DEMONSTRATION AND COMMERCIALIZATION OF THE VARIABLE SPEED SYNCHRONOUS GENERATOR ON DIRECT DRIVE WIND TURBINES

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

5. 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

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

1. PROJECT SUMMARY

A. PROJECT DESCRIPTION

Wind power is one of the key renewable energy sources for Alaskan rural villages. The principal savings will be in capital cost reduction to make the power system more affordable.

Cheng Power Systems, Inc.'s (CPS) Variable Speed Synchronous Generator (VSSG) is a patented technology which has gone through substantial demonstrations on a 75 kW diesel engine driven generator. The system synchronizes the output frequency at any speed of the generator. The technology has been reviewed by NREL as a potential replacement for the doubly fed generator and the permanent magnet generator (PMG). The substantial savings comes from the fact that the rotation of the magnetic field on top of mechanical rotation, similar to that of the doubly fed generator, is provided by a commutating electronic methodology with phase lock circuit to provide frequency lock on the power transmission line. The variable speed oscillator on the doubly fed generator and slip rings were removed to create a substantial savings by as much as 50% of the doubly fed generator.

VSSG will reduce the cost of the PMG by removing the AC/DC/AC converter and eliminate the cost of the permanent magnet material. The permanent magnet material is an imported component mostly from China where the pricing is subject to arbitrary political reasons instead of an actual cost. NREL estimated that using VSSG over PMG would result in a savings of approximately 60%. NREL considers the VSSG technology as a transformational technology for wind power and will have a paradigm shift in the market place. The technology is considered at TRL 5 and at completion of the grant reach TRL 8.

B. PROJECT INNOVATION

VSSG, by using commutating electronics, saves complexity of control of the rotating magnetic field on the armature. The application to the wind generator for Alaska will have low initial cost as well as low maintenance cost. A more complicated system will have more expensive maintenance costs. The only cost for the VSSG system will be the electronic circuit, which is less expensive in hardware cost. VSSG is able to tolerate the Arctic cold conditions, similar to the computer and fly-by wire systems required by modern aircraft to fly above 30,000 feet at -60°F.

The proposed application to the wind generator requires the configuration to be a multi-poled system to adopt the direct drive configuration which will eliminate the need for the complicated gearbox and its lubrication system.

The proposed configuration will use a 100kW direct drive wind generator as a test bed.

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

Co-generation should be considered because of high potential of renewable resources that could be added to a micro grid in rural Alaska. A co-generative byproduct of wind is wind generated electric thermal or wind to heat after satisfying the primary electric load. Therefore, heating efficiency should be considered as typical Alaska Wind-Diesel installations have secondary loads through a heat recovery system.

2. TECHNOLOGY VALIDATION AND DATA COLLECTION

A. OBJECTIVES

The project is aimed at replacing 100 kW direct drive wind turbine with VSSG. The direct drive wind turbine is a direct drive system with a maximum rotating speed of 150 rpm. We propose a multi-poled VSSG which will provide synchronous power at 60 Hz to interface with the Alaskan micro-grid. The 2-pole VSSG system has been demonstrated to have a wide speed range such that the mechanical speed is made up by the rotational magnetic field electronically to create synchronous rotation speed so the optimum frequency will be maintained regardless of the rotating mechanical speed. Figure 1 demonstrates the diesel driven VSSG which goes from idle to 3600 rpm synchronous speed. The square wave represents the source that the output frequency needs to follow which is synched to the square wave at any speed from 800 to 3550 rpm.

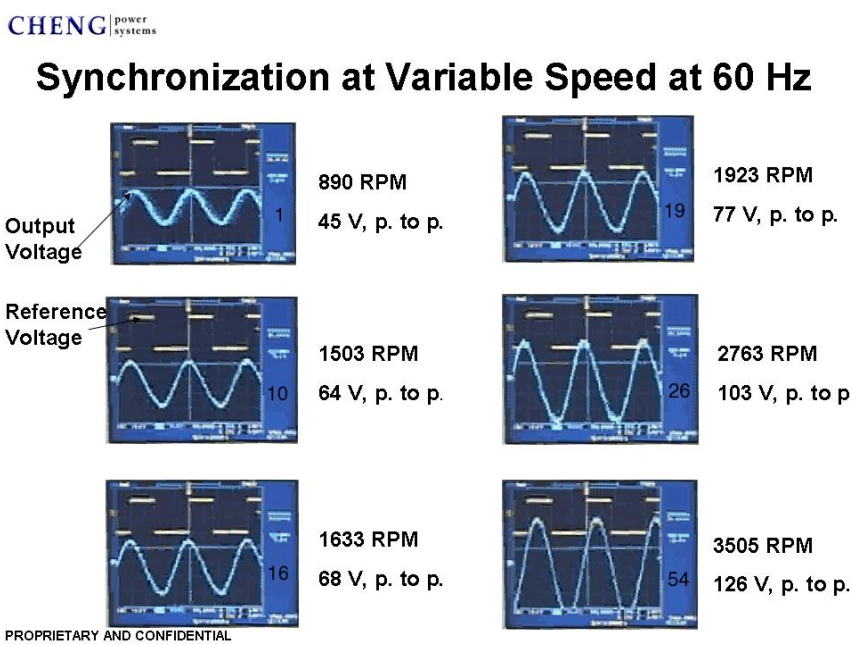

Figure 1 – Diesel Driven VSSG

The proposed demonstration will configure the 2-poled VSSG into a multi-poled generator which will be optimized around 16 poles. The design phase of the demonstration unit will determine if the configuration will be an axial magnetic field configuration or a radial configuration.

B. DATA COLLECTION

The data collection will first be done by an electrical driven motor to create variable speed and power for the generator test. Speed range and power output performance curves will be collected to project the performance data. A load bank will handle a 100 kW load will be used as the energy synch during the test. The test data also includes all performance characteristics of the electronic circuit in terms of dynamic variables due to unpredictable wind speed in the actual application.

Once the lab tests are successful, efforts will be made to replace the PMG and the direct drive wind turbine for the field test.

The instrumentation not only measures power output but measures purity of the wave form in the dynamic response of the variable speed which will include a fully analyzable instrument, training computer data recording system, etc. The power current voltage characteristics and the generator temperature rise will be monitored against power output. Vibration nodes will be noted and measured.

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	$107,000
3	Prototype design and component procurement	$215,000
4	System integration and SCADA deployment	$91,500
5	Energy Production and Test	$85,000
6	Prototype test and design revision	$215,000
7	Project demonstration and final report	$68,000
		$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 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 Helggesson, BS from Cal Tech, MS Stanford U, PhD MIT all in electronics engineering who substantially 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'

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: 9·5·2013

By: John Cameron Title: Vice President & General Manager