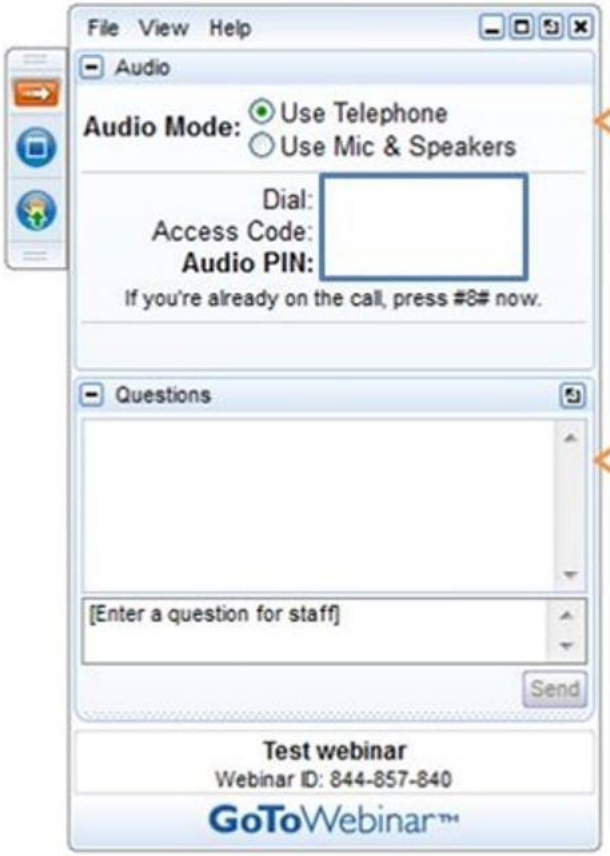
Energy Storage Technology Advancement Partnership (ESTAP) Webinar:

Energy Storage in Sterling: A Massachusetts Municipal Microgrid

October 25, 2016

Hosted by Todd Olinsky-Paul
ESTAP Project Director
Clean Energy States Alliance

Housekeeping



All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

You will find a recording of this webinar, as well as all previous CESA webcasts, archived on the CESA website at

www.cesa.org/webinars

State & Federal Energy Storage Technology Advancement Partnership (ESTAP)

Todd Olinsky-Paul

Project Director

Clean Energy States Alliance (CESA)

Thank You:

Dr. Imre Gyuk
U.S. Department of Energy,
Office of Electricity Delivery and
Energy Reliability

Dan Borneo
Sandia National Laboratories

CleanEnergy States Alliance

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

ESTAP is a project of CESA

Clean Energy States Alliance (CESA) is a non-profit organization providing a forum for states to work together to implement effective clean energy policies & programs:

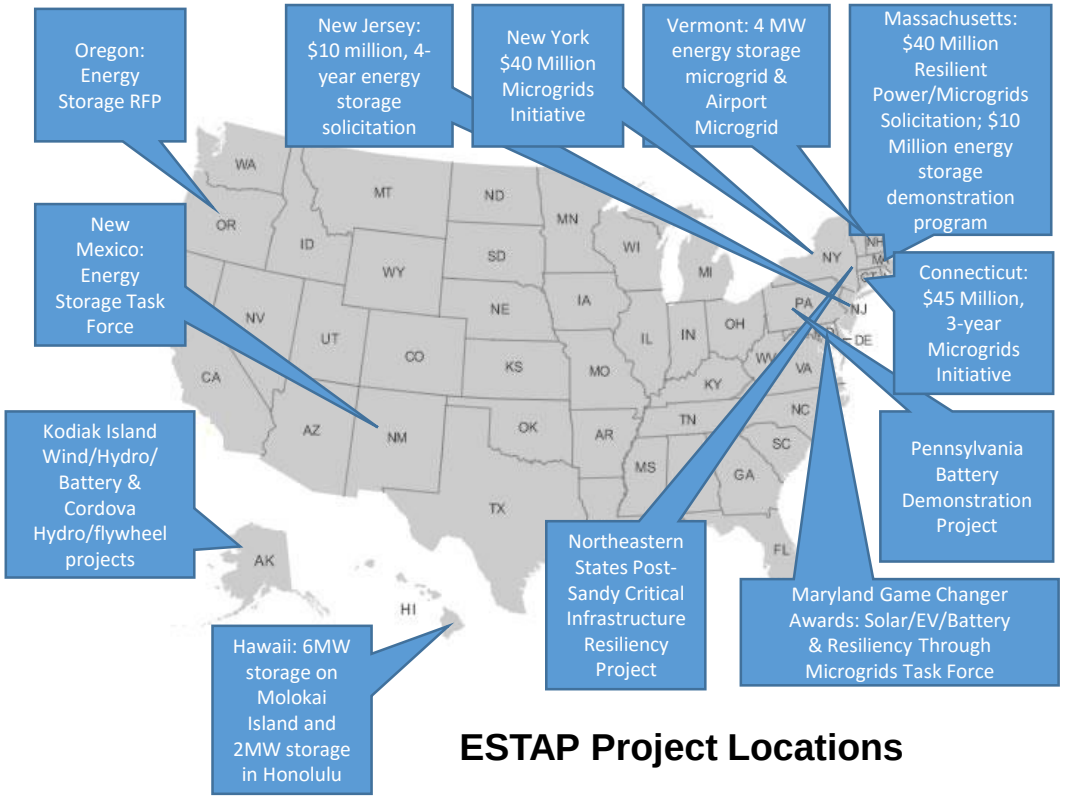
State & Federal Energy Storage Technology Advancement Partnership (ESTAP) is conducted under contract with Sandia National Laboratories, with funding from US DOE.

ESTAP Key Activities:

1. Disseminate information to stakeholders
   - ESTAP listserv >3,000 members
   - Webinars, conferences, information updates, surveys.

2. Facilitate public/private partnerships to support joint federal/state energy storage demonstration project deployment

3. Support state energy storage efforts with technical, policy and program assistance



ESTAP Project Locations

CleanEnergy States Alliance

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

Energy Storage Technology Advancement Partnership

More CESA Projects

Overview

ESTAP Resource Library

ESTAP Webinars

ESTAP News

ESTAP Listserv Signup

ESTAP

Project Director: Todd Olinsky-Paul

Contact: Todd Olinsky-Paul, Todd@cleanegroup.org

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The Energy Storage Technology Advancement Partnership (ESTAP) is a federal-state funding and information sharing project, managed by CESA, that aims to accelerate the deployment of electrical energy storage technologies in the U.S.

The project's objective is to accelerate the pace of deployment of energy storage technologies in the United States through the creation of technical assistance and co-funding partnerships between states and the U.S. Department of Energy.

ESTAP conducts two key activities:

1) Disseminate information to stakeholders through:

- The ESTAP listserv (>2,000 members)
- Webinars, conferences, information updates

NEW RESOURCES

October 14, 2015
Resilience for Free: How Solar+Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Net Cost
By Clean Energy Group

September 30, 2015
Webinar Slides: Energy Storage Market Updates, 9.30.15

UPCOMING EVENTS

December 16, 2015
ESTAP Webinar: State of the U.S. Energy Storage Industry,

More Events

LATEST NEWS

November 30, 2015
Massachusetts Takes the Lead on Resilient

Panelists

- **Dr. Imre Gyuk**, U.S. Department of Energy Office of Electricity Delivery and Energy Reliability
- **Sean Hamilton**, Sterling Municipal Light Department
- **Roger Lin**, NEC Energy Solutions
- **Scott Reynolds**, Reynolds Engineering
- **Dan Borneo**, Sandia National Laboratories
- **Dr. Raymond Byrne**, Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

Sterling Municipal Light Department

NEC ENERGY SOLUTIONS

Sandia National Laboratories

Creating a Microgrid based Utility of the Future

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE

The Groundbreaking of the Sterling P-V Storage Microgrid was a Joyous Occasion!

