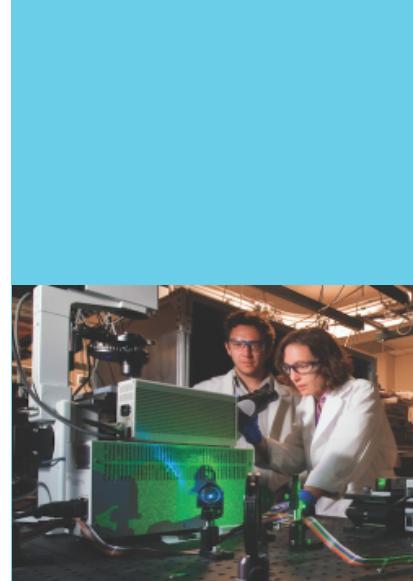


Energy Storage Project Team



Daniel Borneo
2018

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Example Deployment Project: Sterling Municipal Light Department



- Conducted an economics analysis showing ~6 year payback for battery system (2.5 years with grants)
- Installed a 2 MW/ 3.9 MWh Li-ion battery storage system in Sterling Massachusetts
- Along with the existing PV array, ES can island from grid and provide 12 days of backup power to the Sterling police station
- Demand reduction application saves the ratepayers ~\$400,00 per year by decreasing the costs associated with capacity and transmission charges



The Value Proposition for Energy Storage at the Sterling Municipal Light Department

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Abstract—The Sterling Municipal Light Department (SMLD) is a progressive public power utility located 10 miles NNE of Worcester, Massachusetts in the Town of Sterling, MA. The utility has a long history of investment in renewable generation, with more than 35% of generation coming from renewable sources. The goal of this report is to identify potential benefits and value added from demand-side energy storage. Results are presented in the analysis below, which include frequency regulation, capacity regulation to modify a network load, reduction in capacity payments to ISO New England, and grid reliability.

Index Terms—energy storage, ISO New England

again that this cheap discharge profile would be difficult for chemical energy storage systems.

The methodology for estimating maximum potential revenue from an energy storage system participating in energy and regulation markets is outlined in [3]. The problem was solved as a linear programming problem using the data from the California Independent System Operator (CAISO) data presented. For the CAISO data, frequency regulation provided significantly more revenue opportunity than arbitrage. An analysis of potential revenue from energy storage in the Electrical Reliability Council of New England (ERCC) is presented in [4]. An analysis of all load zones in ERCC for 2011–2013 found that the highest revenue opportunity was in load zone 3, which is the western load zone, far from energy storage. Because there is only one market for frequency regulation in ERCC, and the majority of revenue was from frequency regulation, the location of the system does not impact potential revenue.

The Sterling Municipal Light Department (SMLD) is a progressive public power utility located 10 miles NNE of Worcester, Massachusetts in the Town of Sterling. The primary building was originally the 1883 Sterling High School. Serving the Towns of Sterling for over 100 years, there are more than 3700 residential consumers, more than 1000 commercial customers, and power through a transmission line to 160 miles of distribution lines. The SMLD is a member of ISO New England (ISO-NE) and a wholesale aggregator of power with power purchases from generation throughout New England and New York.

The SMLD has a long history of investment in renewable generation. Approximately 35% of power generation comes from wind, and the utility has invested in a 1.5 MW solar array. Solar accounts for approximately 30% of the approximate peak load. Two 1-megawatt solar installations went on line in 2003, placing SMLD at the top of the Solar Electric Power Association Top 10 utility rankings for day/year for new solar power per customer [1]. SMLD currently has 3 MW of solar installed.

Prior research on energy storage in ISO-NE is described in [2], where the authors discuss the integration of flywheel and battery storage for frequency regulation in regional and deregulated markets. Preliminary results were presented for 3 MW of flywheel storage in ISO-NE. Beacon Power's testing found that on average, a 1 MW system incurs 100 kWh per hour, which corresponds to 6,000 equivalent charge/discharge cycles per year. Over a 20 year life, this results in approximately 125,000 full charge/discharge cycles. The authors

note that a large amount of revenue is lost in the first year of storage in ISO-NE due to the high cost of the system. The potential revenue is estimated to be approximately \$1.5 million per year.

The paper is organized as follows. Section II provides an overview of potential benefits. Section III summarizes the results of a financial analysis of the potential benefit. The expected benefits are summarized in Section V.

