Abstract: Multi Stage Flywheel/Battery Energy Storage System

Project Summary

a. Project Description

Chugach Electric Association, Inc. (Chugach) introduced non-dispatcable resources into its generation portfolio in 2011. Non-dispatchable resources can present significant grid control challenges, especially when introduced to a relatively small grid. Since these resources have been integrated into the grid, Chugach has been researching potential solutions to address issues associated with ramp rate control, curtailment avoidance, frequency regulation, voltage support, peak shaving support, wind power coordination with hydro and thermal resources, and the ability to more accurately forecast power requirements to minimize/eliminate modifications to scheduled gas commitments.

Chugach believes that a promising solution, which addresses many of the stability issues listed above, can be solved by means of a multi stage energy storage system consisting of a Flywheel Energy Storage System (FESS) paired with a Battery Energy Storage System (BESS). For this demonstration project, a 1 MW capacity battery bank paired with a 200 kW capacity flywheel would be installed at Chugach's International Substation.

A battery that Chugach may consider purchasing is a 1 MW capacity system composed of two 500 kW capacity modules capable of delivering a maximum of 500 kWh for 2 hours. This will either be one high cycle performance battery and one deep cycle performance battery or two high cycle performance batteries depending on further design development. Current high cycle battery technologies have a design life of up to 4,500 cycles or 20 years. One of the benefits of these types of technologies is that they are modular and expandable. Further, use of energy storage has the potential to significantly reduce energy curtailment from non-dispatchable resources and reduce spinning reserve requirements, thus enhancing the utilization of existing technology on the grid.

The flywheel technology Chugach is considering is a Smart Energy Generation 4 flywheel manufactured by Beacon Power. Each flywheel has a capacity of 100 kW (Standard Power) to 150 kW (High Power) and capable of providing 25 kWh for 15 minutes and 12.5 kWh for 5 minutes, respectively. Chugach is proposing to install two Beacon flywheels. Beacon flywheels are designed for 100,000 equivalent full charge and discharge cycles with a 20 year design life. Additionally, there is no energy storage degradation with cycle duty, depth of discharge, charging rate, time or temperature.

The idea behind installing complementary technologies is that the flywheel would act as the first stage response to any grid instabilities as they pertain to non-dispatchable resources; i.e., frequency and ramp rate control, while the battery system would provide stability control for second stage grid instabilities and could potentially provide peak shaving if the installed deep cycle battery capacity was large enough. The battery system would assist in curtailment avoidance, improve predictability of power output, and

contribute to load leveling and/or spinning reserve requirements. Combining the two technologies has the added benefit of significantly increasing the life of the batteries by reducing the large number of cycles on the batteries, while the flywheel manages the rapid response cycling.

b. Project Innovation

The implementation of this type of technology to augment the availability and utilization of existing non-dispatchable resources is an important technology that needs to be evaluated. This demonstration project for energy storage will assist in establishing the requirements for a more stable grid and assist in establishing methods of how best to manage and utilize the full potential of the growing renewable energy market in Alaska.

c. Project Site and Demonstration Environment

All equipment (battery enclosure, inverter, all materials required for grid interconnection) required for the project would be located on Chugach property at our International Substation, adjacent to Chugach's headquarters at 5601 Electron Drive. This location is advantageous for several reasons:

- Locating the project on Chugach property will help reduce cost and provide ease of access for equipment monitoring and maintenance, and allow integration into Chugach's system controls.
- It is an ideal location to tie into Chugach's non-dispatchable resources as Fire Island Wind's interconnection is located at the International Substation.
- The location will make it more cost effective to link to Chugach's SCADA system which will allow us to track and trend data acquired from the module while in operation.
- The site is secure, surrounded by fence with barbwire, and monitored by video surveillance.
- Chugach has a skilled work force that can properly operate and maintain the equipment.

d. Priority

Consistent with the guidance of AS 42.45.375(d), this is a high priority project that is for the benefit of Alaska residents, will be supported by matching contributions on a dollar-for-dollar basis, and has the potential for widespread deployment in the State.