On a splendid New England Autumn day Federal, State, and municipal partners joined in kicking off a very significant project in Sterling, MA. The project by the Sterling Municipal Light Department was 1 of 11 projects selected for funding by the MA DOER resiliency initiative. The DOE Office of Electricity through Sandia National Laboratory provided extra funding to help increase the size of the project from 1MW to 2MW and helped formulate the solicitation for a storage system provider .

The future microgrid will be embedded in the Sterling distribution network, linking the police station and dispatch center with 6MW of PV and 2MW of storage. During emergencies this grid can island and provide mission critical support. During ordinary times the microgrid opens up, providing local green energy and local grid services. In particular, by shaving off parts of the annual and monthly load peaks resulting in an expected payback period of less than 7 years.

And so, on this glorious October day I had the pleasure of joining Judith Judson who heads DOER, Matt Beaton, MA Energy Secretary, Sean Hamilton from Sterling, Board Members, and State Representatives in breaking ground for the grid of the future!

Sterling, Massachusetts: Creating the Utility of the Future!

Sterling Municipal Light Dept. Energy Storage Project

Department of Energy Resources
Community Clean Energy Resiliency Initiative

Sean Hamilton - General Manager

October 25,2016

Value of Energy Storage

- **Grid Resiliency-Police and Dispatch Center**
- **Intermittent Resources-3.4 mw Solar**
- **Regional Network Service (RNS) -Monthly Peak**
- **Capacity Load Obligation Payments –Annual Peak**
- **Energy Arbitrage**

- Source: The Value proposition for Energy Storage for Sterling Municipal Light Department
- Author Dr. Raymond Byrne, Sandia National Laboratories. www.energysterling.com

Grant Timeline

- First Application $2.8 million April 2014
- December 2014, awarded $1.465 million
- Grant awarded to Town of Sterling
- Contract Signed October 2015
- October-April, Hired OPM, Design Engineers
- Collaborated with CESA, Sandia National Laboratories and DOE creating RFP.
- 32 RFPs requested, 4 finalist, NEC vendor
- October 25, Foundation in, Trench complete

Micro Grid Capable

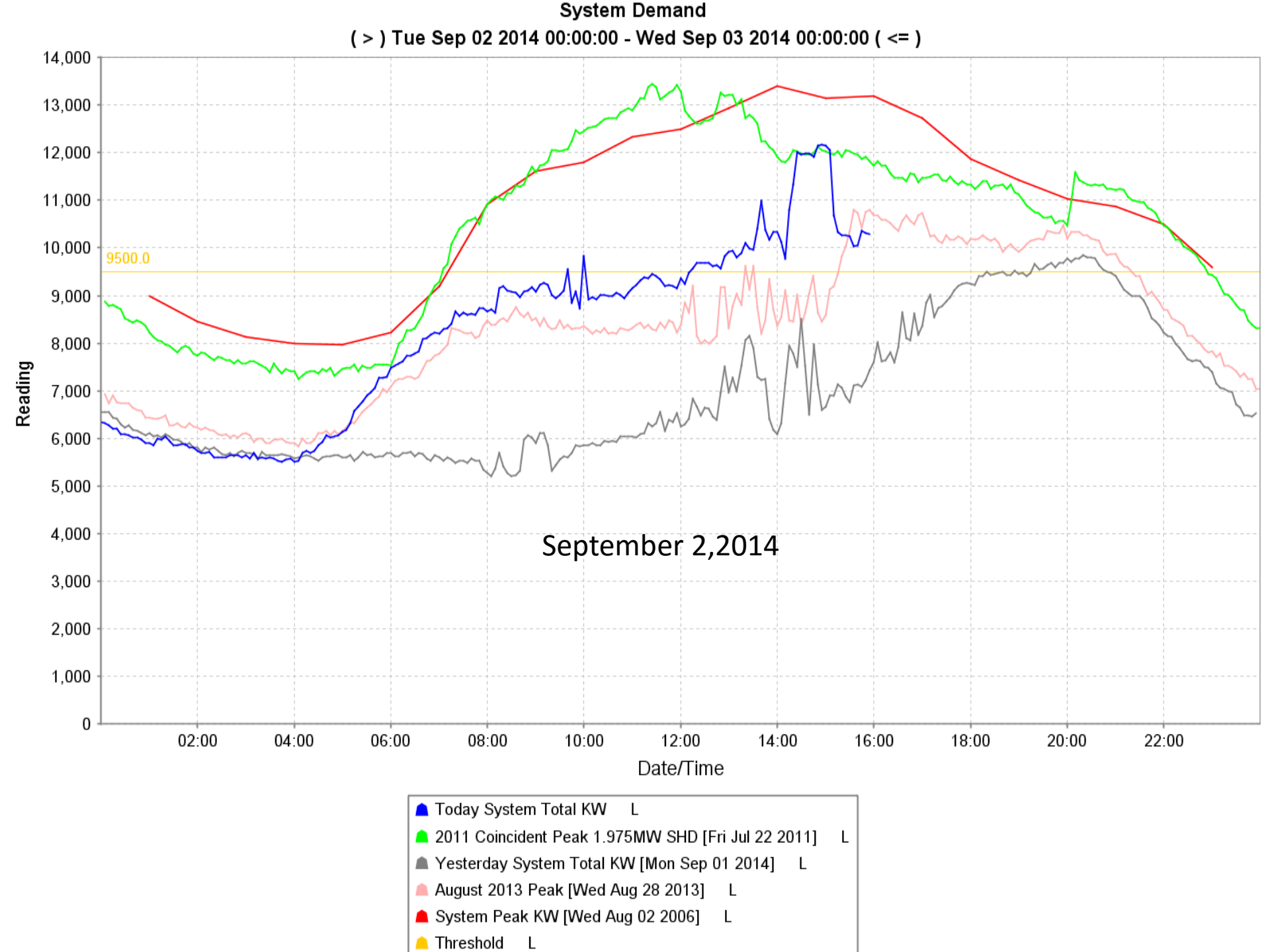
SEPA Solar Watts Per Customer Comparision

SEPA 2013

Rank	Utility	W/C
1	Sterling Municipal Light Dept (MA).	831
2	San Diego Gas & Electric Company (CA)	461
3	Silicon Valley Power/City of Santa Clara (CA)	427
4	Arizona Public Service (AZ)	368
5	Hawaiian Electric Company, Inc. (HI)	329
6	Pacific Gas and Electric Company (CA)	281
7	Hawaii Electric Light Company (HI)	182
8	Maui Electric Company Ltd (HI)	178
9	Kauai Island Utility Cooperative (HI)	167
10	Imperial Irrigation District (CA)	159

SEPA 2015

Village of Minster (OH)		2,104
2	City of Palo Alto Utilities (CA)	1,846
3	Roseville Electric Utility (CA)	1,416
4	Carey Municipal Electric Utility (OH)	1,351
5	Vineland Municipal Electric Utility (NJ)	1,318
6	Ashburnham Municipal Light Plant (MA)	1,079
7	Sterling Municipal Light Department (MA)	848
8	Imperial Irrigation District (CA)	750
9	Guam Power Authority (GU)	710
10	Silicon Valley Power (CA)	613


System Demand
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Date/Time
September 2,2014
Today System Total KW L
2011 Coincident Peak 1.975MW SHD [Fri Jul 22 2011] L
Yesterday System Total KW [Mon Sep 01 2014] L
August 2013 Peak [Wed Aug 28 2013] L
System Peak KW [Wed Aug 02 2006] L
Threshold L

