Application of Variable Speed Synchronous Generator (VSSG) Technology to the Diesel/Renewable Micro-Grid in Alaska, Resulting in Reduced Fossil Fuel Consumption and Emissions

Applicant Contact Information

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Total Project Cost	$825,000
Grant funds requested:	$750,000
Match Funds Committed:	$75,000

Previous project/app title(s) and/or number(s) for grants from the Renewable Energy Fund, Emerging Energy Tech. Fund or Denali Commission Emerging Energy Tech. Grant program

Marsh Creek, LLC
AEA Grant Agreement 7310061
Development of High Efficiency Diesel Electric Generator Set for Energy Projects in Alaska

1. Project Summary

a. Project Description

Diesel electric generator sets are an indispensable source of electrical power in collaboration with variable renewable resources in rural Alaska. Because of a large installed base and substantial amount of fossil fuel consumed by diesel generators a lot of efforts have been directed to improving the diesel engine's efficiency thus reducing overall fuel cost and environmental impact.

For achieving best efficiency rotational frequency of the diesel engine should be adjusted according to the load demand. However, all commercially available diesel generator sets are manufactured with a fixed coupling between the diesel and electric generator because the required rotational frequency of an electric generator is fixed by the grid frequency. The result is that maximum efficiency is achieved at full power, dropping as power demand decreases. Isolated micro-grids are known for their high variability of demand, both diurnally and seasonally. Many attempts have been made to allow variable engine speed while producing grid frequency power.
For example, electronic packages such as the doubly fed generator were found to be bulky and expensive and have been tried and rejected by diesel genset companies such as Cummins. A recent innovation by Cheng Power Systems is the VSSG which uses low cost commutating electronics together with a phase lock circuit to maintain power production synchronized to the grid frequency while allowing variable engine speed.

The VSSG system has been demonstrated on a 2 pole 75 kW synchronous generator driven by a diesel engine. Synchronous frequency was successfully maintained at all speeds from idle up, as seen in Figure 1.

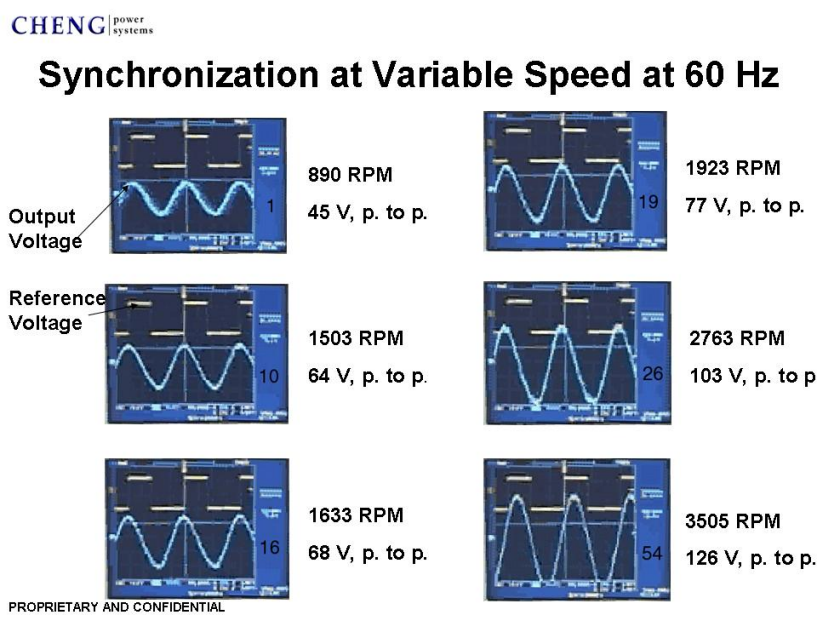

Figure 1. Oscilloscope shots of output frequency, locked at 60 Hz at all engine rpm.