II. OVERVIEW OF ENERGY STORAGE VALUE PROPOSITIONS

There are many potential benefits from chemical energy storage [7]. This paper considers benefits specific to SMLD, and includes energy arbitrage, frequency regulation, reduction

Example Deployment Project: Sterling Municipal Light Department



- Issue
 - Lack of knowledge and experience regarding procurement of a combined system lead to a difficult and arduous process for vendors
- Lessons Learned
 - For successful integration of storage, it can be helpful to have 1 project combining PV and Storage done by 1 company rather than 2 separate projects done by 2 companies
 - There is a growing need for companies who can do both

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**Energy Storage Procurement
Guidance Documents for Municipalities**

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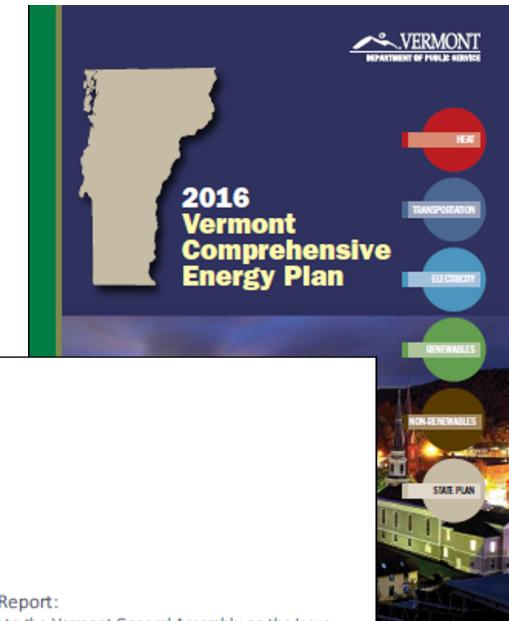
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Example Deployment Project: Green Mountain Power



- 4Mw/3.4MWh of a combined lead-acid and li-ion system Installed in Rutland, Vermont
 - Integrated with 2.5 MW of PV
- Helps with ancillary services, backup power for an emergency shelter, and demand management
- Issues
 - Project built with 4 - 500KW multi input (DC) inverters
 - 500KW ea. of LA and Li-ion, plus ~500KW of PV per inverter
 - Inverters limit output
 - Reduced demand reduction capability
- Lessons Learned
 - Not designing for flexibility of applications limited DR value

