Energy Storage Technology Advancement Partnership (ESTAP) Webinar

Massachusetts' Municipal Utility Energy Storage Projects: Examples from Sterling, Templeton, and Wakefield

Hosted by
Todd Olinsky-Paul and Val Stori, CESA

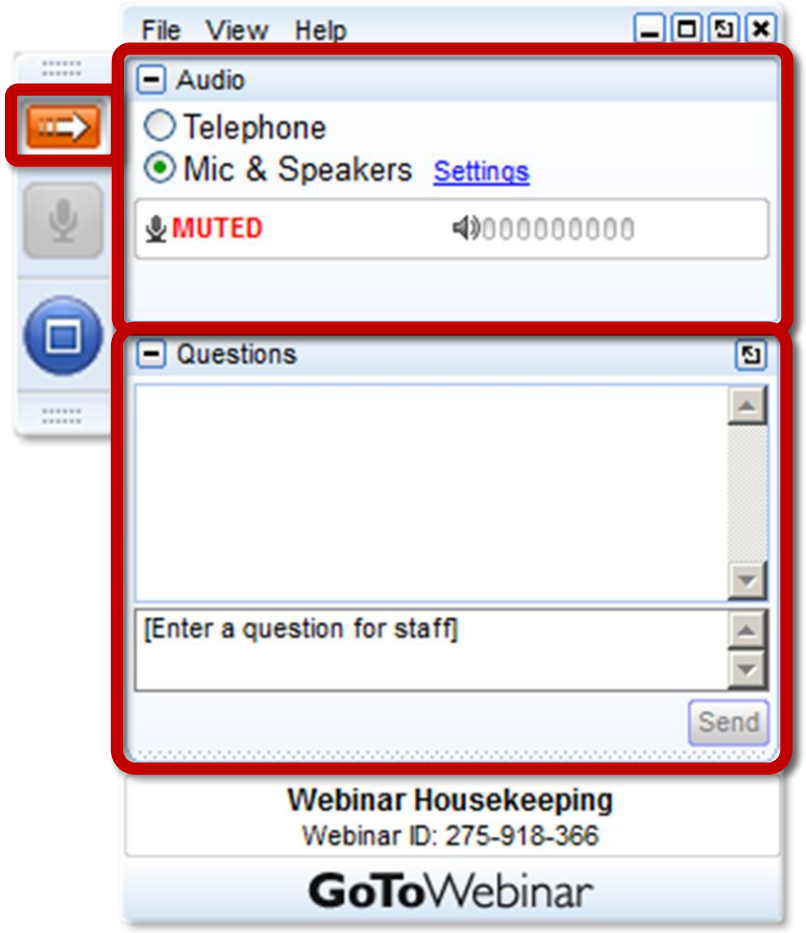
June 25, 2019

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

CleanEnergy States Alliance

Housekeeping



Join audio:

- Choose Mic & Speakers to use VoIP
- Choose Telephone and dial using the information provided

Use the orange arrow to open and close your control panel

Submit questions and comments via the Questions panel

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ALASKA ENERGY AUTHORITY

STATE OF CALIFORNIA ENERGY COMMISSION

DEPARTMENT OF ENERGY & ENVIRONMENT

EnergyTrust of Oregon

IOWA economic development

MASSACHUSETTS CLEAN ENERGY CENTER

IPA ILLINOIS POWER AGENCY

NEW MEXICO emnrd Energy, Minerals and Natural Resources Department

OEI Wisconsin Office of Energy Innovation

NEW YORK STATE OF OPPORTUNITY. NYSERDA

BPU New Jersey's cleanenergy njcleanenergy.com program™

CONNECTICUT GREEN BANK SM

New Hampshire PUBLIC UTILITIES COMMISSION

Maryland Energy Administration

STATE OF WASHINGTON Department of Commerce Innovation is in our nature.

MI Energy Michigan Agency for Energy Michigan Energy Office

STATE OF RHODE ISLAND OFFICE OF ENERGY RESOURCES

VERMONT CLEAN ENERGY DEVELOPMENT FUND PUBLIC SERVICE DEPARTMENT

SMUD™ Powering forward. Together.

COMMERCE DEPARTMENT

MassDEP

PRAIRIE ISLAND INDIAN COMMUNITY

DOER Massachusetts Department of Energy Resources

OREGON DEPARTMENT OF ENERGY

CONNECTICUT ENERGY ENVIRONMENT

Rhode Island Commerce CORPORATION

Illinois Department of Commerce & Economic Opportunity

Office of the People's Counsel District of Columbia Advocating, Protecting and Educating DC Consumers

Smart Electric Power Alliance

NREL NATIONAL RENEWABLE ENERGY LABORATORY

ACEP Alaska Center for Energy and Power

www.cesa.org

Energy Storage Technology Advancement Partnership (ESTAP) (bit.ly/ESTAP)

ESTAP is supported by the U.S. Department of Energy Office of Electricity and Sandia National Laboratories, and is managed by CESA.

ESTAP Key Activities:

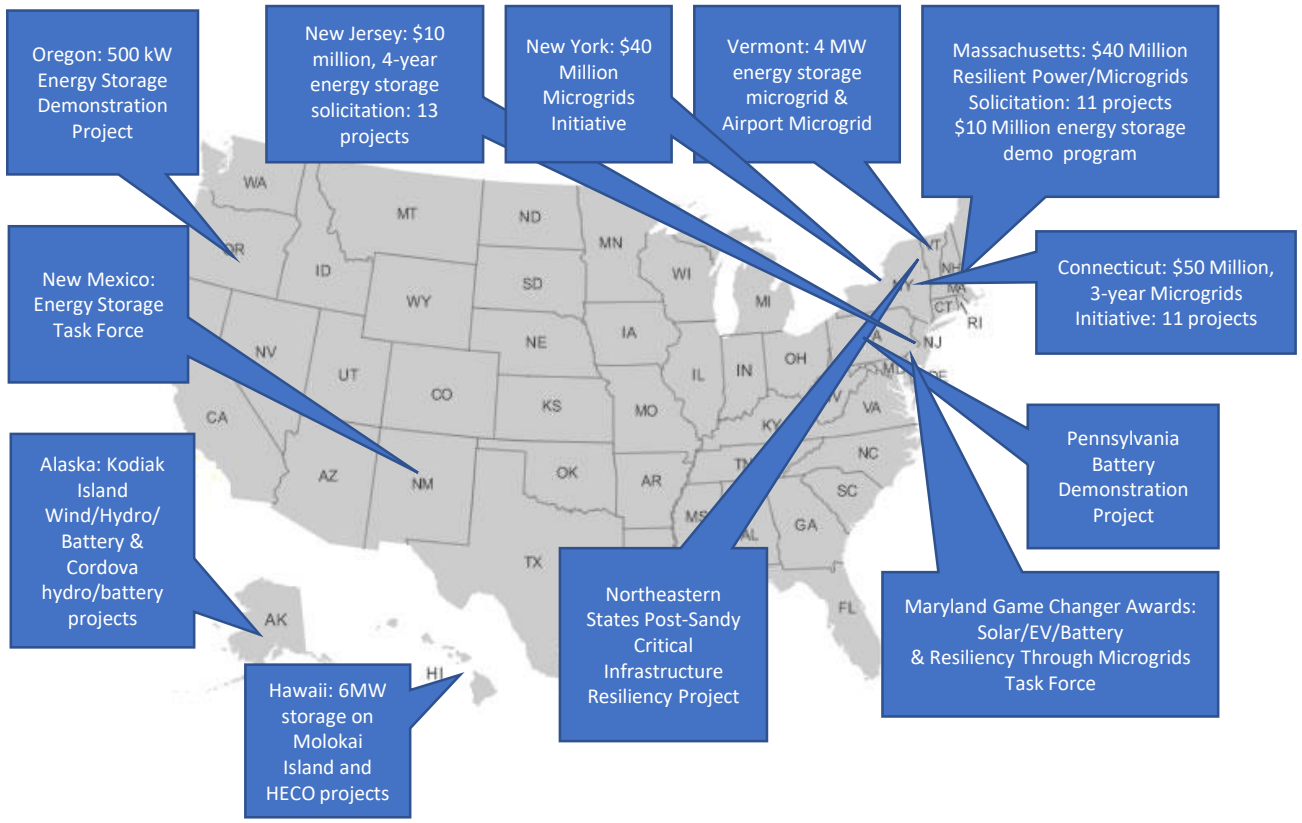
1. Disseminate information to stakeholders

   - ESTAP listserv >5,000 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:



