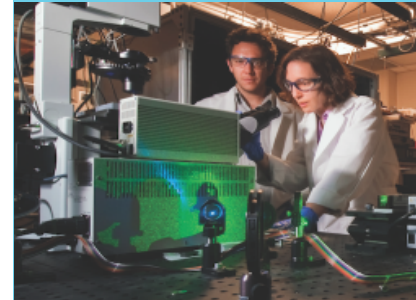


Energy Storage Project Team



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. SMLD has a long history of investment in renewable generation, with approximately 25% of generation coming from renewable sources. The goal of this report is to identify potential benefits and value streams from electrical energy storage. Benefits considered in this analysis include energy arbitrage, frequency regulation, reduction in network load, reduction in capacity payments to ISO New England, and grid reliability.

Index Terms—energy storage, ISO New England

I. INTRODUCTION

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 1937 Sterling High School. Serving the town of Sterling for over 100 years, there are more than 3700 residential, commercial, municipal and industrial customers. Customers are fed power through approximately 160 miles of distribution lines. The SMLD is a member of ISO New England (ISO-NE) and a wholesale supplier 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 25% of power generation comes from renewable sources, primarily wind, hydro, and solar. Solar accounts for approximately 30% of the department's peak load. Two 1-megawatt solar installations went on line in 2007, placing SMLD at the top of the Solar Electric Power Association's Top 10 utility rankings for that year for new solar watts per customer [1]. SMLD currently has 1 MW of solar installed.

Previous research on energy storage in ISO-NE is described in [2], where the authors discuss the integration of flywheel-based energy storage for the frequency regulation in regulated and deregulated markets. Preliminary results were presented for 3 MW of flywheel storage in ISO-NE. Science Power's study found that on average, a 1 MW system injects 180 kWh per hour, which corresponds to 6300 equivalent charge/discharge cycles per year. Over a 20 year life, this results in approximately 125,000 full charge/discharge cycles. The authors

argue that this charge/discharge profile would be difficult for chemical energy storage systems.

The methodology for estimating net annual potential revenue from an energy storage system participating in energy and regulation markets is outlined in [3]. The problem was formulated as a linear program (LP) optimization, and results for California Independent System Operator (CAISO) data were 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 Texas (ERCOT) is presented in [4]. An analysis of all load zones in ERCOT for 2011–2015 market data found that frequency regulation provided significantly more potential revenue than arbitrage. Because there is only one market for frequency regulation in ERCOT, and the majority of revenue was from frequency regulation, the location of the system does not impact potential revenue. The analysis also highlights the variability from year to year in potential revenue. A winter ice storm and a summer heat wave resulted in significantly higher prices in ERCOT in 2011, and led to significantly higher potential revenue from energy storage (more than twice the 2012/2013 potential revenue). An analysis of the PJM interconnection, which includes pay-for-performance, is summarized in [5]. Once again, frequency regulation provided significantly more potential revenue than arbitrage in PJM for the data analyzed. An early summary of potential arbitrage revenue in various markets is found in [6].

The goal of this paper is to identify and quantify potential benefits of electrical energy storage for the SMLD. Benefits considered in this study include energy arbitrage, frequency regulation, reduction in network load, reduction in capacity payments to ISO New England, and grid reliability. The paper is organized as follows. Section II provides an overview of each potential benefit. Section III summarizes the results of a financial analysis of each potential benefit. The expected benefits are summarized in Section V.