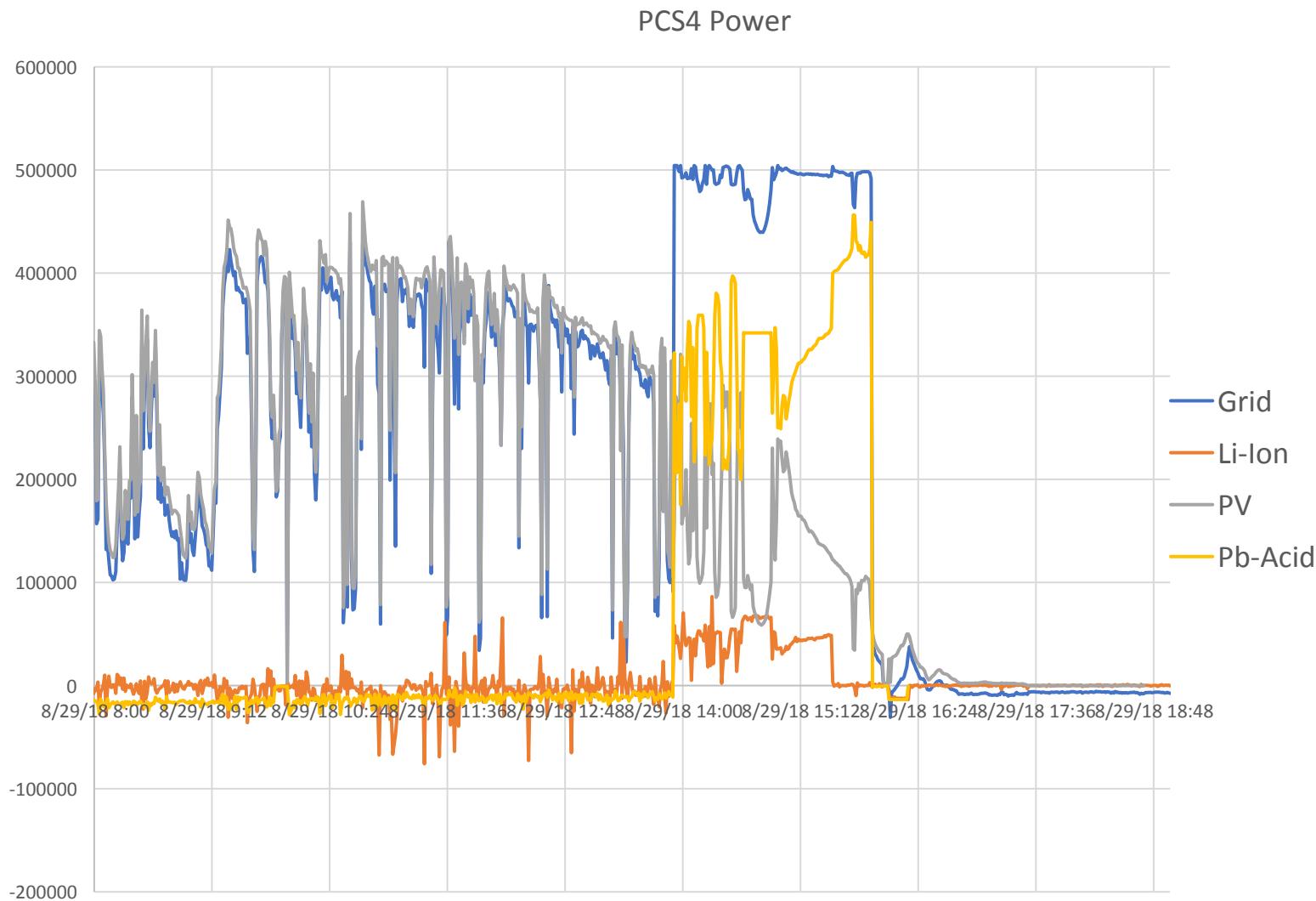


Act 53 Report:
A Report to the Vermont General Assembly on the Issue
of Deploying Storage on the Vermont Electric
Transmission and Distribution System

Final Report – November 15, 2017



GMP Operational Data



EWEB Energy Storage Project



- **System**
 - A .5MW/1MWh NEC Li-on system
 - Installed by Worley Parsons
 - Will support 50 kW of solar
- **Location**
 - The ESS will be located at Howard Elementary School
- **Completion Date**
 - Operational October 2018
- Partners
 - DOE/OE, Sandia, EWEB, ODOE, Contractor: Worley Parsons
- **Goals**
 - Demonstrate battery storage and distributed generation as a part of EWEB's community resiliency plan
 - Eugene is located in an area vulnerable to earthquakes
 - In the event of a disaster the ESS can provide power to the emergency water distribution system located at Howard Elementary School
 - The system will also be utilized to test microgrid use cases
 - Increased site reliability
 - Energy Arbitrage
 - Voltage support
 - Peaking shifting



Lessons Learned



- Microgrid Controller
 - For smaller distributed microgrids, it is cost ineffective to have a fully featured microgrid controller
 - Costs for a fully featured controller can be 50% of the cost of the battery system
- System Design
 - Current design is 2 smaller systems combined in a master-slave configuration
 - Preferred to have a single system
 - Fewer conduits
 - Fewer conductor runs
 - Smaller footprint
 - Simpler metering
 - Simpler configuration

Cordova Electric Energy Storage Project



Cordova Electric Energy Storage Project

- System: Saft, 1 MW, 1 hour Li-ion Battery
- Location: Cordova, AK
- Completion: Estimated Summer of 2019
- Partners: CEC, DOE-OE, Sandia, PNNL, SAFT
- Goals :
 - Reduce Diesel - In winter, the two CEC run-of-river projects, Hum Power Creek, freeze up and diesel generation is required to supplement the hydro.
 - Maintain system frequency while eliminating need for Hydro spinning reserve requirement
 - Microgrid services. (Fuel savings are estimated at ~ 35,000 gallons/year.)
- Lessons Learned during Analysis
 - Batteries have calendar aging capacity loss of 1.5% per year, our chemistry is estimated at 0.5%
 - Capacity loss is kWh; kW remains near constant, round trip DC efficiency drops slightly
 - Deep cycling causes rapid loss of life – this indicates frequency control as a high-value case
- Frequency controls (small charges/discharges) can occur while bulk charging or discharging is conducted
- Removal, recycling, replacing a full battery set can cost 60% of initial package cost.
- Factory warranties and required annual maintenance are expensive