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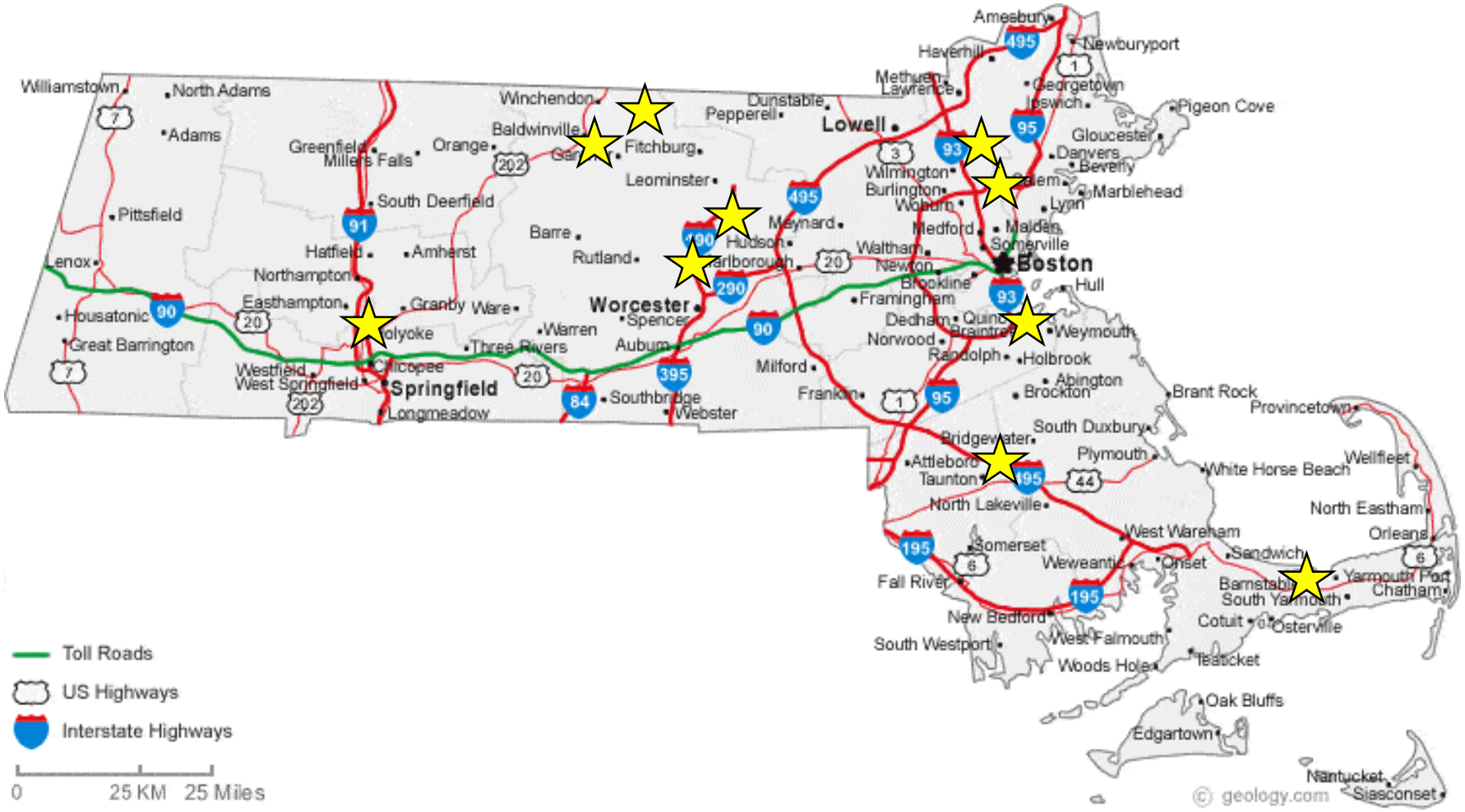
Sandia National Laboratories

CleanEnergy States Alliance

Massachusetts MLP storage projects



Sterling
Templeton
Wakefield
Ashburnham
Taunton
West Boylston
Braintree
Reading
Holyoke
Cape &
Vineyard
Electric Coop

Webinar Speakers

- **Dr. Imre Gyuk**, Director of Energy Storage Research, U.S. Department of Energy - Office of Electricity Delivery and Energy Reliability
- **Sean Hamilton**, General Manager, Sterling Municipal Light Department
- **Jason Viadero**, Power Generation Engineer, Massachusetts Municipal Wholesale Electric Company (MMWEC)
- **Dave Polson**, Engineering & Operations Manager, Wakefield Municipal Gas & Light Department
- **Todd Olinsky-Paul**, Project Director, Clean Energy States Alliance (moderator)
- **Val Stori**, Project Director, Clean Energy States Alliance (moderator)

U.S. DEPARTMENT OF ENERGY

Sterling Municipal Light Department

MMWEC MASSACHUSETTS MUNICIPAL WHOLESALE ELECTRIC COMPANY Public Energy Partners

WMGLD WAKEFIELD MUNICIPAL GAS AND LIGHT DEPARTMENT

CleanEnergy States Alliance

Massachusetts' Municipal Utility Energy Storage Projects: Examples from Sterling, Templeton, and Wakefield

ENERGY STORAGE TECHNOLOGY ADVANCEMENT PARTNERSHIP (ESTAP) WEBINAR
Made possible by U.S. DOE-OE and Sandia National Laboratories

Clean Energy States Alliance (CESA)

Sean Hamilton-General Manager
Sterling Municipal Light Department

"It is not the strongest of the species that survives, nor the most intelligent, but rather the one that is most adaptable to change."

—*Charles Darwin*

Sterling 2MW / 3.9 MWHR Battery Storage Project

Collaboration is Key!

Keep Members Of Your Staff, Board and Town Officials Informed

Seek Out Permitting Authorities Early, IE: Fire, Building

Don’t Be Too Rigid, Allow For Contingencies In The Budget

DOE, Sandia, DOER And Other MLPs Provide A Great Resource

Sterling Dedicates Massachusetts First Community 1 MW Solar + 1 MW/2 MWHR Battery Storage, April 14,2018

Sterling Municipal Light Department

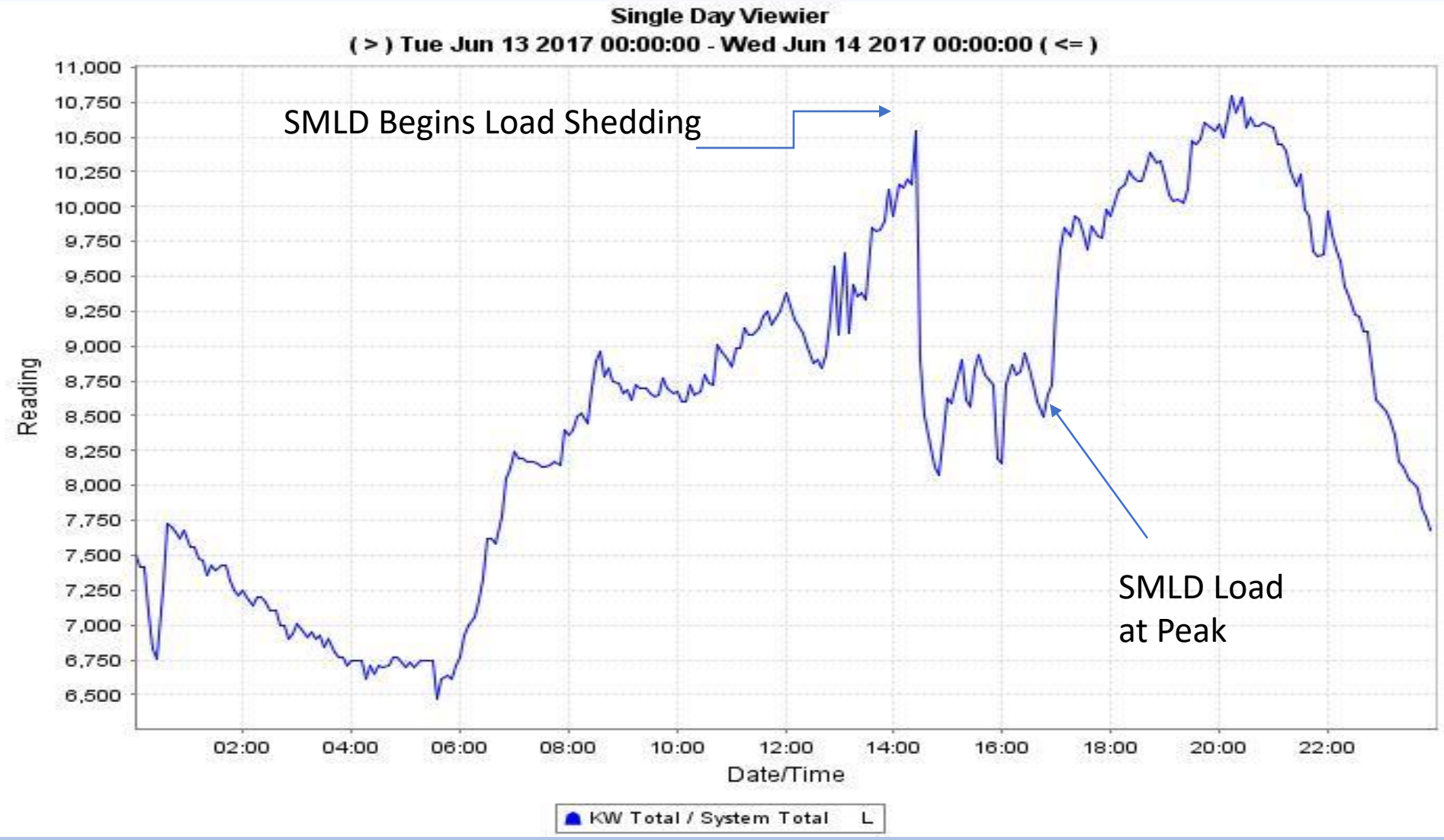
<u>New Project -April 2018</u>

1 MW Community Solar with

1 MW/2 MWHRs Battery Storage

- **Battery charging performed 100% with solar.**
- **Shift low cost solar to peak periods.**
- **Allows residents access to solar , otherwise unavailable.**
- **Peak Shaving Benefits shared with all ratepayers.**
- **Providing 400 Program Subscribers 25% of their Energy needs.**