Final Real-Time Locational Marginal Prices ($/MWh) 9/2/2014

Hour	HUB	WCMA	NEMA	SEMA	CT	RI	NH	VT	ME
1	44.23	44.35	44.48	44.03	44.40	44.39	43.85	43.75	41.88
2	38.15	38.31	38.22	37.84	38.36	38.17	37.74	37.75	36.11
3	32.98	33.11	33.01	32.68	33.09	32.96	32.67	32.54	31.54
4	28.23	28.34	28.26	28.01	28.26	28.19	28.02	27.90	27.13
5	28.06	28.19	28.07	27.83	28.17	27.97	27.89	27.81	26.98
6	32.97	33.10	32.98	32.67	33.11	33.09	32.86	32.82	31.77
7	37.33	37.46	37.49	37.03	37.51	37.24	37.44	37.29	36.38
8	40.87	40.99	41.07	40.62	41.05	40.90	41.01	40.86	39.96
9	35.01	35.09	35.25	36.10	35.06	41.63	35.25	34.96	34.33
10	45.85	45.99	46.13	46.51	46.09	50.20	46.07	45.92	44.34
11	73.81	74.12	74.15	73.39	74.69	73.55	74.11	74.15	71.31
12	89.80	90.11	90.35	89.45	93.48	89.51	90.14	89.86	86.67
13	185.70	186.25	187.11	185.44	190.47	185.53	186.15	184.95	178.01
14	554.71	555.62	560.77	555.12	558.00	555.55	555.69	551.95	530.00
15	206.54	206.72	209.37	207.47	308.93	207.60	206.72	205.66	196.51
16	70.45	70.57	71.51	70.86	158.68	70.91	70.15	70.67	65.38
17	86.23	86.34	87.48	86.72	168.94	86.71	85.96	86.14	80.60
18	133.90	134.22	135.05	134.18	174.45	134.14	133.38	133.73	126.21
19	72.92	73.14	73.35	72.90	107.74	72.81	72.65	73.38	68.10
20	75.16	75.35	75.60	75.14	82.61	75.08	75.14	75.41	71.28
21	74.36	74.62	74.61	74.20	75.75	73.96	74.14	74.76	70.18
22	55.07	55.27	55.32	54.86	55.76	54.56	54.81	54.91	52.16
23	38.60	38.75	38.82	38.36	39.02	38.21	38.48	38.42	36.99
24	54.55	54.76	54.98	54.15	55.00	54.01	54.41	54.12	52.48
AVG	88.98	89.20	89.73	88.98	104.53	89.45	88.95	88.74	84.85
On Peak AVG	114.94	115.20	116.00	115.08	138.17	115.68	114.99	114.73	109.50
Off Peak AVG	37.06	37.20	37.19	36.78	37.24	37.00	36.86	36.75	35.53

Special Thanks to :

- SMLD Commissioners - For their support of this project.
- Town of Sterling - For their continued support
- Judith Judson-Ma. DOER Commissioner
- Dr. Imre Gyuk - U.S. Dept of Energy, Energy Storage Program Director.
- Sandia National Laboratories - Daniel Borneo PE., Dr. Raymond Byrne
- Todd Olinsky-Paul- Project Director at CEG and CESA
- MMWEC - Market Analysis
- Jared Carpenter, Jim Frawley-Grant Technical Information

NEC
NEC ENERGY SOLUTIONS

Energy Storage Technology

GSS® Grid Storage Solution

The GSS® grid storage solution

An Integrated System

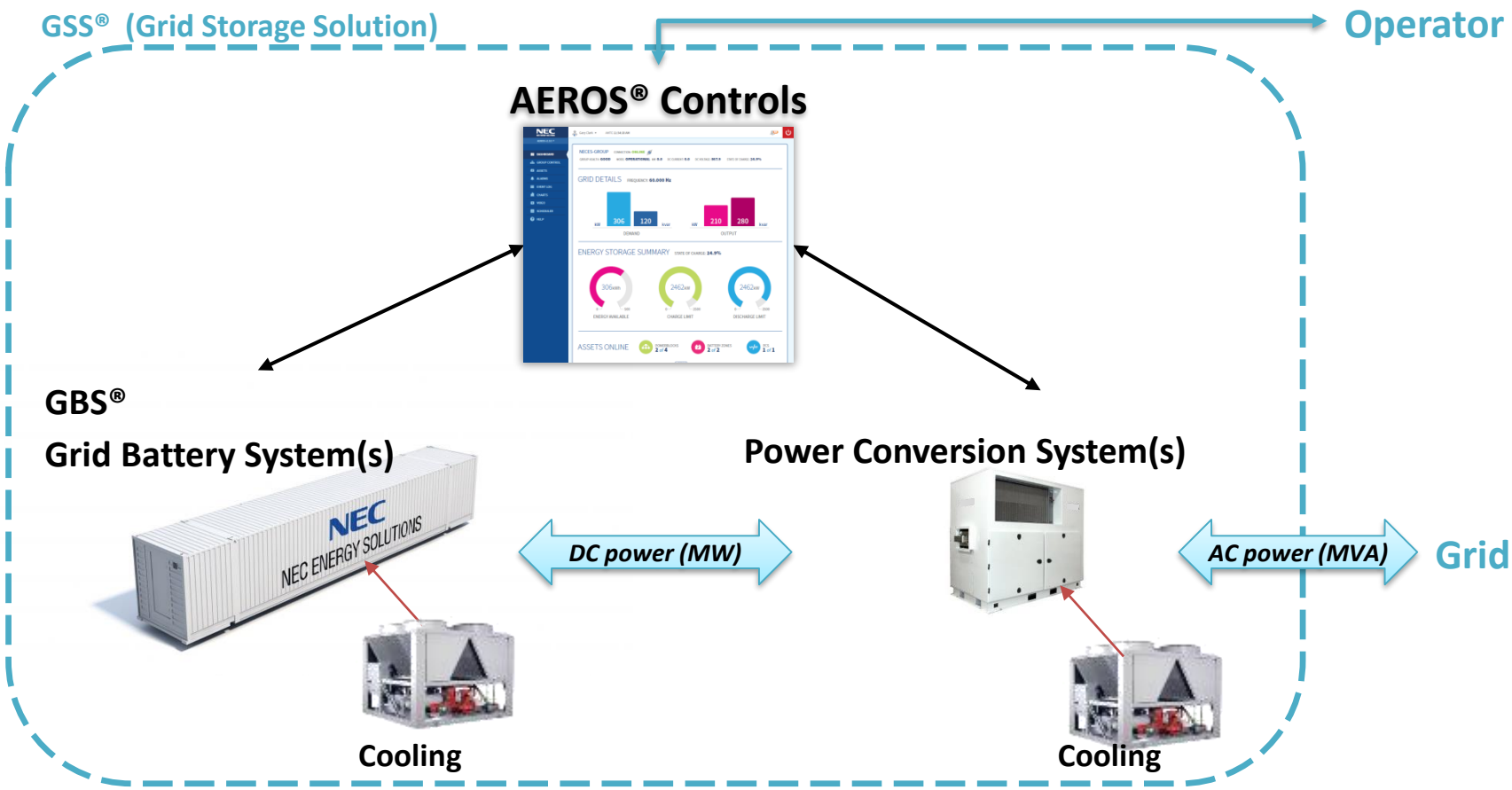
- The GSS® grid storage solution is a fully integrated, turnkey, AC energy storage plant ready to interconnect to the grid
  - Configured-to-order from factory-assembled, standard modular components
  - Designed and manufactured by NEC Energy Solutions:
    - AEROS® controls, a complete energy storage command and controls software package
    - GBS® grid battery systems; energy storage with BMS and controls hardware in outdoor-rated enclosures (standard containerized, but custom enclosures possible)
  - Includes necessary equipment from third-parties, engineered to work with all NEC ES equipment
    - Power conversion hardware (inverters) from leading manufacturers around the world
    - Thermal management units (air conditioning or water chillers) for battery cooling

