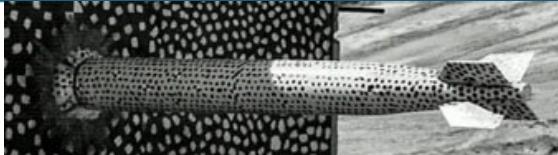


This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government

Sandia Energy Storage Analytics – Equitable Regulatory Environment Thrust Area



Presented by

Ray Byrne, Ph.D.

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Sandia Equitable Regulatory Environment Thrust Area



Energy Storage Analytics

- Economic valuation
- Technical evaluation
- Demonstration support

Energy Storage Policy

- Outreach to states
- Identifying opportunities & barriers to energy storage deployment
- Technical standards
- DOE Energy Storage Database
- Energy Storage Finance Summits

Control Strategies for Energy Storage

- Energy storage value is derived from proper dispatch/controls
- Identifying new grid services/value streams enabled by controls
- Maximizing revenue and/or grid benefit



Energy Storage Analytics

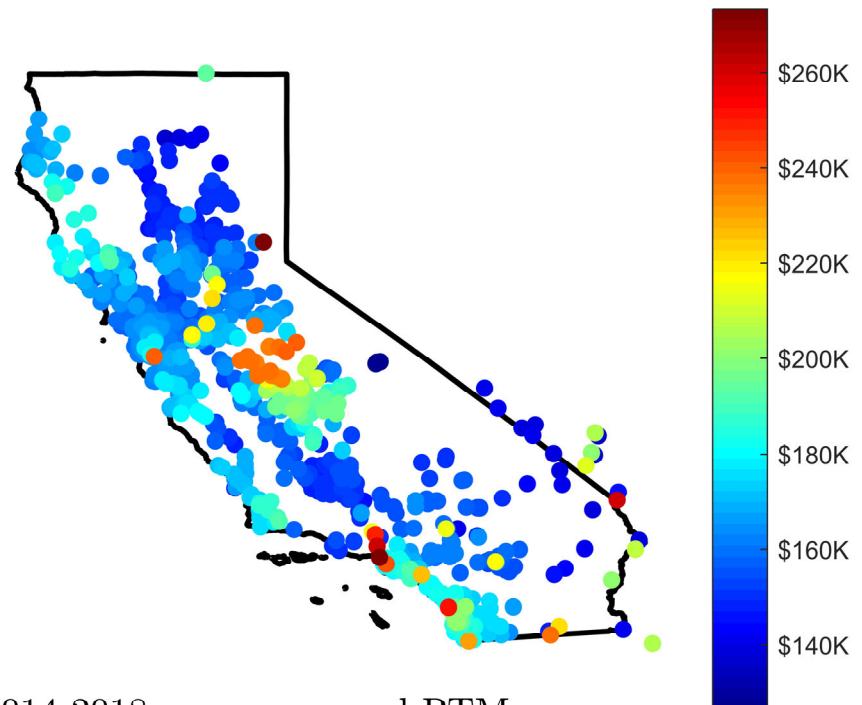


Economic valuation – Market Areas

- California ISO – solar + storage DA market
- California ISO – solar + storage RT (HASP) market
- ISO NE (part of demo support) – storage + wind

Economic valuation – Vertically Integrated Utilities

- None this year



2014-2018 average annual RTM revenue from solar + storage (\$K)

Raymond H. Byrne, Tu A. Nguyen, Alexander Headley and Rodrigo D. Trevizan, “Opportunities and Trends for Energy Storage Plus Solar in the CAISO Real-Time Market: 2014-2018”, proceedings of the 2020 IEEE SPEEDAM Symposium, June 24-26, 2020, pp. 1-8.

Raymond H. Byrne, Tu A. Nguyen, Alexander Headley, Felipe Wilches-Bernal, Ricky Concepcion and Rodrigo D. Trevizan, “Opportunities and Trends for Energy Storage Plus Solar in CAISO: 2014-2018”, proceedings of the 2020 IEEE Power and Energy Society Annual Meeting, August 2-6, 2020, pp. 1-5.