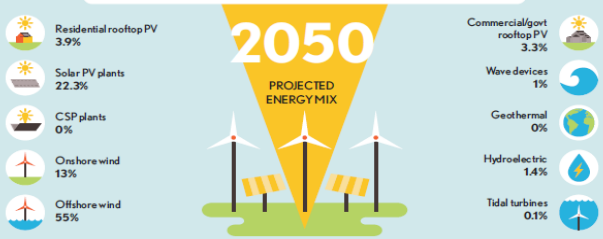
June 13,2017 – ISO-NE Peak Day



Drawbacks-Peak Unpredictable, Ex: Earlier in Year, Later in Day, Solar Output Reduced,

100% MASSACHUSETTS

Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

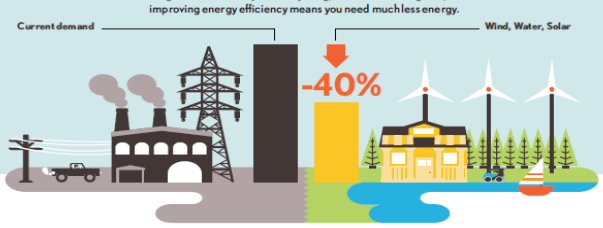


- Residential rooftop PV 3.9%
- Solar PV plants 22.3%
- CSP plants 0%
- Onshore wind 13%
- Offshore wind 55%
- Commercial/govt rooftop PV 3.3%
- Wave devices 1%
- Geothermal 0%
- Hydroelectric 1.4%
- Tidal turbines 0.1%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

Operation jobs: 37,950
Construction jobs: 53,490
=10,000

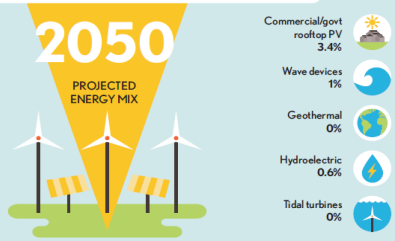
Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.



VISIT THESOLUTIONSPROJECT.ORG
TO LEARN MORE AND 100.ORG TO JOIN THE MOVEMENT

100% CONNECTICUT

Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

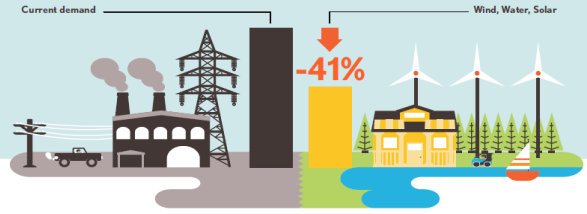


- Residential rooftop PV 4%
- Solar PV plants 41.1%
- CSP plants 0%
- Onshore wind 5%
- Offshore wind 45%
- Commercial/govt rooftop PV 3.4%
- Wave devices 1%
- Geothermal 0%
- Hydroelectric 0.6%
- Tidal turbines 0%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

Operation jobs: 21,662
Construction jobs: 40,487
=10,000

Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.



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100% NEW HAMPSHIRE

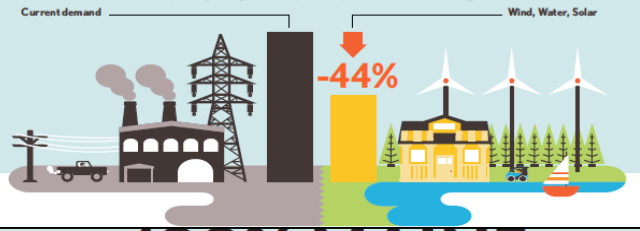
Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

- Residential rooftop PV 4.5%
- Solar PV plants 24.2%
- CSP plants 0%
- Onshore wind 40%
- Offshore wind 20%
- Commercial/govt rooftop PV 3.3%
- Wave devices 1%
- Geothermal 0%
- Hydroelectric 6.5%
- Tidal turbines 0.5%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

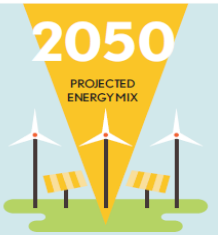
Operation jobs: 5,697
Construction jobs: 10,402
=10,000

Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.



100% RHODE ISLAND

Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

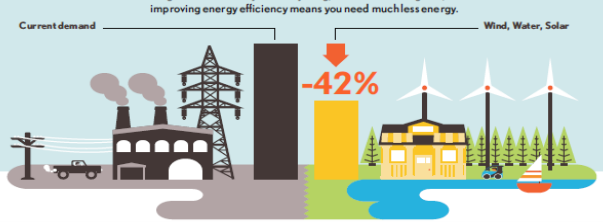


- Residential rooftop PV 4.4%
- Solar PV plants 17.8%
- CSP plants 0%
- Onshore wind 10%
- Offshore wind 63%
- Commercial/govt rooftop PV 3.7%
- Wave devices 1%
- Geothermal 0%
- Hydroelectric 0.1%
- Tidal turbines 0.1%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

Operation jobs: 5,775
Construction jobs: 7,473
=10,000

Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.



100% VERMONT

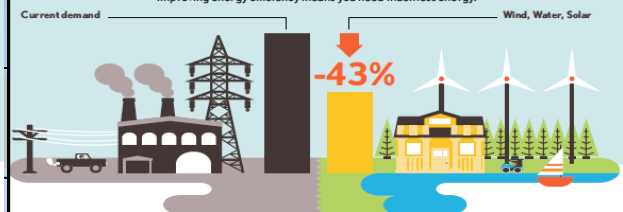
Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

- Residential rooftop PV 4.2%
- Solar PV plants 3.6%
- CSP plants 0%
- Onshore wind 25%
- Offshore wind 0%
- Commercial/govt rooftop PV 2.8%
- Wave devices 0%
- Geothermal 0%
- Hydroelectric 64.3%
- Tidal turbines 0%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

Operation jobs: 1,005
Construction jobs: 2,496
=10,000

Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.



100% MAINE

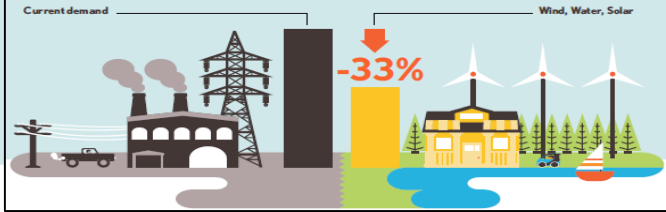
Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

- Residential rooftop PV 5.4%
- Solar PV plants 15%
- CSP plants 0%
- Onshore wind 35%
- Offshore wind 35%
- Commercial/govt rooftop PV 1.8%
- Wave devices 1%
- Geothermal 0%
- Hydroelectric 5.8%
- Tidal turbines 1%

40-Year Jobs Created
Number of jobs where a person is employed for 40 consecutive years

Operation jobs: 13,381
Construction jobs: 17,771
=10,000

Using WWS electricity for everything, instead of burning fuel, and improving energy efficiency means you need much less energy.