II. OVERVIEW OF ENERGY STORAGE VALUES

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

Example Deployment Project: Sterling Municipal Light Department

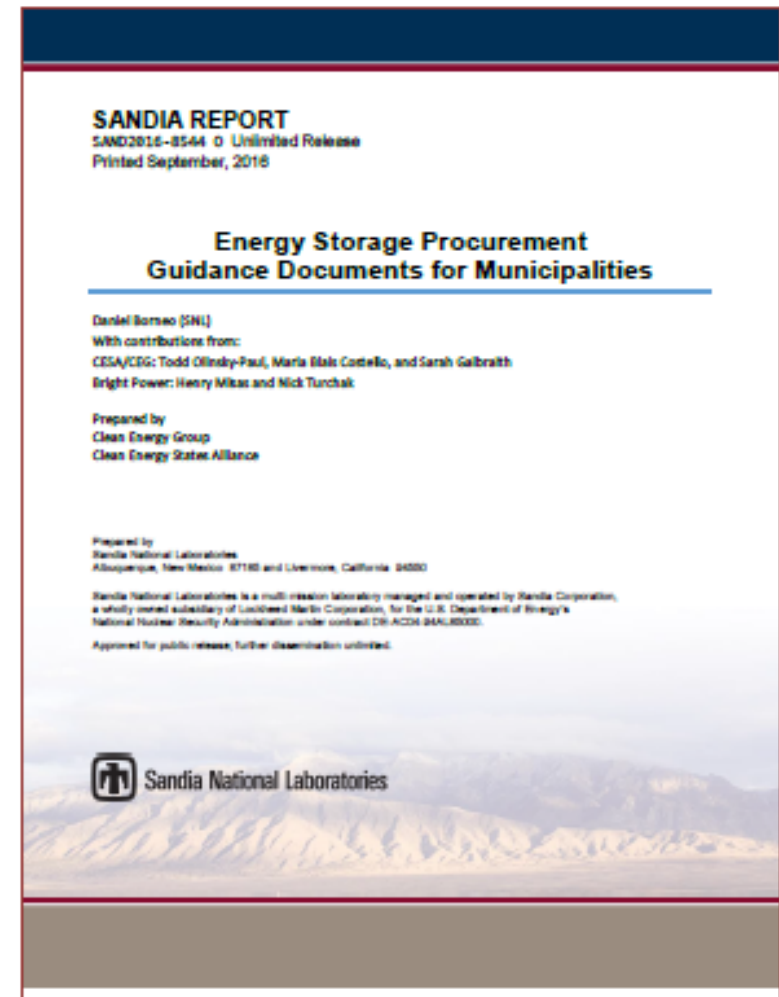


- Issue

- Lack of knowledge and experience regarding procurement of a combined system lead to a difficult and arduous process for vendors

- Lessons Learned

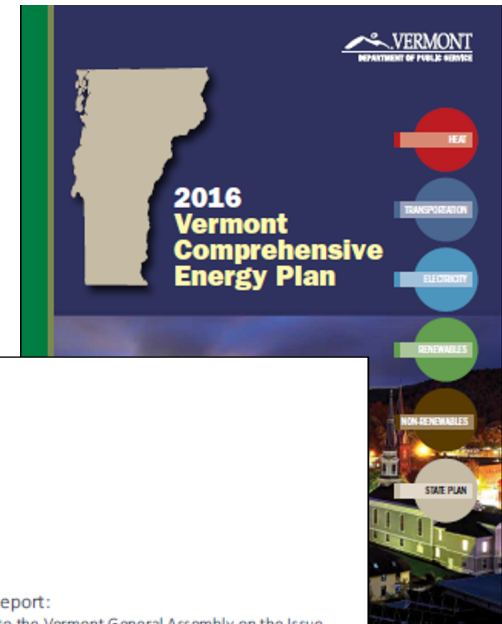
- For successful integration of storage, it can be helpful to have 1 project combining PV and Storage done by 1 company rather than 2 separate projects done by 2 companies
- There is a growing need for companies who can do both



