project demonstration and final report	$ 185,847	$ 424,720

Marsh Creek services - $851,429, UAF services $324,337. UAF services include 15 days of testing at the ACEP facility in Fairbanks. Matching funds will be provided in a form of in-kind in the amount of $122,984.

Total budget of the project is $1,298,750.

At the end of the first year the project is expected to reach TRL level 6.

4. Project Team Qualifications

The project team includes people who have practical experience implementing similar projects or elements of such projects:

John Lyons, Marsh Creek, LLC, electrical engineer with nearly 30 years of Alaskan experience in power generation and distribution design, construction, maintenance and operations. John brings extensive hands on experience to the team with the integration of wind energy and hydroelectric energy with diesel plants in rural Alaska. John has pushed the envelope for displacing diesel fuel with renewable energy by utilizing electric thermal in integration designs.

Vladimir Leonov, Marsh Creek LLC, electrical engineer, PhD, 15-years of experience in BAE SYSTEMS – defense contractor, implementing projects involving computer modeling and prototyping of discrete control systems, power electronics, for defense and aircraft industries.

Richard Wies, Ph. D, P. E., University of Alaska Fairbanks, Associate Professor of Electrical and Computer Engineering, registered Electrical Engineer in the State of Alaska with over 12 years of experience focused on standalone hybrid electric microgrid systems. Richard's current research interests encompass the development of smart grid control and distribution strategies for the stable and efficient operation of standalone hybrid wind-diesel-battery-thermal storage microgrid systems in rural Alaska villages. Richard's main research contributions to date are the development of standalone hybrid wind-diesel-pv-battery electric power system performance and stability models to investigate techniques for reducing diesel fuel consumption and maintaining system stability with high penetration and highly variable wind resources.

5. Discussion of Commercialization of Funded Technology

Proposed thermal energy storage is expected to become an integral component of hybrid energy projects. It will compliment or replace electrical battery energy storage, as well as secondary boilers type of loads. This will open opportunities for Alaskan companies to become equipment manufacturers and suppliers of dispatch control intellectual property.

Combination with smart metering for thermal energy dispatch opens a market opportunity for intelligent customer terminals and the IP associated with it.

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.

Signature: John Cameron Date: 03/03/2012

By: John Cameron Title: Vice President & General Manager