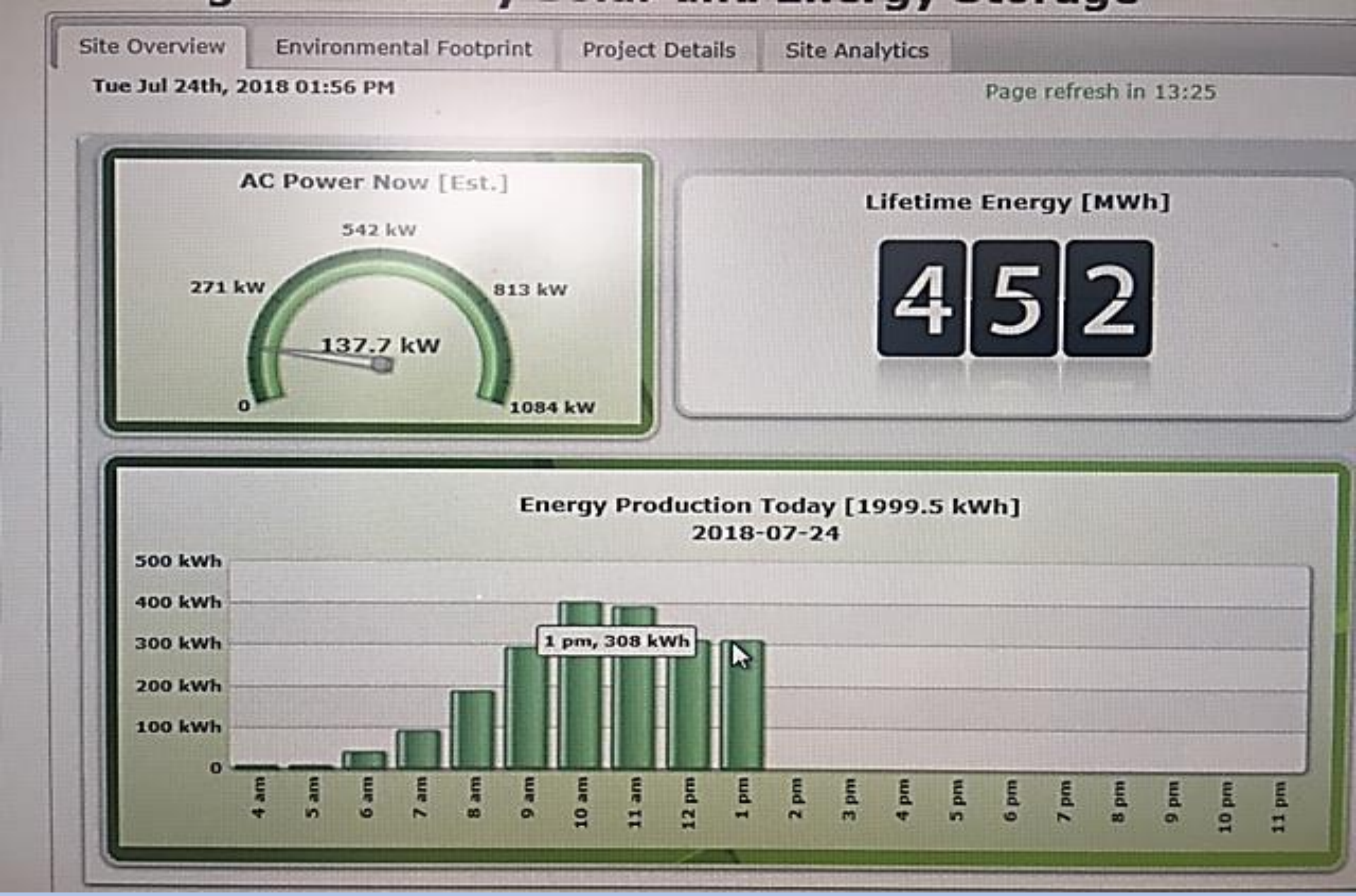


U.S. electricity generation by source, amount, and share of total in 2017[1]

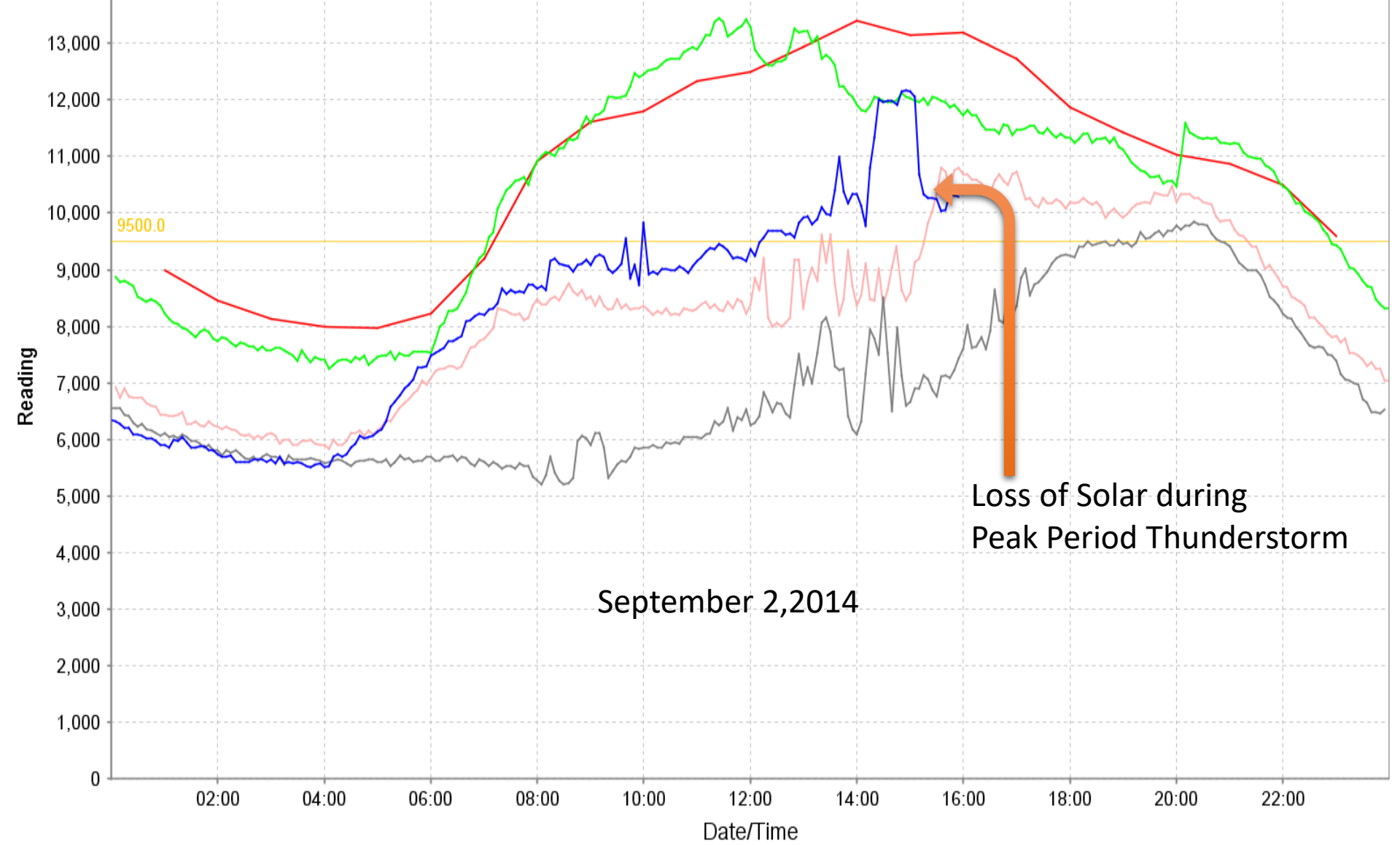
Energy source	Billion kWh	Share of total
Total - all sources	4,015	
Fossil fuels (total)	2,516	62.7%
Natural gas	1,273	31.7%
Coal	1,208	30.1%
Petroleum (total)	21	0.5%
Petroleum liquids	13	0.3%
Petroleum coke	9	0.2%
Other gases	14	0.4%
Renewables (total)	687	17.1%
Hydropower	300	7.5%
Wind	254	6.3%
Biomass (total)	64	1.6%
Wood	43	1.1%
Landfill gas	11	0.3%
Municipal solid waste (biogenic)	7	0.2%
Other biomass waste	3	0.1%
Solar (total)	53	1.3%
Photovoltaic	50	1.2%
Solar thermal	3	0.1%
Geothermal	16	0.4%
Pumped storage hydropower[3]	-6	-0.2%
Other sources	13	0.3%
		20.0%
Nuclear	805	

Renewable energy

any naturally occurring, theoretically inexhaustible source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear fuel.



July 24,2018 @ 2 pm , High Humidity with intervals of sunshine, solar at <15%,Natural Gas 64%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Reading
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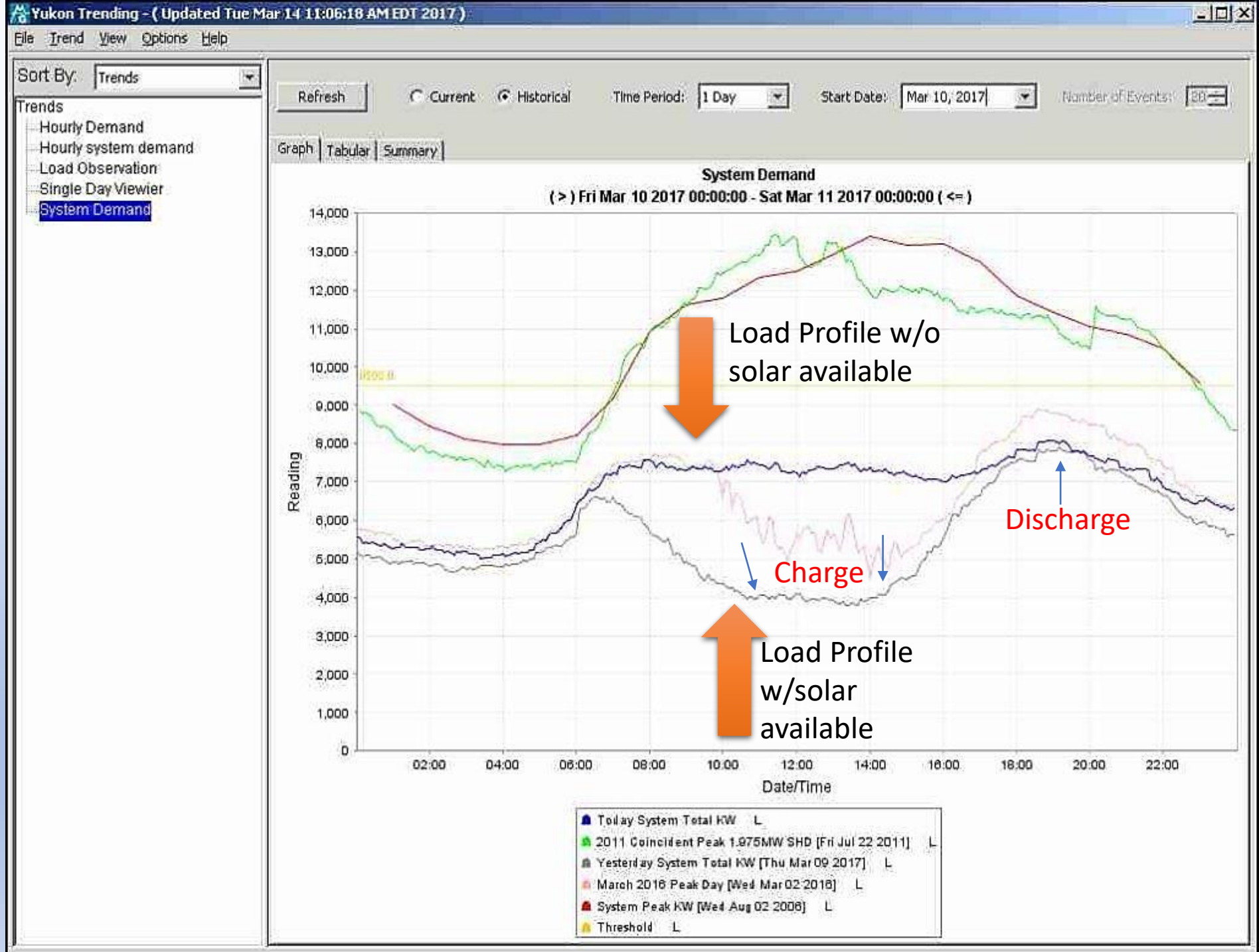
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Date/Time
Loss of Solar during
Peak Period Thunderstorm
September 2,2014
Today System Total KW L
2011 Coincident Peak 1.975MW SHD [Fri Jul 22 2011] L
Yesterday System Total KW [Mon Sep 01 2014] L
August 2013 Peak [Wed Aug 28 2013] L
System Peak KW [Wed Aug 02 2006] L
Threshold L

