

EESDP14

Electrical Energy Storage Demonstration Projects

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Helix Power: Electric Grid Ancillary Service through Advanced Flywheels

Project Scope

Helix Power is a developer of next generation power management hardware for utility scale applications. Helix recently completed a conceptual design program with Sandia National Laboratories for a power management solution that can store or deliver 1MW of power for 90 seconds utilizing a cutting edge flywheel energy storage system capable of 1,000,000+ cycles in a lifetime. This system is ideal for applications that require 150 full charge and discharge cycles a day such as mining, train power management, grid scale UPS systems, microgrids, and renewable energy grid connection power management. Helix Power's hardware design may be used as a stand-alone system or in a hybrid system with either generation or longer duration energy storage assets

The objective of the project was to advance the conceptual design of the Helix Power system by reducing technical and programmatic risk. During the project, Helix Power focused on design improvement, strategic supplier relationships, customer relationships, and in-depth analytic approaches to the value proposition for launch applications.

Background

Helix Power is focused on a class of power management problems that are not cost effectively addressed by existing solutions. According to the president of Helix Power, Matthew Lazarewicz, "existing solutions inherently involve a tradeoff of performance with efficiency, product life, and/or O&M expenses." The Helix Power system is technically a flywheel energy storage system, but it is best described as a power management device that can significantly improve power quality. The system is designed to inject or absorb 1MW+ of rated power for 90 seconds to control power ramps for grid connected systems or isolated systems while simultaneously improving power quality. A single module will be sized to source or sink 1MW for 90 seconds and modules may be installed individually or in sets.

Response time will be on the order of milliseconds and cycle life will be at least two orders of magnitude greater than batteries. Flywheels can cycle at 100% rated power, do not lose performance with time and do not need to be oversized to improve expected system life.

Energy storage is analogous to memory storage used in computers. Computer manufacturers use multiple types of memory storage including RAM (short-term), hard drives (long term/internal), thumb drives (portable), and bulk external storage (long-term/external). Most of those technologies are not economically interchangeable and users choose the optimal mix of economics and performance for their requirements. In this analogy, Helix Power provides the RAM equivalent for short-term storage that can be paired with other assets to optimize both economics and performance.

Prime applications for the Helix system require high power, short duration, and frequently cycling variations in power. These characteristics are prominent where there is a cyclic load and in isolated systems where a significant portion of the power is produced by intermittent resources. Currently, existing power infrastructure is ill-suited to such sudden, cyclic, high power demands because most generators respond too slowly to efficiently meet these load requirements and these requirements far exceed the cycle life of batteries. This type of power demand profile is both common and growing due to increasing variability of both generation and load.

On the generation side, increasing short duration variability is the inevitable result of increasing wind generation, increasing solar generation and decreasing coal generation. On the load side, increasing variability stems, in part, from an on-going industrial shift from induction to synchronous electric motors. Both of these trends are continuing worldwide. Helix Power hardware will provide a solution to the resulting ramping issues that can tax the efficient operating limits of existing solutions.

Technology

Modern, advanced flywheels store energy using a built-in motor/generator to spin a rotor up to very high speeds. Energy is retrieved by electronically switching the motor to operate as a generator that produces electricity as the rotor is decelerated. Currently, flywheel systems are available from a number of manufacturers but tend to cost more than competing energy storage solutions. Therefore, they are usually used in niche applications. In addition, available systems have fairly low power ratings and cannot be used cost effectively to serve high power applications. To date, flywheel power ratings have been limited, in part, as a consequence of the challenge of developing a high power motor that operates in vacuum.

The Helix module is designed to offer high power, short duration, and fast response ("HPSF").

The Helix HPSF will be able to source or sink 1MW for 90 seconds with greater than 80% round trip energy storage efficiency and steady state power losses <1% of rated power. For applications with events of this duration, the Helix module will provide the most cost effective solution. This capability gives Helix a strong competitive advantage for sudden, cyclic, high power demands.