Custom enclosure GSS® grid storage solution

Standard containerized GSS® grid storage solution

GSS® grid storage solution equipment

Three major functional components

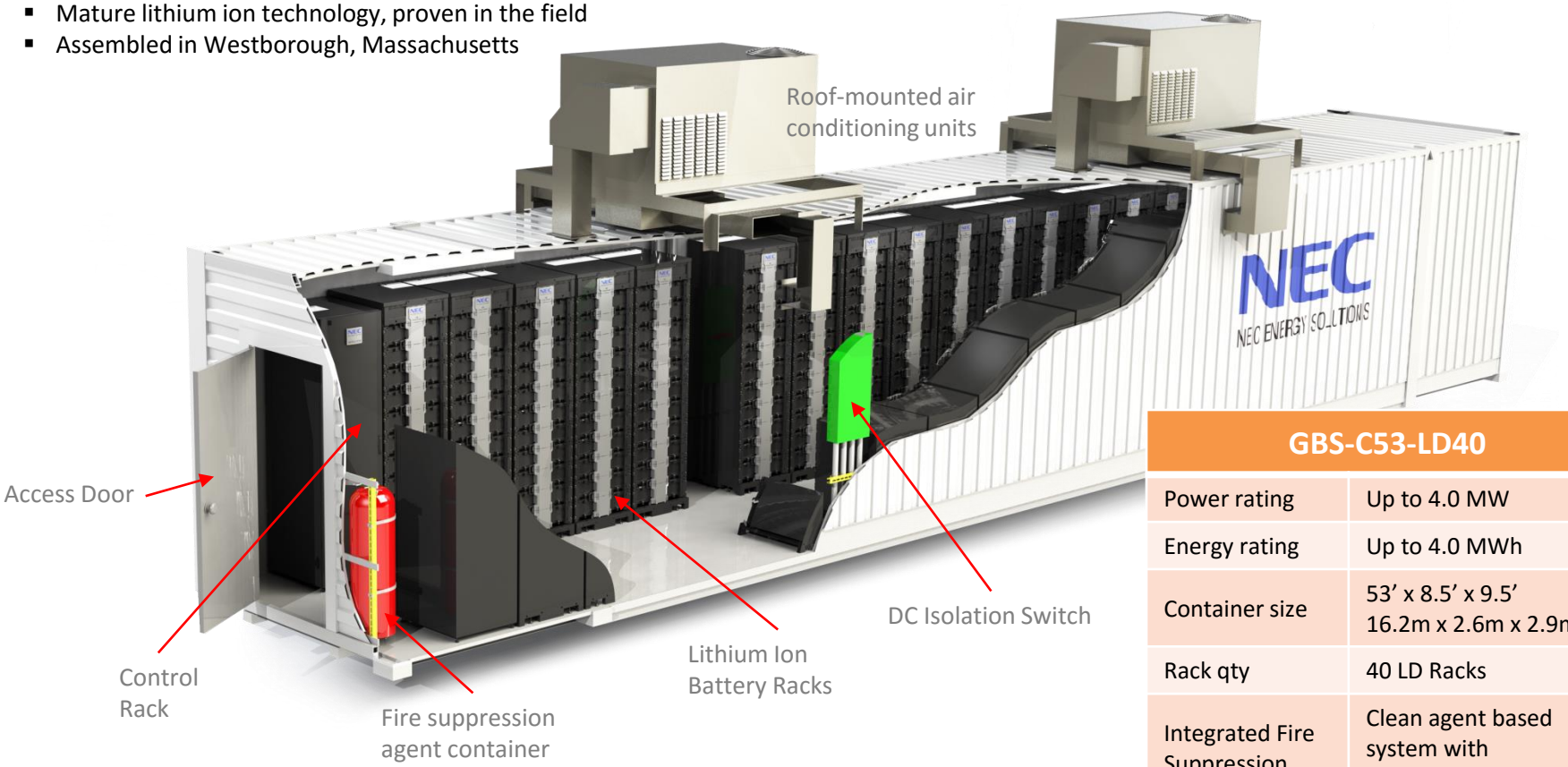


About the GBS® battery system

Standard containerized lithium ion battery

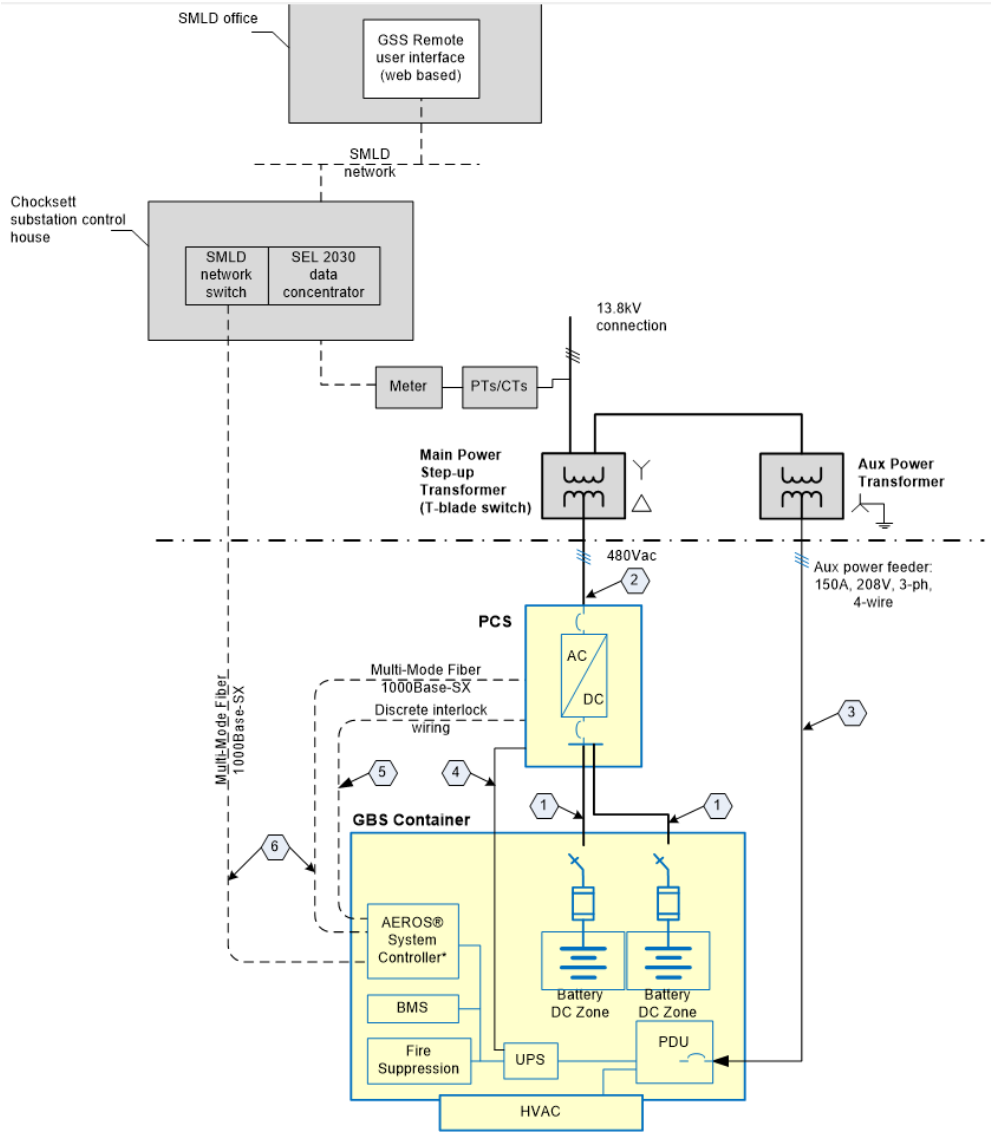
GBS® LD 53’ container

- Long Duration (LD) energy storage technology, up to 4MW/4MWh in a single container
- Designed for 1 hour of energy storage or more
- Mature lithium ion technology, proven in the field
- Assembled in Westborough, Massachusetts