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

Note Hour 14 During Thunderstorm

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	530.0
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


Yukon Trending - (Updated Tue Mar 14 11:06:18 AM EDT 2017)
File Trend View Options Help
Sort By: Trends
Trends
Hourly Demand
Hourly system demand
Load Observation
Single Day Viewier
System Demand
Refresh
Current
Historical
Time Period: 1 Day
Start Date: Mar 10, 2017
Number of Events: 30
Graph Tabular Summary
System Demand
(>) Fri Mar 10 2017 00:00:00 - Sat Mar 11 2017 00:00:00 (<=)
Reading
14,000
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12,000
11,000
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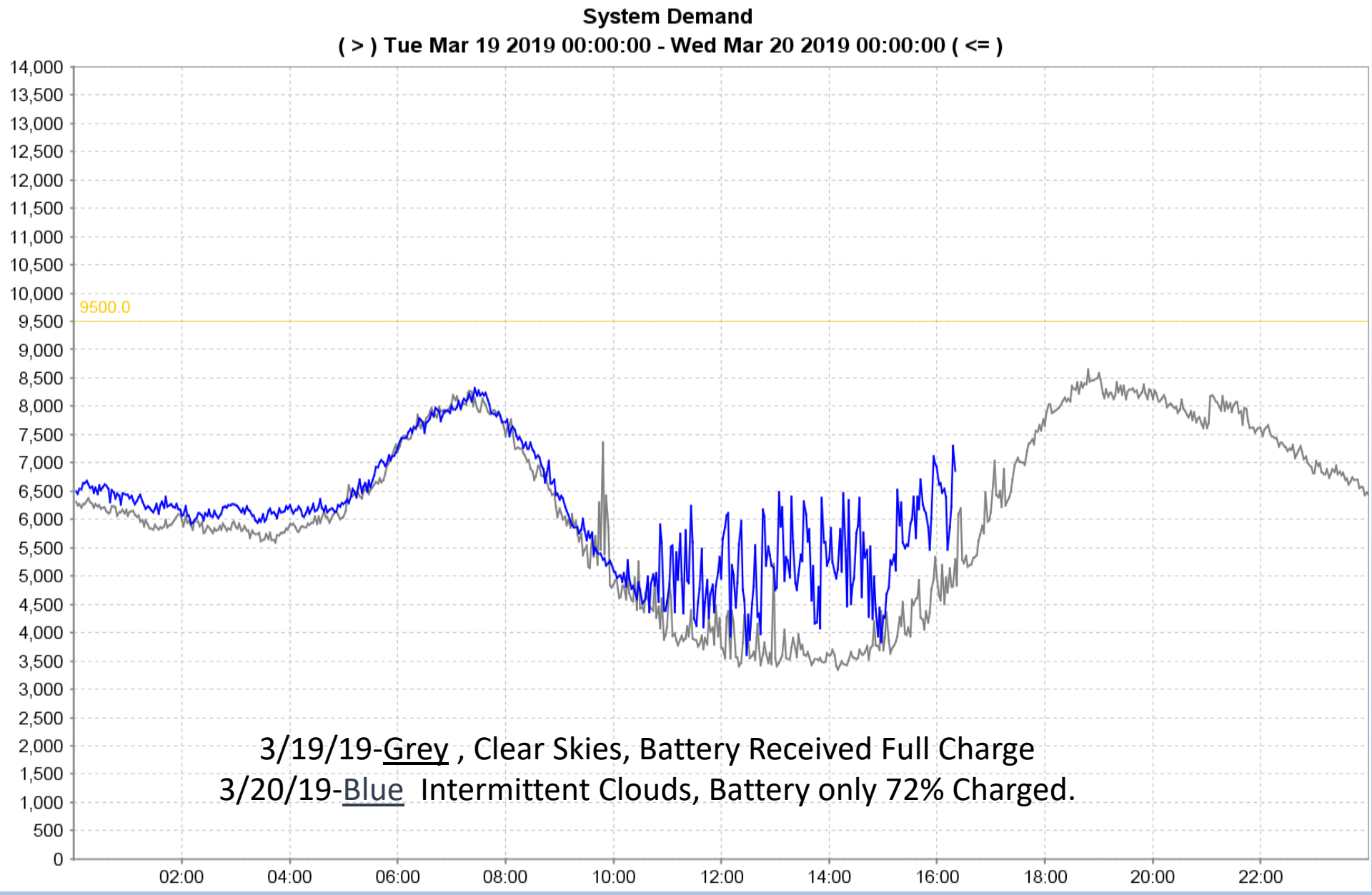
16:00
18:00
20:00
22:00
Date/Time
Load Profile w/o solar available
Discharge
Charge
Load Profile w/solar available
Today System Total KW L
2011 Coincident Peak 1.975MW SHD [Fri Jul 22 2011] L
Yesterday System Total KW [Thu Mar 09 2017] L
March 2016 Peak Day [Wed Mar 02 2016] L
System Peak KW [Wed Aug 02 2006] L
Threshold L


System Demand
(>) Tue Mar 19 2019 00:00:00 - Wed Mar 20 2019 00:00:00 (<=)
14,000
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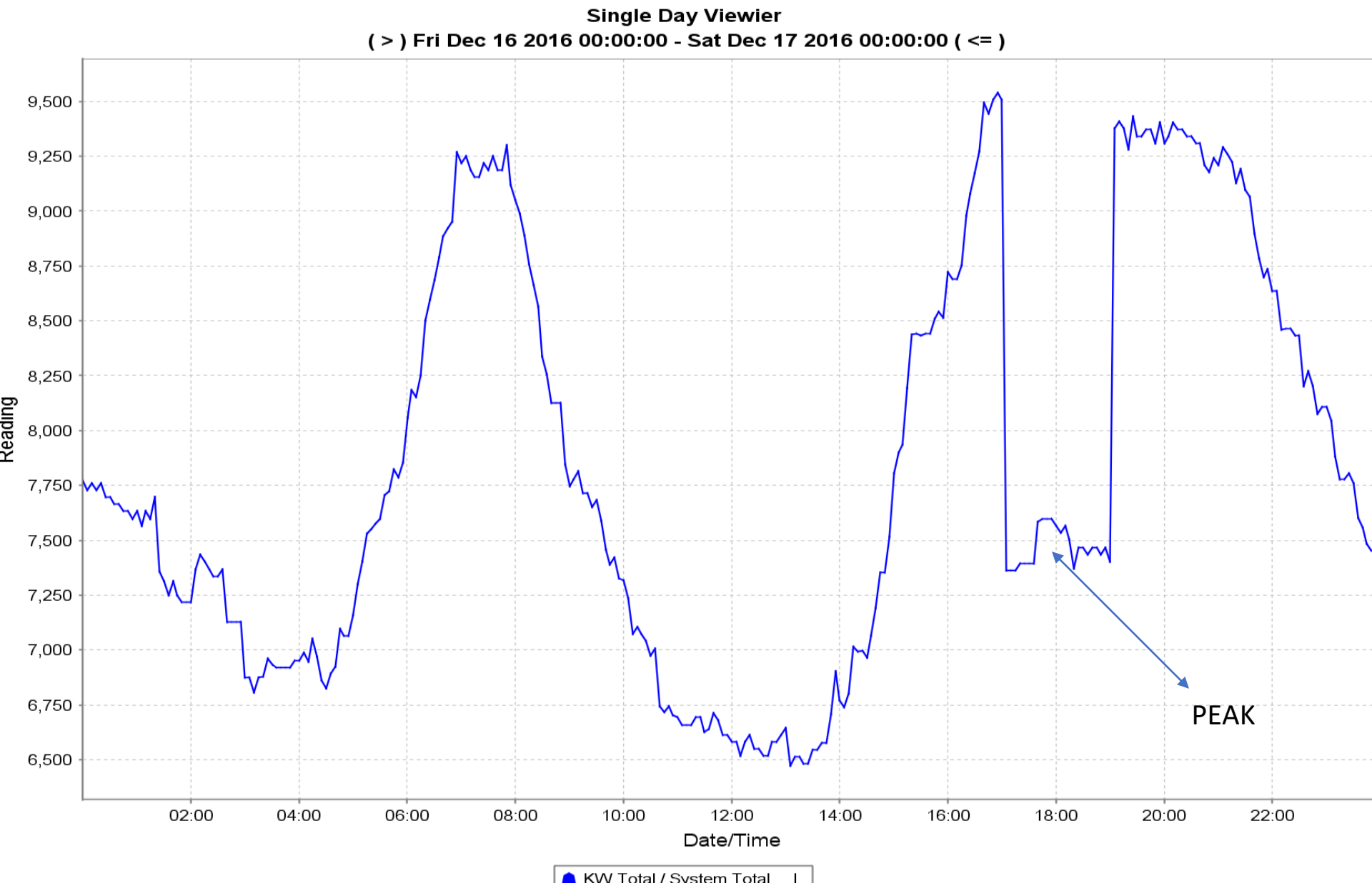
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
3/19/19-Grey , Clear Skies, Battery Received Full Charge
3/20/19-Blue Intermittent Clouds, Battery only 72% Charged.