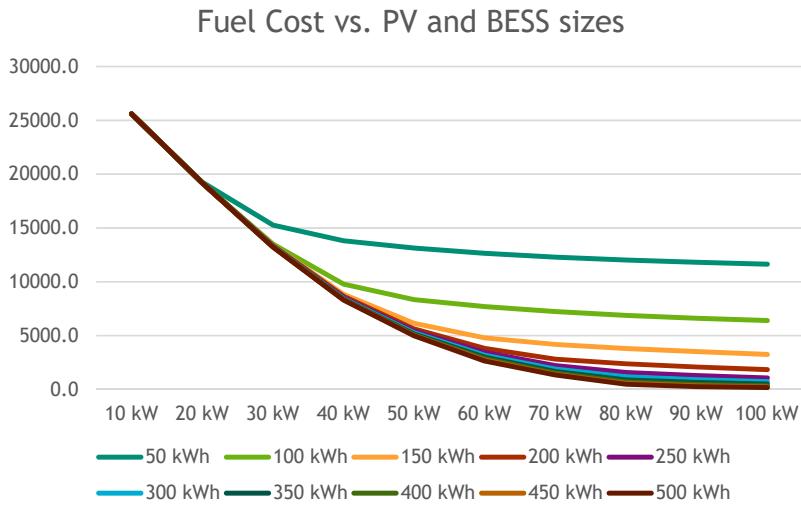
Energy Storage Analytics

Demonstration Support

- Hyde Park state park, NM
- Colorado (Poudre Valley Co-Op)
- Vermont (Vermont Electric Cooperative)
- Puerto Rico
- San Carlos Apache Tribe and Picuris Pueblo



Hyde Park Analysis



2019 Revenue of 5MW/20MWh ESS in ISO-NE

Month	Energy Arbitrage (\$)	Frequency Regulation (\$)	RNS Saving (\$)	Capacity Payment saving (\$)	Total (\$)
1	302.8178	157,977.7	53,858.33	35,390	247,528.8
2	-1,064.7	104,984.4	53,858.33	35,390	193,168
3	-2,553.54	93,776.78	53,858.33	35,390	180,471.6
4	-2,188.86	74,434.98	53,858.33	35,390	161,494.5
5	2,566.631	77,972.77	53,858.33	35,390	169,787.7
6	56.75653	65,849.01	53,858.33	35,390	155,154.1
7	-1,788.16	90,695.1	53,858.33	35,390	178,155.3
8	-1,885.43	72,941.23	53,858.33	35,390	160,304.1
9	21,142.84	93,032.53	53,858.33	35,390	203,423.7
10	-18.8004	108,903.3	53,858.33	35,390	198,132.8
11	21,241.72	92,042.68	53,858.33	35,390	202,532.7
12	-1,168.12	123,145.2	53,858.33	35,390	211,225.4
Annual	34,643.15	1,155,755.7	646,299.96	424,680	2,261,379

Energy Storage Policy



Outreach to States (Sandia and PNNL)

- New Mexico Public Regulation Commission, Santa Fe, NM, Fall 2019
- PNM Public Advisory Committee Meeting, Albuquerque, NM, November 2019
- Nevada Public Utility Commission, Carson City, NV, January 2020
- Maryland Public Utility Commission, April 2020 (webinar)
- Utah Public Utility Commission, July 2020 (webinar)
- Iowa State University Electric Power Research Center/MISO Workshop Series, Fall 2020 (webinar)
- Federal Energy Regulatory Commission (FERC), September 2020 (webinar)

Energy Storage Policy Analysis

- State by state analysis of energy storage policy (in progress)

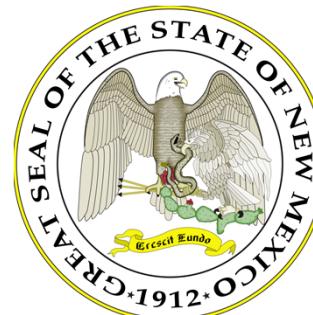
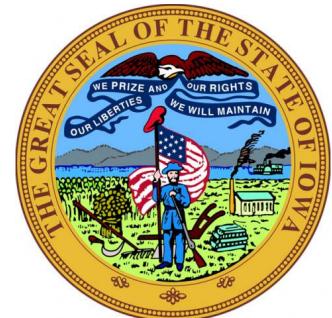
DOE Energy Storage Database