GBS-C53-LD40	
Power rating	Up to 4.0 MW
Energy rating	Up to 4.0 MWh
Container size	53’ x 8.5’ x 9.5’ 16.2m x 2.6m x 2.9m
Rack qty	40 LD Racks
Integrated Fire Suppression	Clean agent based system with smoke/heat detection

Sterling Project Overview – One Line Diagram



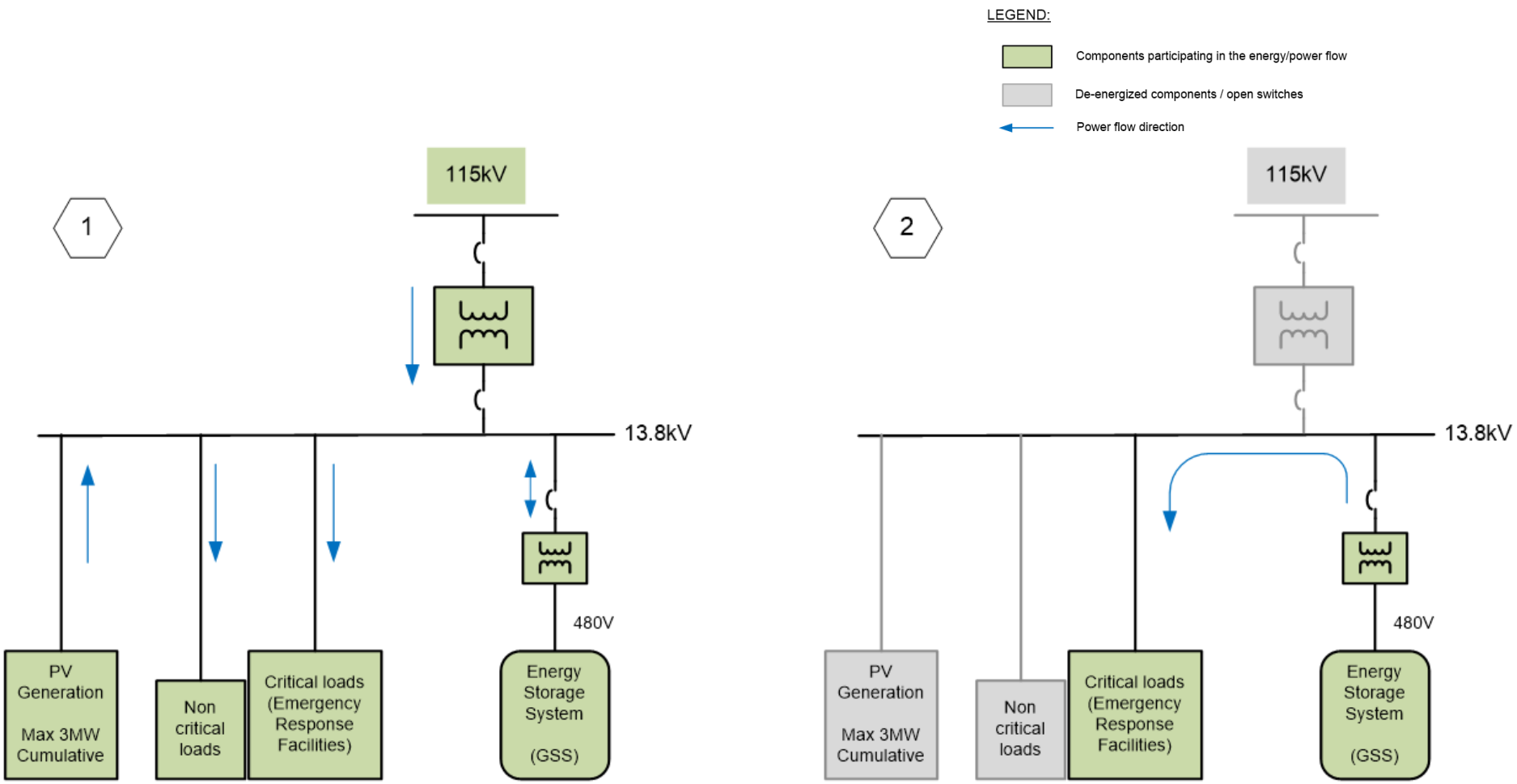
LEGEND:

- Multiple Conductors, 3-ph
- Fuse
- Manual Disconnect Switch
- Circuit Breaker
- 52 Circuit Breaker
- Fused Disconnect Switch
- Electric Power
- Controls/Communication

GBS	Grid Battery System
LV	Low Voltage
MV	Medium Voltage
PCS	Power Conversion System
PDU	Power Distribution Unit panel
UPS	Uninterruptible Power Supply

- NEC Energy Solutions Provided Equipment
- Equipment provided by others (project specific)
- n Identifier for cable schedule

Overview of Operating Modes



Sandia National Laboratories

Exceptional service in the national interest

Sandia National Laboratories Energy Industry Acceptance - Storage Projects

Daniel Borneo, P.E.

Sandia National Laboratories

ESTAP Webinar

Oct. 25, 2016

Program Sponsor: DOE/OE Stationary Energy Storage Program - Dr. Imre Gyuk

U.S. DEPARTMENT OF ENERGY

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SAND Document SAND2016-9303 C

SNL Industry Acceptance – ES Projects Team

MISSION STATEMENT: Encourage investment in Energy Storage though field deployments by insuring systems are safe, reliable, and cost effective.

APPROACH: - Work with national and international entities that include the DOD, State Energy offices, Other National Labs**, Utilities, project developers, installers, integrators, Universities and Consumers to:

- Conduct grid and system Analysis
- Develop Energy Storage Projects
- Support State and International renewable/resiliency/Energy Storage initiatives
- Develop public information programs concerning energy storage

** Partnering relationship with sister Labs – PNNL, ORNL, NREL

SNL Industry Acceptance – ES Projects Team

Capabilities

- Grid analysis & modeling
  - ES applications, sizing, technologies
  - Using commercial and Sandia developed analysis tools (PYOMO, PLEXOS,PSLF)
- Project Development and Implementation
  - Request for Information and Proposals (RFI & RFP)
  - Project designs and specifications
  - Data Acquisition Systems (DAS) design and implementation
  - Technical support during the construction of ESS'
  - ESS commissioning/testing plan development and implementation.
  - Start-up, commissioning and testing support.
- System Analysis
  - Remote monitoring and data acquisition
  - Analysis of operational test data
  - System optimization algorithms.
- Policy, regulatory and state support through CESA resources
  - Webinars, Papers, Presentations

SNL Industry Acceptance - ES Projects 2016

International Projects:
- Canada – WEICAN
- Singapore

FY16 – 20 Projects

Stock Image source: http://www.devarticles.com/c/a/Web-Services/Cooking-With-Web-Services-PHP-and-GD/3/

Program Funding provided by
DOE/OE Stationary Storage Program
Program Manager: Dr. Imre Gyuk

Thanks

Dan Borneo - drborne@sandia.gov

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Sandia National Laboratories



Sterling Municipal Light Department Analysis

Ray Byrne, Ph.D.

Acknowledgment: This research was funded by the U.S. Department of Energy Office of Electricity Energy Storage Program, under the guidance of Dr. Imre Gyuk.

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Sterling Municipal Light Department

Sandia National Laboratories

- Potential value streams:
  - Energy arbitrage
  - Reduction in monthly network load (based on monthly peak hour)
  - Reduction in capacity payments (based on annual peak hour)
  - Grid resilience
  - Frequency Regulation
- Energy Arbitrage
  - Buy low, sell high
  - Analyzed 33 months of data (January 2013-September 2015)
  - Optimization using perfect foresight
  - Cycling limitations were not included (can be added later)

TABLE V

Maximum Potential Arbitrage Revenue, Average Monthly Arbitrage Opportunity for a 1 MW Plant.

	1 MWh	2 MWh	3 MWh	4 MWh
Monthly Average	$3,395	$5,117	$6,227	$6,949
Annual Savings	$40,738	$61,407	$74,722	$83,383

Potential Value Streams (cont.)