Ice Storm 2008

Resiliency Benefits
2mw/3.9mwhr -Battery Energy Storage
1 mw/2 mwhr Community Battery Storage

1. BESSs provides Power up to 25 Days to critical facility(CF)
2. BESS Located in Main Substation and across from CF.
3. Substation 2,300’ from Critical Facility.
4. Separate Circuit for BESS and CF.
5. MicroGrid Capable with Solar across the street.
6. Live Test Performed April 27,2017

Began Construction 10-12-2016
Reduces RNS Peak on 12-16-2016



BARRON'S
THE DOW JONES BUSINESS AND FINANCIAL WEEKLY www.barrons.com JUNE 11, 2018

COVER STORY

Dramatic advances in storage technology and declining costs for wind and solar energy are upending the electricity business.

How Batteries Will Transform The Power Business

By Jack Hough

STERLING, MASS.–Until recently, this tidy, quiet town in central Massachusetts was best known to outsiders for its eight-acre corn maze out by Davis Farmland, and for a little statue near the corner of Main and Park immortalizing the lamb that is said to have followed young Mary Sawyer to school one day in 1812, inspiring a well-known poem. Lately, however, Sterling welcomes visitors from far away who don't come for outdoor fun or nursery rhymes.

"As soon as it came on-line, they started rolling in–Japan, Switzerland, Sweden, Brazil, Colombia–13 different countries so far," says Darren Borge, operations supervisor at the town's light department. The visitors come to peek inside a single shipping container placed in late 2016 at the power substation on Chocksett Road. There, twin rows of what look like post office boxes pack lithium-ion batteries that together can hold two megawatts of power. That's enough to make Sterling, population 8,000, the country's per capita energy-storage leader–and a glimpse of the future of the electricity business.

High-power batteries have already infiltrated the chain-saw aisle at Home Depot and are poised to disrupt the car industry in the decades ahead. Now, they are quickly multiplying across the U.S. power grid. In Sterling, those two megawatts are enough to provide savings and resiliency–to smooth out power demand and avoid peak charges, and in the event of an outage, run the nearby police department and fire dispatch for more than a week.

Photo supplied by NEC

2MW energy storage system built by NEC for Sterling Municipal Light Department in Sterling, Massachusetts.

Last year, the nation installed half a gigawatt of energy storage–equal to 250 Sterlings. Over the next eight years, the country will add more than 35 gigawatts of storage, or 17,500 Sterlings, predicts the Energy Storage Association, a Washington, D.C., industry group. That's enough to save $4 billion in yearly operating costs. Stephen Byrd, a utility analyst for Morgan Stanley, calls that storage forecast credible. He reckons the U.S. storage market will eventually be worth at least $20 billion, and $35 billion under more bullish assumptions.

That's excellent news for many stakeholders. Consumers stand to save on power and see fewer disruptions. Towns can cut

(over please)

Wallstreet is Watching

Value of all SMLD Battery Storage
$1,061,549* as of 06/01/2019

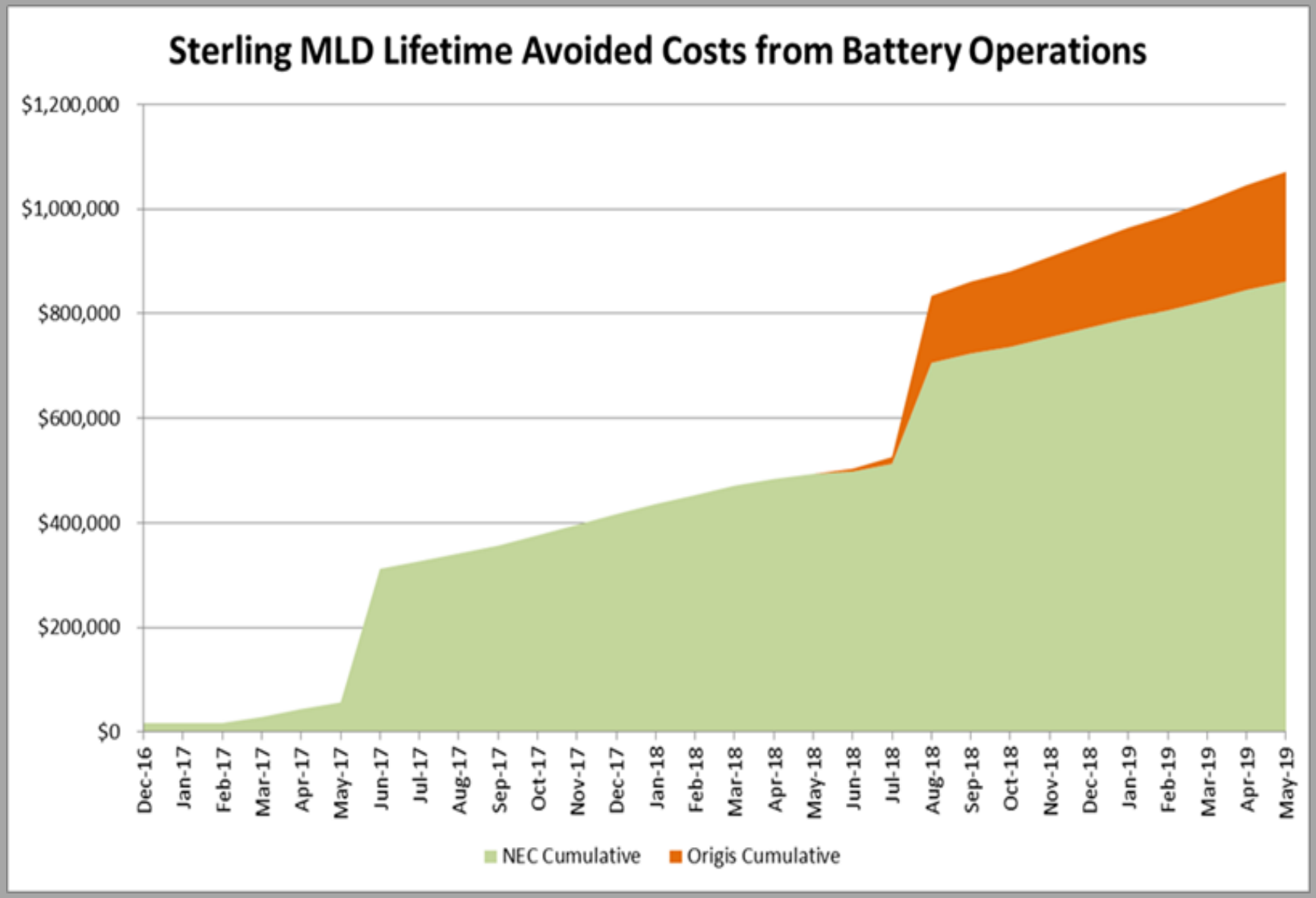
- **Grid Resiliency-Police and Dispatch Center**
- **Smoothing Intermittent Resources**
- **Regional Network Service (RNS) -Monthly Peak**
  - **Captured 28/30 monthly peaks – Charge/Discharge 134 Times**
- **Capacity Load Obligation Payments -Annual Peak**
  - **Captured Annual Peak (06/23/2017) for a value of $255,278**
  - **Captured Annual Peak (8/29/2018) for a value of $308,026**
- **Energy Arbitrage**
- **Frequency Regulation-Not Participating in this Market**

- Source: The Value proposition for Energy Storage for Sterling Municipal Light Department
- Author Dr. Raymond Byrne, Sandia National Laboratories
- * Combined battery Projects