Competitive Position

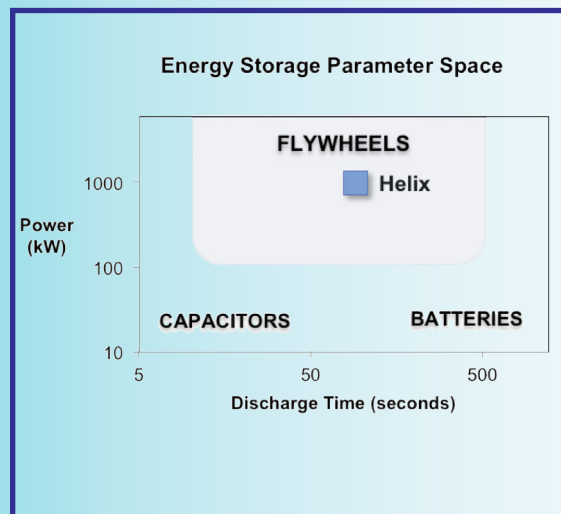
Helix Power addresses power management applications that are underserved by competing technologies such as electrochemical capacitors and batteries. Electrochemical capacitors are most cost effective for applications requiring power for a few seconds or less. Batteries are most cost effective when power is required for 10 minutes or more, provided that a cycle life of a few thousand cycles or less is acceptable for the application. The discharge times of batteries are inherent in the chemistry of the device and are difficult to change. Significantly, a flywheel is an engineered system that can be designed or operated for any discharge time to meet customer specifications. Helix Power is focused on applications where batteries, electrochemical capacitors, and existing flywheels cannot provide an effective solution. Namely, high power, cyclic loads with a 90 second discharge time.



Helix Power

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The shaded area in *Fig. 1* below indicates the parameter space where flywheels compete favorably with other energy storage technologies. Specifically, discharge times from several seconds to several hundred and power levels greater than 100kW.



Path to Commercialization

Helix Power is focused on developing strong customer relationships by utilizing an in-depth analytic approach for launch applications. In an effort to reduce programmatic risk, Helix Power is focused on markets that can be realized within the next five years. Helix has identified its markets with either behind the meter applications or applications collocated with an existing grid connected asset. Helix's focus on behind the meter or collocated assets reduces risk by obviating the need for new interconnection requests and involvement in ISO and RTO processes. In turn, this approach enables productive conversations with potential customers, as there are fewer hurdles to a successful installation. According to Lazarewicz, "many potential customers are currently using one piece of storage equipment where two would be more efficient and lower cost. Helix is proud of its place as a developer of high power,

short term energy storage systems that deliver very high cyclic life." Helix has identified near term markets of up to \$31 billion in behind the meter applications worldwide.

Stakeholder Engagement

Helix Power is actively seeking feedback from industry participants including end use customers, utilities, system integrators, transit systems, hardware manufacturers, and industry groups. The company is active in the energy storage community and has presented its plans at industry forums.

Helix Power believes that customer discovery is an iterative process requiring close communication. To that end, where possible, Helix seeks to thoroughly understand customer issues and then model the Helix Power solution for the customer. Helix is speaking directly with potential customers and providing model analysis of the impact of adding a Helix Power system. In addition, Helix is in discussions with experts within industry organizations in order to better understand the needs of their member base and facilitate new customer discussions. According to Lazarewicz, "potential customers are very pleased with Helix's analytic approach that allows them to quantify multiple value streams from the installation of Helix hardware."

Deliverables to Sandia National Laboratories

Helix Power delivered a series of reports to Sandia National Laboratories over the course of the contract and participated in a peer review. The final report delivered to Sandia National Laboratories included substantial technical, market, safety, and cost information.

Projections (future work)

Helix plans to build, test, and deploy its HPSF Flywheel over the next 18 months. Helix is currently in the process of qualifying potential suppliers and finalizing initial customer requirements.