Commercial diesel generators mostly run at 1800 rpm. With the VSSG we can maintain synchronous frequency at any rpm. We propose to increase the capacity of the generator from 75 kW to 100 kW for a demonstration. The current electronic circuits can easily be transferred from the lab unit to a commercial ready system. For example, this 100 kW matches current available wind turbines' generating capacity. When the wind power is up, the need for diesel power will be down and the diesel engine can be run at a much lower speed, resulting in

fossil fuel savings. Such a combined system can handle changeable wind speed and still provide required output. The technology is considered at TRL 5 and at completion of the grant reach TRL 8.

b. Project Innovation

Innovations include:

- Implementing diesel engine speed control to minimize fuel consumption,
- develop control logic to maintain grid synch frequency at all engine speeds, and
- the engine speed control kit hardware and electronics.

c. Project Site & Demonstration Environment

It is anticipated that the project will be developed at the Cheng Power System facility in Mountain View California and testing at the Marsh Creek facility at 2000 E 88th Ave., Anchorage, AK 99507-3804. Marsh Creek is a UL 508A recognized fabrication shop capable of building custom generator sets that are listed to the UL 2200 standard. Additionally Marsh Creek carries several UL and ETL listings. After completion of the demonstrational prototype it will be transferred to the University of Alaska Fairbanks (UAF) Alaska Center for Energy and Power (ACEP) Energy Technology Facility (ETF) for qualification tests.

d. Priority:

This project is a co-generation project that will capture the recovered heat from the diesel engine jacket water and the recovered heat from the diesel engines exhaust stream further maximizing the overall efficiency and speed of the diesel engine.

2. Technology Validation and Data Collection

a. Objectives

The overall project objective is to bring to commercialization the VSSG in Alaskan micro-grids.

Prove operating at a variable frequency to save fuel and increase operating efficiency of the system.
Prove the technology is sound through third party verification at UAF ACEP test bed.

b. Data Collection

The data collection includes measuring power output vs diesel engine rpm and fuel consumption and in addition will measure the purity of the wave form output, variable diesel speed, power factor, and environmental impact mitigation of the system.

3. Project Schedule & Project Budget

The project milestones will include identification of optimal system configurations, computer modeling, prototype design, construction of a prototype on a test bed, and year end prototype demonstration and the quarterly progress reports. Additional project milestones will include prototype testing, system design revision, final testing, prototype demonstration, and project final report. The project estimated schedule and labor cost budget timeline are presented in the table below. Milestone tasks will be completed in sequential order and be further delineated in the full proposal if selected to move forward.

	Project Tasks	Cost
1	System architecture, requirements definition	$43,500
2	Prototype system modeling and programming	$100,000
3	Prototype design and component procurement	$215,000
4	System integration and SCADA deployment	$91,500

5	Energy Production and Test	$100,000
6	Prototype test and design revision	$200,000
7	Project demonstration and final report	$75,000
		$825,000

Marsh Creek and Cheng Power System services are estimated at $825,000. Services provided include 5 days of testing at the ACEP facility in Fairbanks. Matching funds will be provided in a form of in-kind in amount of $75,000. Grant funds requested in the amount of $750,000. …….

4. Project Team Qualifications

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

John Cameron, Marsh Creek, LLC, has 40 plus years of experience in design, construction, and O&M of primary, backup and emergency power generation systems. As Vice President and General Manager of the Energy Systems Division of Marsh Creek, he is responsible for overseeing energy systems contracts. His experience includes management and implementation of over 2,000 power generation systems ranging up to 15 MW in the U.S., Korea, Russia, Saudi Arabia and Kuwait.

John Lyons, Marsh Creek, LLC, electrical engineer with nearly 30 years of Alaskan experience in power generation, 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.

Dr. Dah Yu Cheng, Cheng Power Systems, Inc., has over 40 years experience in the power generation market. He formed CPS to explore the advancement of the Cheng Cycle, Cheng Low NOx (CLN), Cheng Boost and the VSSG.

Dr. Alan Helgesson, BS from Cal Tech, MS Stanford University, PhD from MIT all in electronics engineering. Dr. Helgesson developed the VSSG circuits for the 75 kW unit.

Maggie McKay, PMP, 5 years of proven construction management stills working with various communities to facilitate communications, permitting, and paperwork on behalf of community leadership and state/federal agencies during grants projects to develop renewable energy resources. Maggie has a B.A. in Anthropology from the University of Colorado at Denver and is currently a Masters student at the University of Alaska, Anchorage in the field of Project Management. Maggie holds a Project Management Professional (PMP), certification.

5. Discussion of Commercialization of Funded Technology

The successful conclusion of the test will lead to a finalization of a retro-fit kit that will easily allow the upgrade of all current generators in Alaska. The winterization of the kit components will be built in Alaska. The success of the experience can be translated to market potential to the lower 48 states and any micro-grid worldwide. Commercialization will be easily obtained. The electrical package will be produced from known components and installation will essentially be ‘plug and play’.