Costs To Install*

>Engineering	$116,212.03
>Feasibility Study	$7,000.00
>BESS (with Inverter)	$2,034,075.00
>Other Equipment	$154,129.61
>Labor Incl- Line Crew	$76,390.25
>Legal	$62,725.06
>Testing/Commissioning	$11,293.95
>Admin, Ops Supv ,GM, Acct.	$80,893.14
Total Cost	$2,542,719.04

* Does not include Optional Substation Communication or Relay Panel upgrades


Sterling MLD Lifetime Avoided Costs from Battery Operations
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
Dec-16
Jan-17
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
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Aug-18
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Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
NEC Cumulative
Origis Cumulative

Visitors to the **Sterling Community Clean Energy Resiliency Initiative Battery Storage Project** include**:**

Representatives from the following 17 countries:

Japan, Denmark, Germany, Sweden, Canada, Finland, Russia, Argentina, England, Taiwan, Switzerland, Brazil, Malaysia, Chile, Ireland, Australia and Thailand (July 2019)

Visitors also include representatives From:

Department of Energy (DOE)
Washington DC- General Accounting Office (GAO)
Alaska-Utility representatives
Puerto Rico
Duke Energy
Clean Energy States Alliance (CESA)
Smart Energy Power Alliance (SEPA)
Massachusetts Municipal Wholesale Electric Company (MMWEC)
Energy New England (ENE)
Massachusetts Citizens Action Network (MCAN)
Northeast Public Power Association (NEPPA)

Other representatives From Utilities:

Municipal Light Departments- (26 total), New Hampshire Electric Coop
National Grid, Unitil, Eversource, United Illuminating, Con Edison

Sterling Video Produced by
Clean Energy States Alliance (CESA) and the
Barr Foundation

Video has been shown around the world

Education Tool for Legislators on Batteries

https://youtu.be/w3It2lwLCm4

https://vimeo.com/217842952/a63a69cd1e

SMLD Battery Projects Now = 810 Watts per Customer

Special Thanks to:

- SMLD Commissioners/Staff/Operations Crew - For their support of this project
- Town of Sterling - For their continued support
- Judith Judson – MA DOER Commissioner-Grant Funding
- Dr. Imre Gyuk - U.S. Dept of Energy, Energy Storage Program Director
- Sandia National Laboratories - Daniel Borneo PE., Dr. Raymond Byrne-Technical
- Todd Olinsky-Paul - Director of CEG and CESA.
- MMWEC - Market Observation, Peak Forecasting and Operations
- Scott Reynolds, OPM and Mike Barrett, PLM, Design Engineering
- Jared Carpenter, Jim Frawley-Grant Technical Information
- Arlen Orchard and SMUD Engineers-Project Technical Information

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

Too Much Solar, Blessing and a Curse.

Templeton Energy Storage Project

Speaker Bio

- Jason Viadero
- Chief of Emerging Technologies at MMWEC
- 3 years in power and distributed generation for MMWEC
- 7 years prior in water infrastructure design & construction
- Leader of MMWEC's emerging technologies Team
- Assisted in development of 4 ES project since 2018

Templeton Municipal Light & Water Department

- **Location**: 30 minutes north of Worcester, near NH state line
- **Customers Served**: 3,851
- **Customer Mix**: residential with few larger C&I
- **Peak System Load**: 11MW
- **Gird interconnect:** 69KV single point of interconnect to Otter River substation

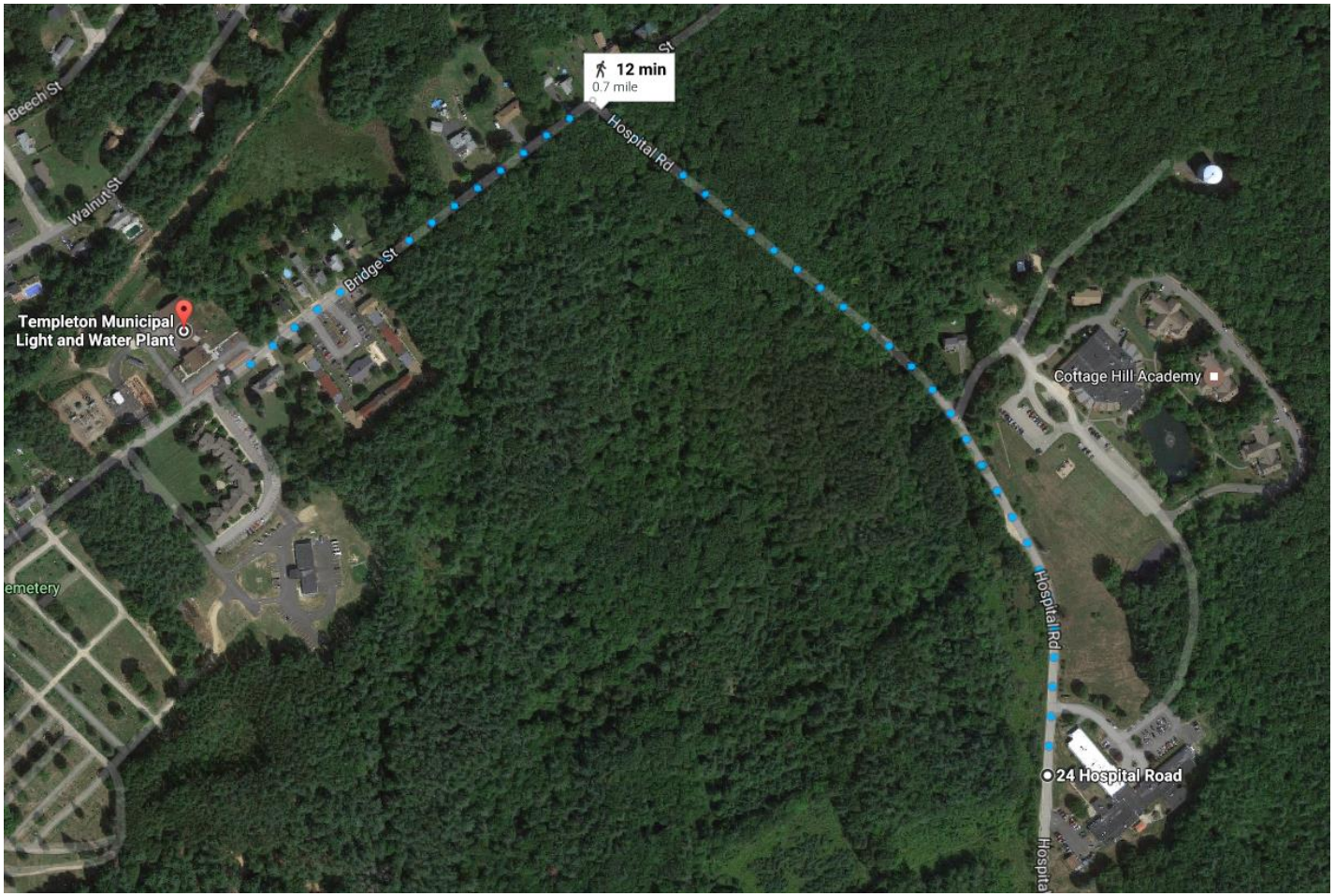
The Project

- **Owner**: Templeton Municipal Light & Water Department
- **Location**: 86 Bridge Street, Baldwinville MA
- **Uses**: Transmission/ICAP reduction. Resilient Microgrid
- **Equipment**: 1.6MW/3.2MWH Lithium Ion battery
- **Installation Cost**: $1.60 million (Against $1.772 Budget)
- **Payback**: 5.3 Years
- **Lifespan**: Warranty 10 years, Projected 15 year life
- **Financing**: $900K through MMWEC Pooled Loan, rest from TMLWP

History

- Initial project idea developed in 2016/early 2017.
- Planed for ICAP/Transmission reduction (future microgrid of 1303 circuit)
- Applied for CCERI Funding 2017 (not awarded)
- Applied for ACES Funding 2017 (not awarded)
- Made decision to construct without funding summer 2018

1303 Circuit (Future Microgrid)



Why This Project Made Sense

- Since Inception, Lithium Ion Battery Cell prices continue to decline.
- Sterling: $1.73 million grant (2016), Wakefield: $800K grant(2018), Templeton $0 grant (2019).
- Installed cost of less than $500/KWH (25% less than Sterling installed cost)

Performance Since Commissioning

- Commissioning Complete May 2019
- 2 Operations in May 2019
- 1.514MW avoided transmission load
- $14,133 transmission savings June 2019
- Projected year 1 savings: $140K ICAP, $150K-$170K Transmission.

Project Photos Before & After

Project Photos

Lessons Learned

- **Leverage Economies of Scale**: System uses same building blocks as AMLP/WMGLD
- **Site Selection Key**: consider ease of interconnection, ease of access & other variables (Site 28’x75’ total area)
- **Joint Action Key to Operational Success**: TMLP battery 1 of 5 batteries controlled by MMWEC (More than 30MW of storage and BTM generation)

Outlook for Future

- Cell Price of Lithium Ion Storage Prices continue to decline
- RNS transmission costs continue to rise for next 5-7 years in New England
- New incentives like Clean Peak provide continued incentive to install peak reducing Energy Storage (even though stand alone economic)
- Consider expansion in 3-5 years.