Technology Validation and Data Collection

a. Objective

Once operational and connected to Chugach's existing SCADA system, data will be continuously collected for data analysis and trending. There are several objectives that would be evaluated during this demonstration project which are as follows:

- Ramp rate control
- Curtailment avoidance
- Frequency regulation
- Voltage support
- Peak shaving/reserve contribution
- More accurate power forecasting

b. Data Collection

Data will be continuously collected once connected with Chugach's SCADA system. Testing will be performed throughout the demonstration period to verify how the FESS/BESS performs.

Project Schedule and Project Budget

The project schedule, assuming grant awards, before the end of 2013, is as follows:

- Design and engineering – January to April 2014
- Equipment procurement – May to October 2014
- Site preparation – May to August 2014
- Installation and commissioning – May to August 2015
- Data collection and analysis – August 2015 to August 2017

The project budget includes the following cost elements:

- Batteries: installed cost is $1,000/kW, total installed capacity is 1 MW, so the budget for the battery system is $1 million
- Flywheels: installed cost of a single flywheel is $220,000, which equates to $2,200/kW. Total installed capacity is 200 kW, so budget for the flywheel system is $440,000.

The total project budget is $1.44 million of which Chugach will provide a match of 100%. Chugach has the financial resources to satisfy this funding commitment.

Project Team Qualifications

The Project Manager will be Paul Risse, Chugach's Sr. Vice President of Energy Supply. Mr. Risse is a Professional Engineer who has worked at Chugach since 1995. Including previous employment at Southern California Edison, Mr. Risse has nearly 30 years of electric utility experience in a variety of engineering and management positions. Mr. Risse was the executive in charge of the development and construction of the recently completed 183 MW Southcentral Power Project. Mr. Risse has a B.S. in electrical engineering and an MBA.

Brian Hickey, Chugach's Executive Manager of Grid Development, is a Professional Engineer who has over 30 years of experience, including 20 at Chugach and 5 years each

as a consultant and at Anchorage Municipal Light and Power. Mr. Hickey has worked in areas such as control center operations, power system protection, hydroelectric and gas turbine plant controls within lightly interconnected power systems, T&D substation design, construction, operations and maintenance, and SCADA/EMS and distribution management systems. Mr. Hickey has a B.S in electrical engineering and a graduate degree in Global Finance.

Jim Arseneaux is Vice President of Engineering at Beacon Power. He is in charge of developing advanced Flywheel Energy Storage Systems for grid frequency regulation and renewable integration. Mr. Arseneaux has been with Beacon Power for 12 years including leading the design of the current 100 kW/25 kWh production unit and the operational 20 MW flywheel plant in Stephentown, NY. He holds several patents for bearing system applications and has B.S. and M.S. degrees in Engineering.

Grid Storage Consulting was founded by Bill Capp and Bill Franks. Prior to GSC, Mr. Capp, a professional engineer, was at Beacon Power for 10 years as President and CEO. He led Beacon's technology development and commercial deployment efforts to align the company's patented flywheel technology with grid-scale energy storage opportunities. Mr. Capp's degrees include Bachelors in aeronautical engineering, Masters in mechanical engineering and an MBA. Prior to joining GSC, Mr. Franks also worked at Beacon Power, as well as a variety of positions in the power and finance industries in Europe and the U.S. Mr. Franks has a B.S in physics and an M.S. in Nuclear Engineering.

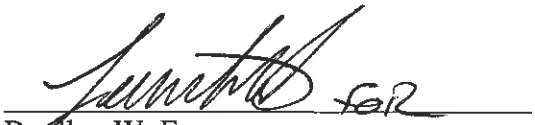
Discussion of Commercialization of Funded Technology

Potential Market: The potential market is state-wide. Any entity generating or purchasing intermittent, non-dispatchable renewable energy, such as wind energy, could benefit from the ability to store and fully utilize energy when not needed and to utilize it during peak periods.

Potential Public Benefit: The primary benefits will be the development of a technology that allows energy storage and discharge, enhances the expansion of wind resources in the State, and provides the ability to more efficiently use intermittent renewable energy.

Applicant Certification

By signature on this application, I certify that Chugach will comply with the matching commitment and any other requirements of a grant.



Bradley W. Evans
Chief Executive Officer
Chugach Electric Association, Inc.

9-5-13
Date