- Reduction in Regional Network Service (RNS) payments
  - Monthly payment based on maximum load
  - Payment for using transmission facilities to move electricity into or within New England
  - Current pool rate, effective June 1, 2015: $98.70147/kW-yr
  - Need to “hit the hour” to reduce load, or else no benefit
  - Having a multi-hour (more capacity) provides no increase in benefit, but increases the odds of “hitting the hour”
  - If policy changes, there could be a detrimental “load adjustment”

TABLE III
RNS Savings for 1 Hour Energy Storage System.

Power (MW)	Annual Savings ($)
1	$98,707
2	$197,403
3	$296,104
4	$394,806

Potential Value Streams (cont.)

- Reduction in capacity payments
  - Each load serving entity is responsible for a fraction of the Forward Capacity Market obligations
  - Based on peak load over the course of the year
  - Rates have been increasing
  - Increasing capacity does not increase revenue, just increases the odds of "hitting the hour"
  - If policy changes, there could be a detrimental "load adjustment"

TABLE I
SMLD Capacity Clearing Price, ISO-NE.

Year	Price ($/kW-Month)
2010-2011	$4.254
2011-2012	$3.119
2012-2013	$2.535
2013-2014	$2.516
2014-2015	$2.855
2015-2016	$3.129
2016-2017	$3.150
2017-2018	$7.025
2018-2019	$9.551

TABLE IV
SMLD Capacity Clearing Price, ISO-NE.

Year	Price ($/kW-Month)	1 MW	2 MW	3 MW	4 MW
2015-16	$3.129	$51,477	$102,958	$154,443	$205,932
2016-17	$3.150	$51,822	$103,649	$155,479	$207,315
2017-18	$7.025	$115,572	$213,153	$346,744	$462,344
2018-19	$9.551	$157,128	$314,269	$471,424	$628,591

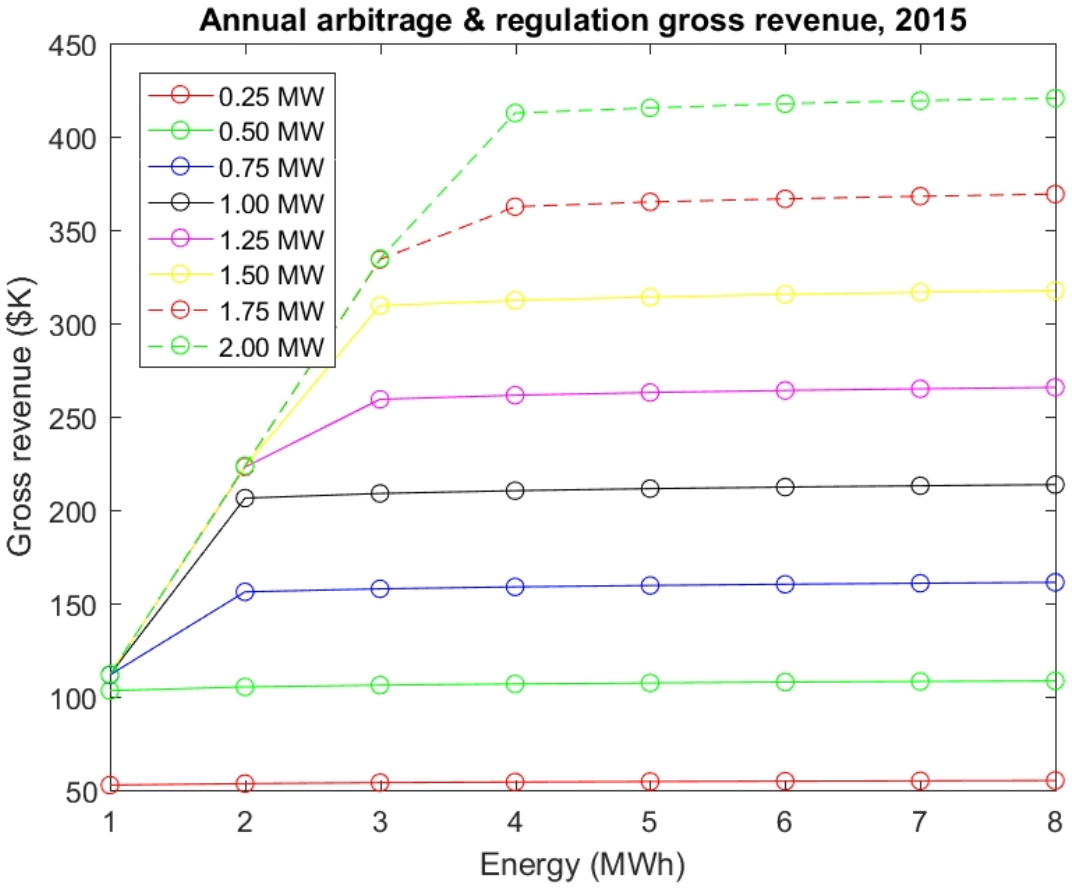
Potential Value Streams (cont.)

- Grid Resilience - SMLD has identified 10kW as the critical load

TABLE VI
Days of Back-up Power for Critical Loads

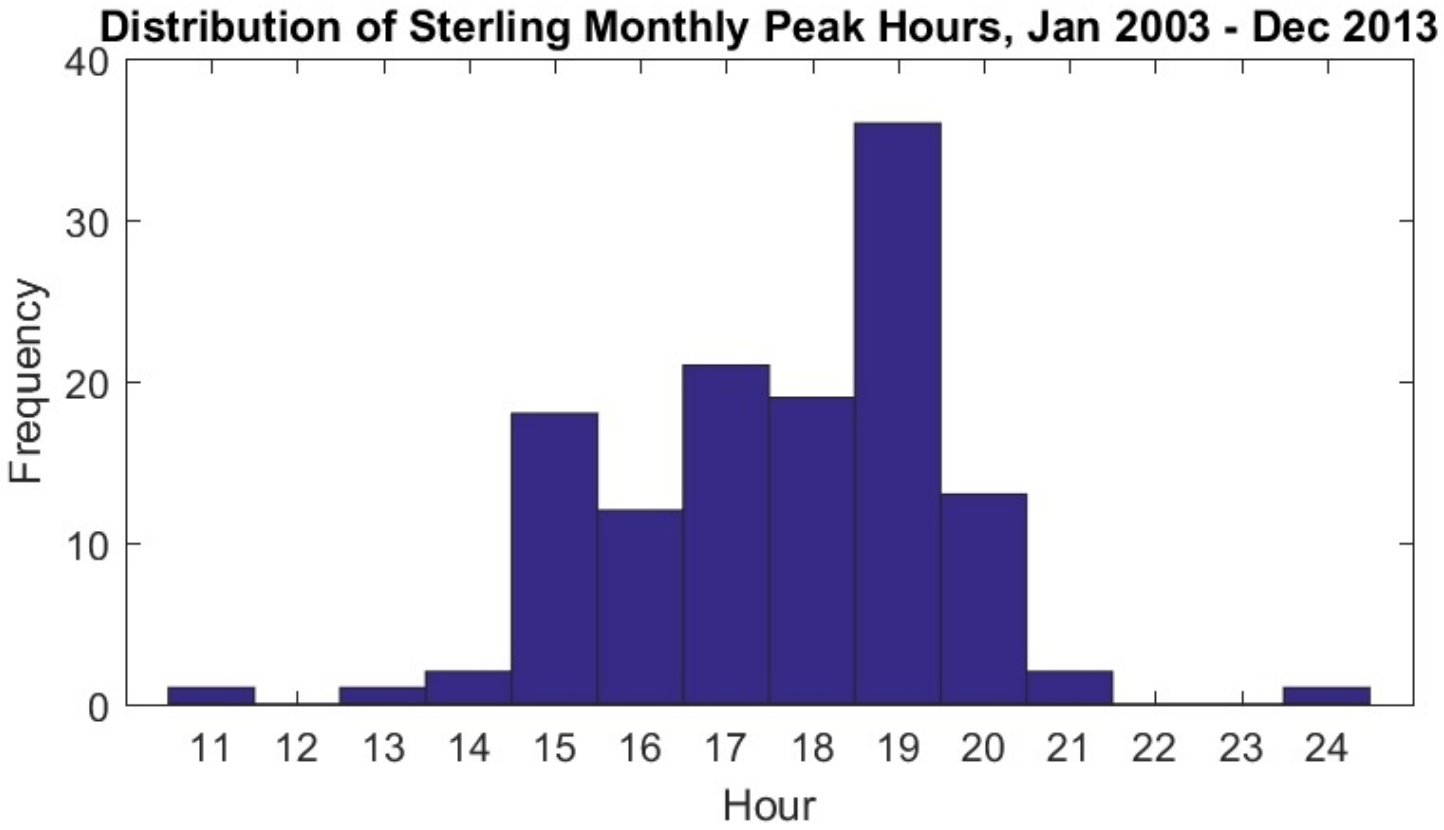
	1 MWh	2 MWh	3 MWh	4 MWh
Days	4.167	8.333	12.5	16.667