Example ES Benefit Analysis Projects

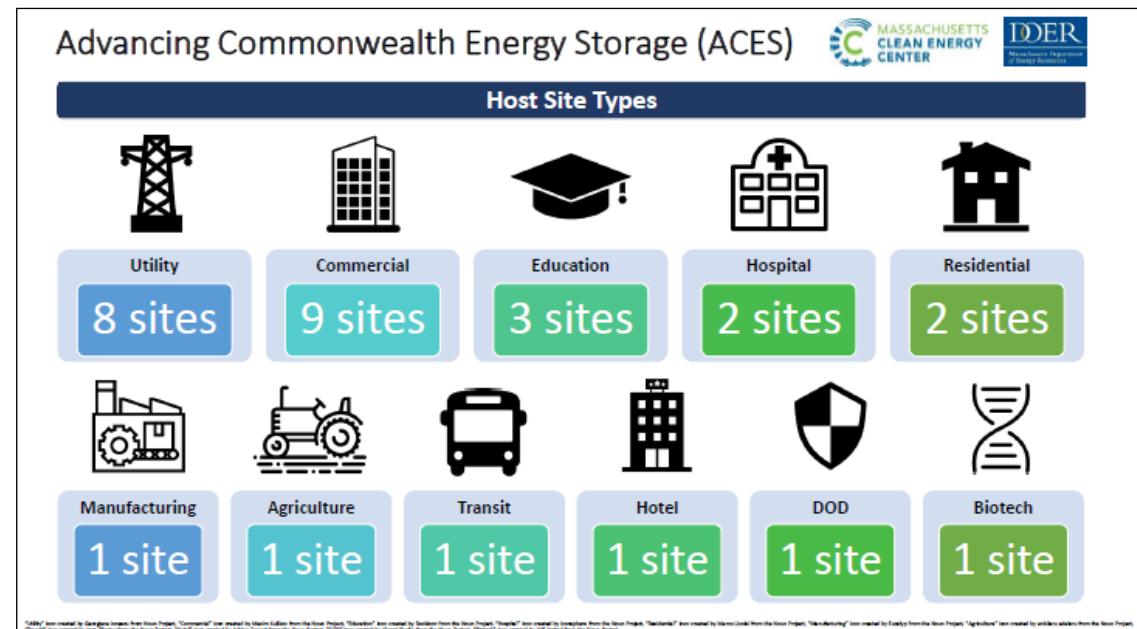


- **Boston Medical Center, Massachusetts:** Optimization analysis for major metropolitan hospital using battery storage for demand charge management and resilient power. Focus on optimizing the BESS with an existing CHP plant to improve power quality and reduce voltage fluctuations to the CHP.
- **Gunnison Rural Electric Co-op, Colorado:** One of several analyses for rural electric co-ops, to show the economic benefits of battery storage. Focus on using battery storage to reduce costs and improve power reliability.
- **Albuquerque Public Schools, New Mexico:** Analysis for Rio Grande High School, optimizing battery for demand charge management.
- **Burlington International Airport, Vermont:** Technical assistance to airport for installation of solar storage microgrid for resiliency and cost savings.
- **Peaker plant replacement:** Analysis of the technical capability of energy storage to replace gas peaker plants for capacity provision and grid stabilization.
- **EV fast chargers:** Analysis of economic opportunity for energy storage co-located with electric vehicle fast chargers, to reduce demand charges that present a barrier to EV adoption.

Example State Technical Support Projects



- **Connecticut:** Department of Energy and Environmental Protection microgrid grant program. Technical support for state agency to review proposals for microgrid grants.
- **Vermont:** VT Energy Storage Study. Technical support to Vermont Department of Public Service to write an energy storage study for the state legislature.
- **Massachusetts:** Mass Clean Energy Council ACES grant program. Technical support for state agency developing energy storage demonstration grant program. This program awarded \$20 million to support 26 energy storage projects demonstrating new applications, business models and economics in the state of Massachusetts.





Thanks

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