- Vetting project database

Energy Storage Finance Summits

- New York – January 2020
- San Francisco (virtual) – October 2020

Energy Storage Pricing Survey



Control Strategies for Energy Storage

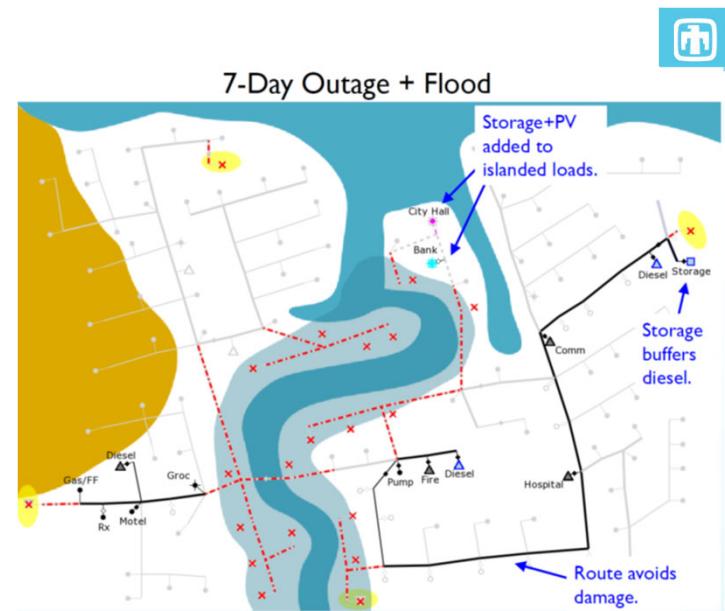
Battery Models for Control

- Cyber Security for Battery Management Systems Lab
- Leading IEEE Battery Management System (BMS) standards activities

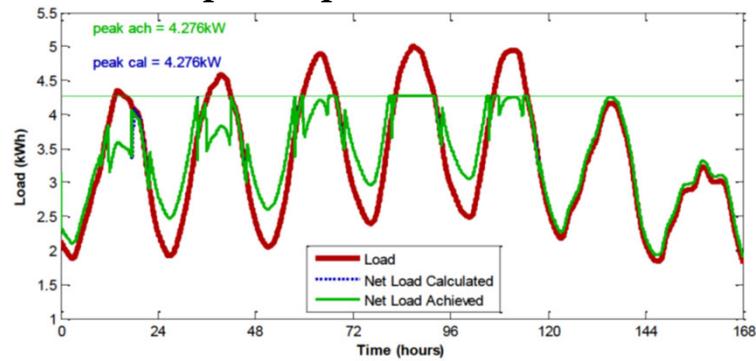
Optimal Siting and Sizing of Energy Storage for Grid Resilience

- Symantec graph theory applied to distribution grid partitioning,
Best paper session, 2020 IEEE PES GM
- Puerto Rico demonstration project

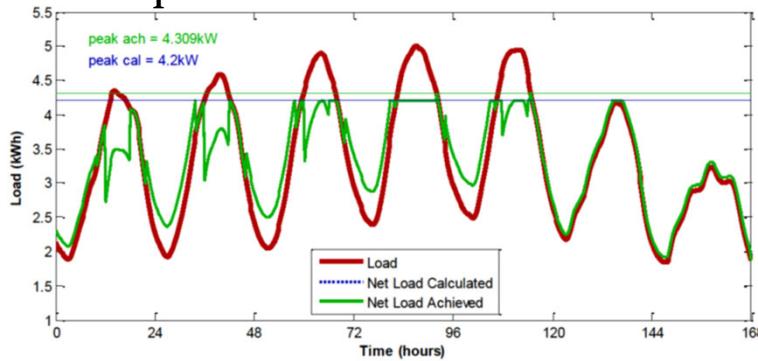
Sizing for Transportation Electrification



Suboptimal performance



Optimistic shortfall



University Collaborations

Montana Tech University – *Small Signal Stability, Transient Stability*

- Dr. Dan Trudnowski
- Dr. Matt Donnelly

Clemson University – *Distributed Control of Energy Storage*

- Dr. Pierluigi Pisu

University of Utah - *Continuous-time Look-Ahead Scheduling of Energy Storage in Real-time Markets*

- Dr. Masood Parvania

South Dakota State University – *Virtual Inertia Control*

- Dr. Reinaldo Tonkoski

Michigan State University – *Optimal Dispatch of Energy Storage with Degradation Models*

- Dr. Joydeep Mitra



FY21 Some Planned Activities



QuEST Enhancements

- Production cost modeling – EGRET/Prescient
- Battery degradation models
- Python/Pyomo scripts for each publication
- QuEST API and documentation
- Extreme climate system models

Demonstration Support

- NRECA
- Cordova, AK
- Puerto Rico
- Vermont
- New Mexico

Energy Storage Policy - Outreach to States

- New England Conference of Public Utility Commissioners (NECPUC)
- New Mexico (Energy Transition Act focus)

Energy Storage Policy Analysis

- State by state analysis of energy storage policy

PNM CRADA

- Expansion planning to meet carbon/renewable goals



Energy Storage Analytics Team



Dr. Babu Chalamala

Dr. Ray Byrne

Dr. Alvaro Furlani Bastos

Mr. Dan Borneo

Dr. Randy Brost

Dr. Hyungjin Choi

Dr. Ryan Elliott

Dr. Alex Headley

Mr. William McNamara

Dr. Tu Nguyen

Dr. Howard Passell

Dr. Brian Pierre

Dr. Luciano A. Garcia Rodriguez

Dr. David Rosewater

Mr. Ben Schenkman

Dr. David Schoenwald

Dr. Ujjwol Tamrakar

Dr. Rodrigo Trevizan