- Frequency Regulation



Impact of Capacity

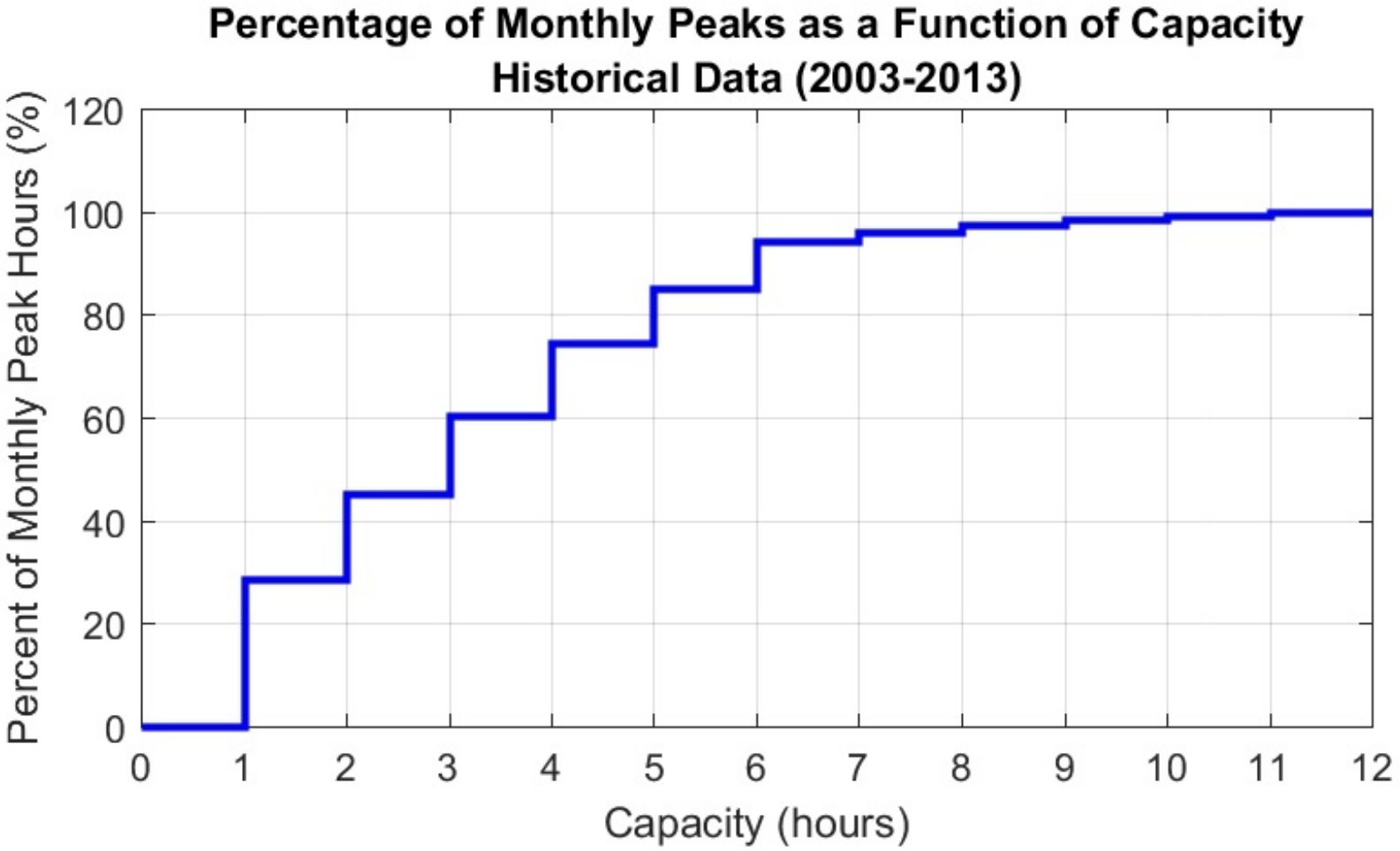
- Increased energy storage capacity increases the likelihood of hitting monthly/annual peaks



Hour	Percent Occurrence
11	0.79 %
12	0.00 %
13	0.79 %
14	1.59 %
15	14.29 %
16	9.52 %
17	16.67 %
18	15.08 %
19	28.57 %
20	10.32 %
21	1.59 %
24	0.79 %

Impact of Capacity

- Impact of capacity on hitting monthly peaks (based solely on historical data)