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

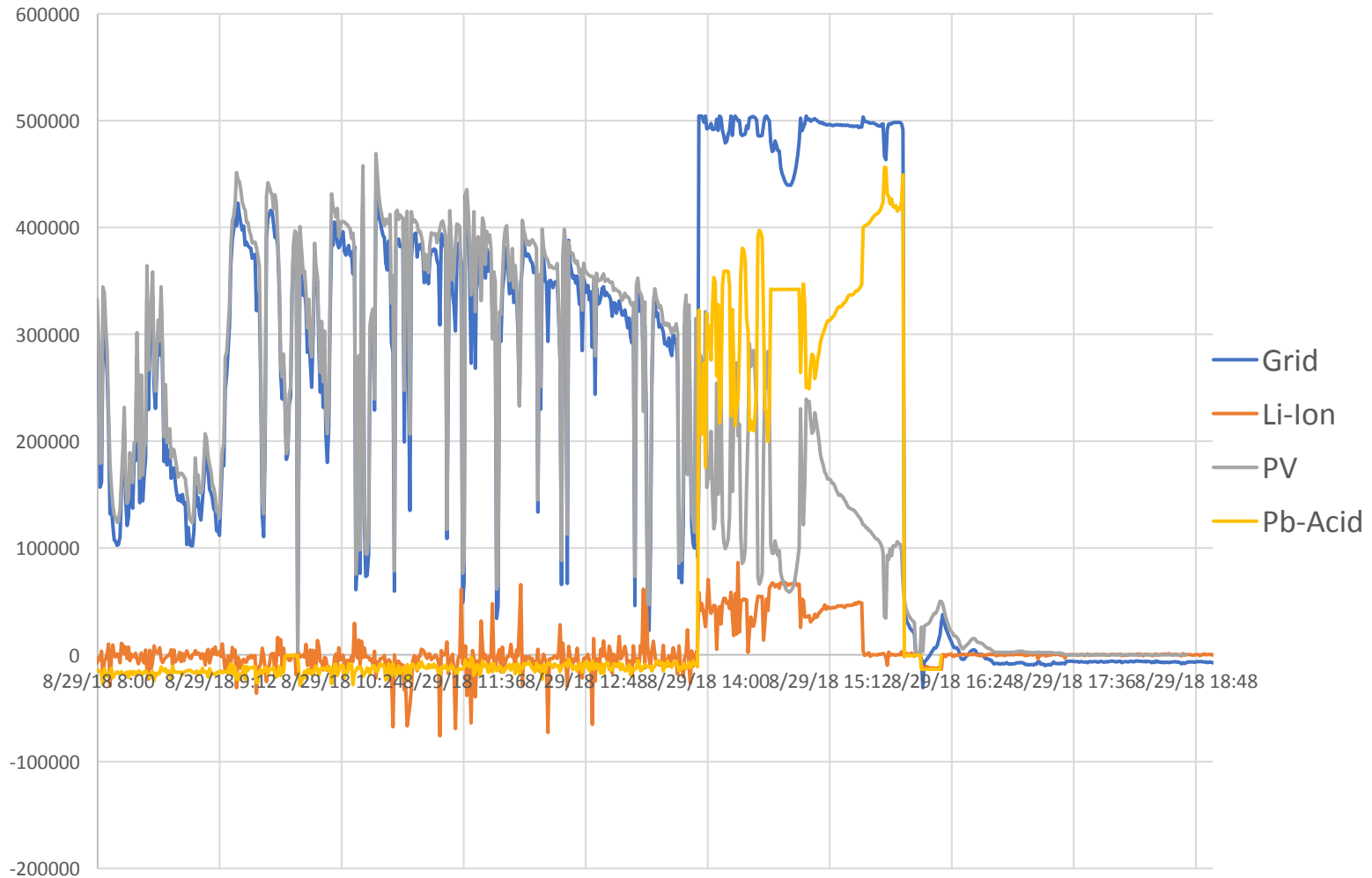
Final Report - November 15, 2017



GMP Operational Data



PCS4 Power



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





- 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

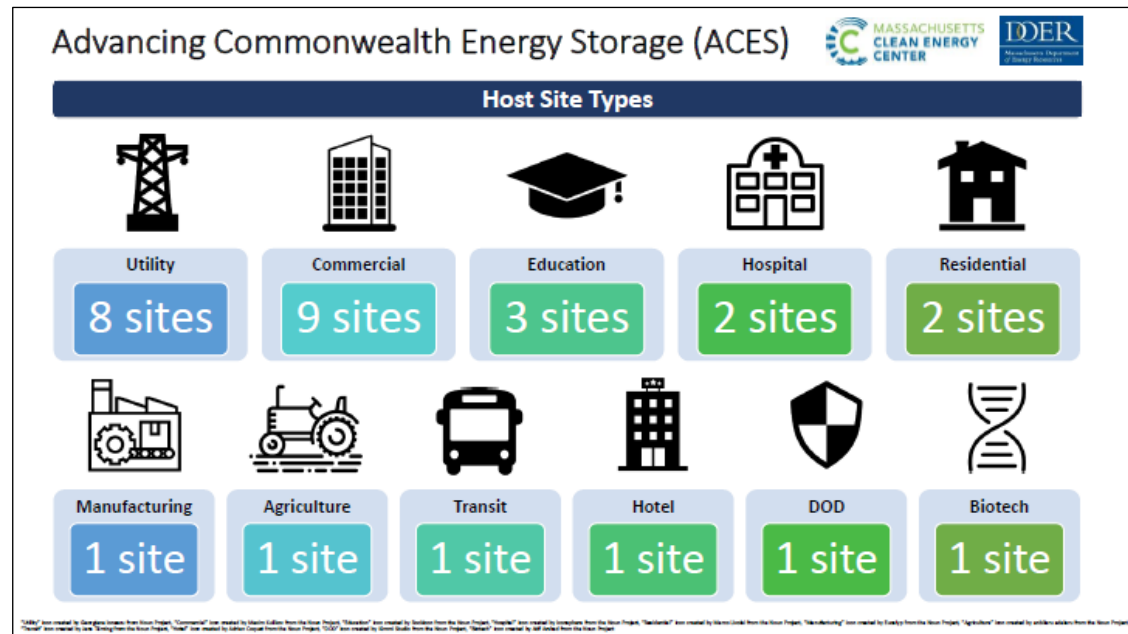


- **Boston Medical Center, Massachusetts:** Optimization analysis for major metropolitan hospital using battery storage for demand charge management and resilient power. Focus on optimizing the BESS with an existing CHP plant to improve power quality and reduce voltage fluctuations to the CHP.
- **Gunnison 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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