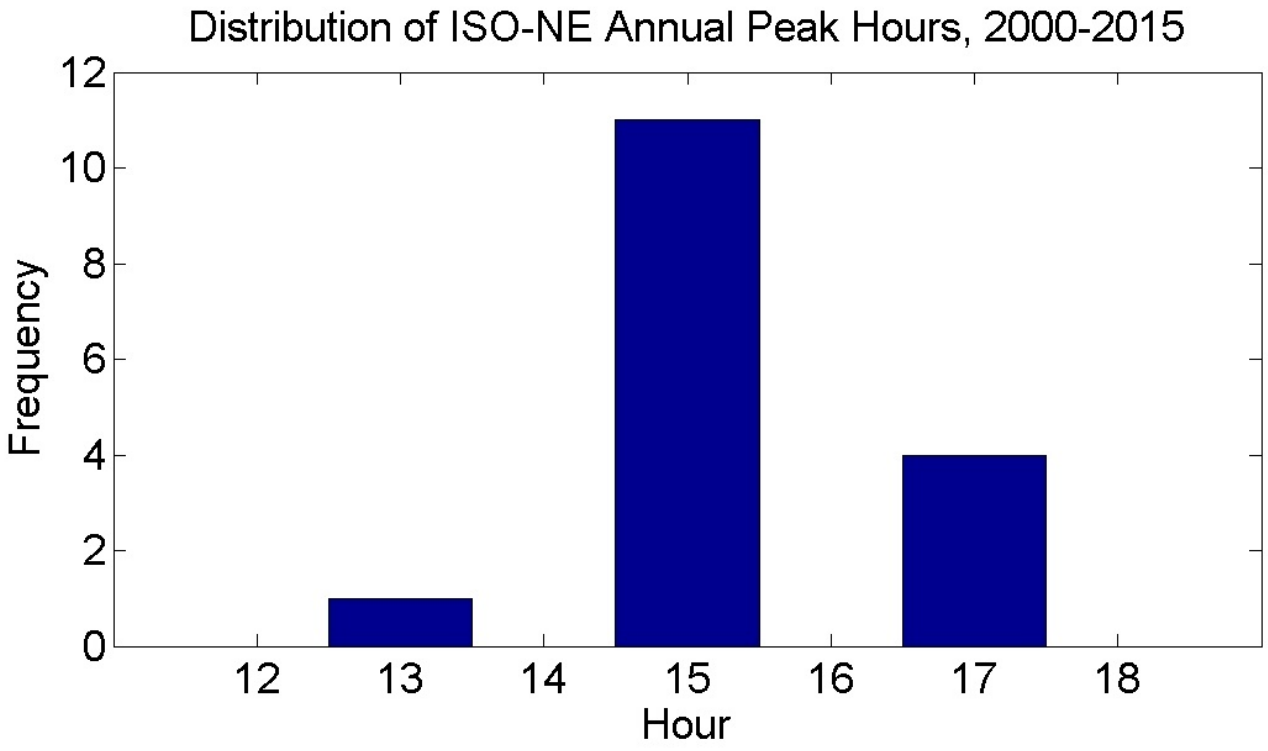


Impact of Capacity

- Distribution of annual peaks

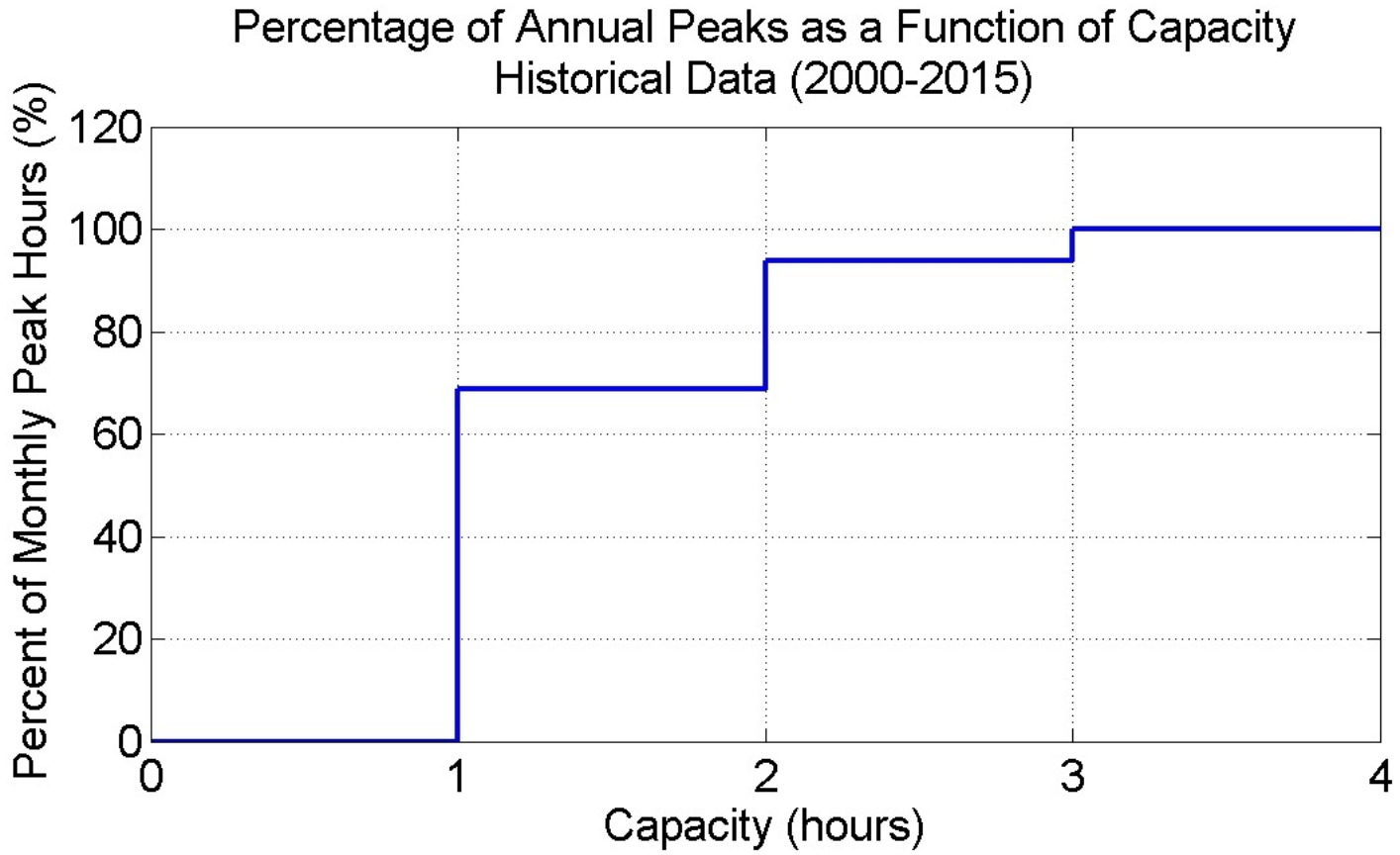
TABLE IX
Distribution of ISO-NE annual peak hours, 2000-2015.

Hour	Percent Occurrence
13	6.25%
15	68.75%
17	25.00%



Impact of Capacity

- Impact of capacity on hitting annual peaks (based solely on historical data)



Summary

- Arbitrage is more synergistic with other peak shaving applications
- Total potential revenue, 1MW, 1MWh system

Description	Total	Percent
Arbitrage	$40,738	16.0%
RNS payment	$98,707	38.7%
FCM obligation*	$115,572	45.3%
Total	$255,017	100%

- For a capital cost of ~1.7M, the simple payback is 6.67 years
- Investigating approaches to incorporate frequency regulation ($213,580 in 2015 potential revenue)

*2017-2018 data. Rates will likely be higher in the future, resulting in additional savings.

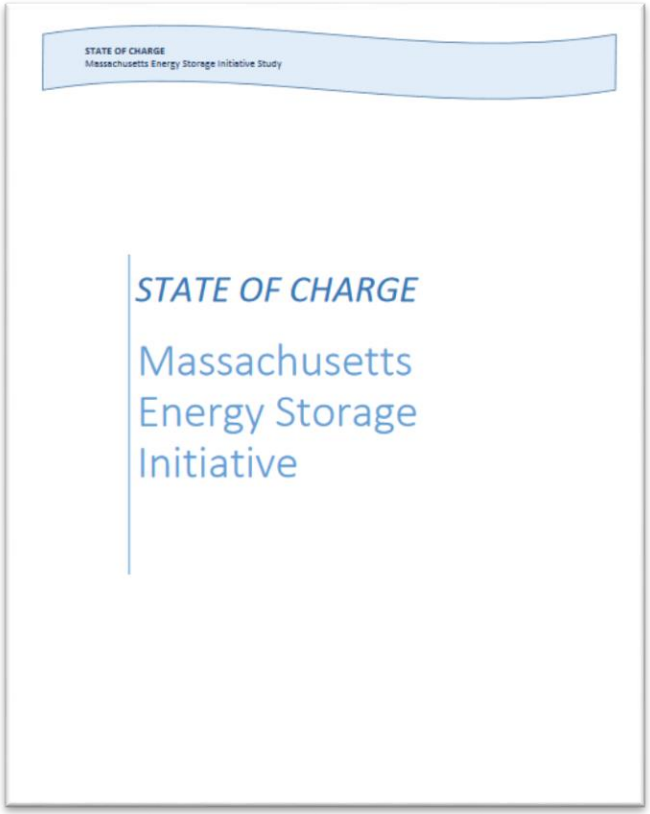
Upcoming Webinar

Energy Storage in Massachusetts: What the Study Said, and What's Next

Thursday, October 27, 3-4:30pm ET

Guest Speakers:

- Will Lauwers, Massachusetts Department of Energy Resources
- Kavita Ravi, Massachusetts Clean Energy Center
- Randell Johnson, Alevo Analytics
- Jacqueline DeRosa, Customized Energy Solutions
- Dr. Imre Gyuk, U.S. Department of Energy Office of Electricity Delivery and Energy Reliability
- Dan Borneo, Sandia National Laboratories



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