WMGLD's Energy Storage Project

David Polson
DPolson@WMGLD.com
Date: 6/25/2019 rev 3

Agenda

1. Project Team
2. Overview
3. Project Details
4. Financing, Agreements and Operations
5. Project Justification
6. Project Schedule
7. Physical Layout
8. Construction
9. Equipment
10. Lessons Learned
11. Year-to-date Savings

Project Team

Core Project Team:

- Wakefield Municipal Gas & Light Department, (WMGLD)
- Massachusetts Municipal Wholesale Electric Company (MMWEC)
- NEC Energy Storage Solutions (NEC) the Massachusetts based integrator of Grid Scale Storage (GSS) solutions utilizing lithium ion technology
- Special thanks to MA DOER / Mass CEC for financial support via the ACES energy storage grant program

Project Support:

- PLM Engineering - Hopkinton, MA
- Power Line Contractors – Wilmington, MA
- Hayes Engineering – Wakefield, MA

Overview

This project presented a clear and innovative path forward to meet many of the core goals of WMGLD as well as providing benefits to the Commonwealth.

- Utilizing a proven storage technology, lithium ion
- Experienced local integration partnership between NEC, WMGLD and MMWEC the project was completed on-time and on-budget
- We were immediately able to realize significant financial benefits for the ratepayers of Wakefield that will be realized for the next 10+ years.
- This energy storage system supports leveling out peak loads on the WMGLD distribution system
- Manage cost for capacity and transmission services to the ratepayers of Wakefield
- Able to respond to high real time pricing
- Reduction in NEMA system load during peak hours helping to drive down congestion.
- Reduction in system peak demand and reduction in required capacity and reserves for the NEMA load zone.
- Manage cost of energy to the ratepayers of Wakefield (shifting inexpensive power generated mid-day and overnight to use on peak)
- Reduce dependence on higher carbon emitting, less efficient peaking generation for evening hours.

Project Details

- Construction of a 3MW/5MWh system with an actual output of 2.4MW/4.8MWh behind the meter storage system interconnect through WMGLD's Beebe Substation located in Wakefield MA
  - Started in September 2018
  - Completed January 31, 2019
  - Project Installed cost was $3.2M less $680k from Mass CEC for a total installed cost of $2.52M
- This storage system was interconnected to provide support for WMGLD's distribution system and peak load reduction for our system
- The location of Wakefield and the Beebe Substation is in the NEMA region and along a 115KV transmission corridor making this an ideal location to deploy storage technology in an area currently facing major congestion and transmission constraints

<u>Summary:</u>

- This project supports managing electric rates for citizens of Wakefield
- Reducing congestion in an area with major transmission constraints
- Lowering emissions for the energy generation sector to meet the mandates of the Global Warming Solutions Act.

Financing, Agreements and Operations

Through an innovative partnership WMGLD was able to secure financing and implement operations and maintenance agreements with MMWEC

Financing:

- WMGLD has a 15 year equipment only lease agreement
- After 15 years ownership transitions to WMGLD

Agreements:

- Interconnection agreement
- Operations, dispatch, maintenance and service agreement
- License agreement

Operations:

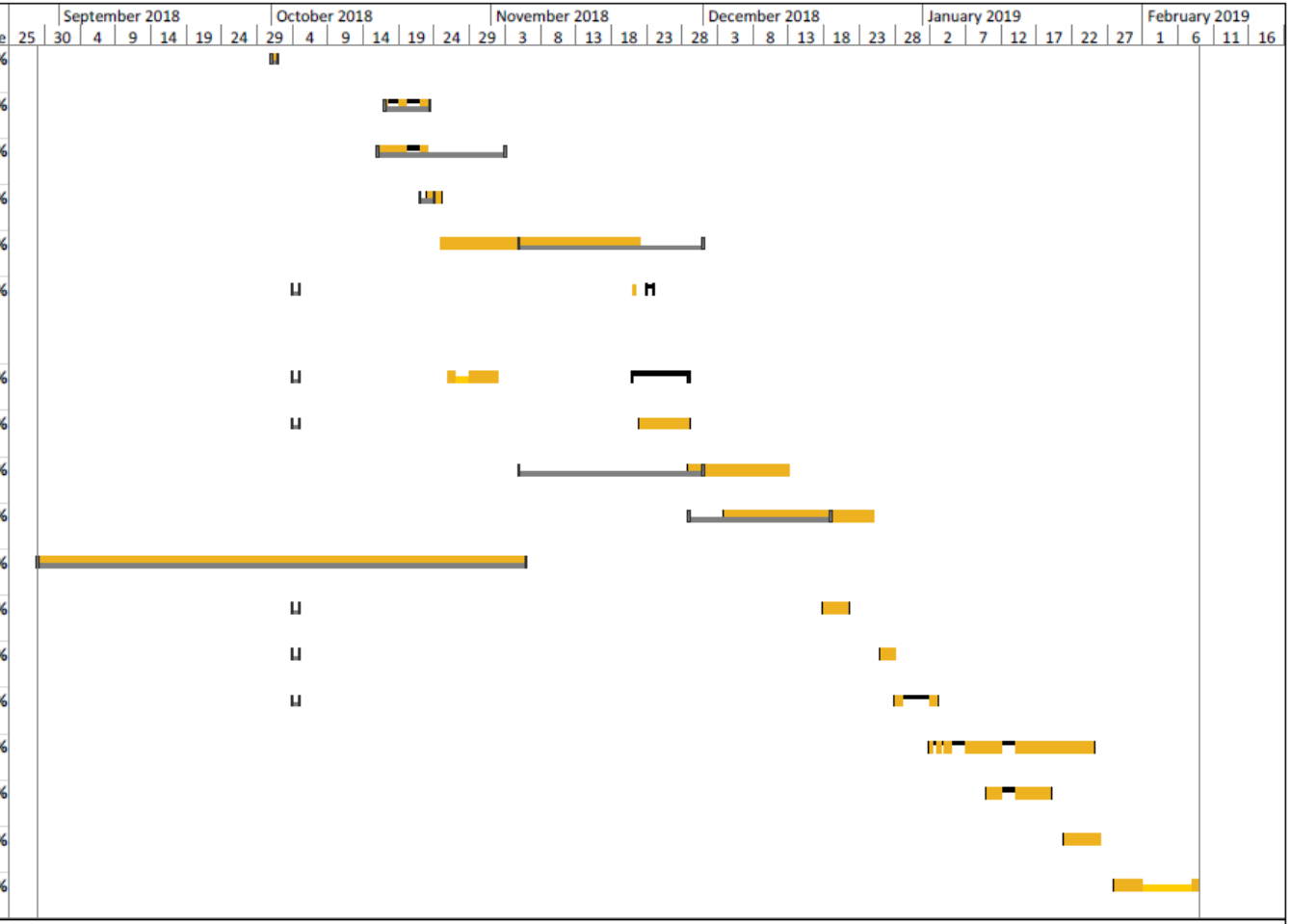
- The operations agreement MMWEC maintains SOC, charges to full capacity as needed and discharges the system as needed

Project Justification

- This project was first evaluated based on a 15 year life cycle with simple payback of 11 years
- Project was not justifiable based on the 15 life cycle of the batteries and the payback
- Grant funding had a significant impact along with longer projected battery performance
  - Simple payback was reduced to 8 years with grant funding
  - Battery performance is guaranteed for 10 year with a projected life cycle of 20 years with proper battery management
- Provides a direct and measurable financial impact for WMGLD
- This technology provides a positive environmental impact

Project Schedule

ID	Task Name	Duration	Start	Finish	% Complete
1	**Admin**	1 day	Mon 10/1/18	Mon 10/1/18	100%
3	**Submittals**	4.25 days	Wed 10/17/18	Tue 10/23/18	100%
34	**Site Preperation**	5 days	Tue 10/16/18	Mon 10/22/18	100%
38	**Demo existing foundation**	2 days	Tue 10/23/18	Wed 10/24/18	100%
40	**Foundations**	20 days	Thu 10/25/18	Wed 11/21/18	100%
45	**Foundation / Equip Connections**	1 day	Fri 11/23/18	Fri 11/23/18	100%
48	**Pre-Cast Stuctuers**	6 days	Wed 11/21/18	Wed 11/28/18	100%
54	**Grounding**	5 days	Thu 11/22/18	Wed 11/28/18	100%
58	**Ductbank & Conduit Installa**	10 days	Thu 11/29/18	Wed 12/12/18	100%
71	**Cable Installation**	15 days	Tue 12/4/18	Mon 12/24/18	100%
102	**Transformers**	49 days	Wed 8/29/18	Mon 11/5/18	100%
105	**Cubicle # 10 Spare work**	3.5 days	Tue 12/18/18	Fri 12/21/18	100%
111	**SCADA Integration**	2 days	Wed 12/26/18	Thu 12/27/18	100%
114	**Testing & Commissioning**	4 days	Fri 12/28/18	Wed 1/2/19	100%
117	**Mechanical**	17 days	Wed 1/2/19	Thu 1/24/19	100%
137	**Cold Commissioning**	7 days	Thu 1/10/19	Fri 1/18/19	100%
143	**Hot Commissioning**	5 days	Mon 1/21/19	Fri 1/25/19	100%
148	**Punch List & Project Closeou**	1 day	Mon 1/28/19	Mon 1/28/19	100%

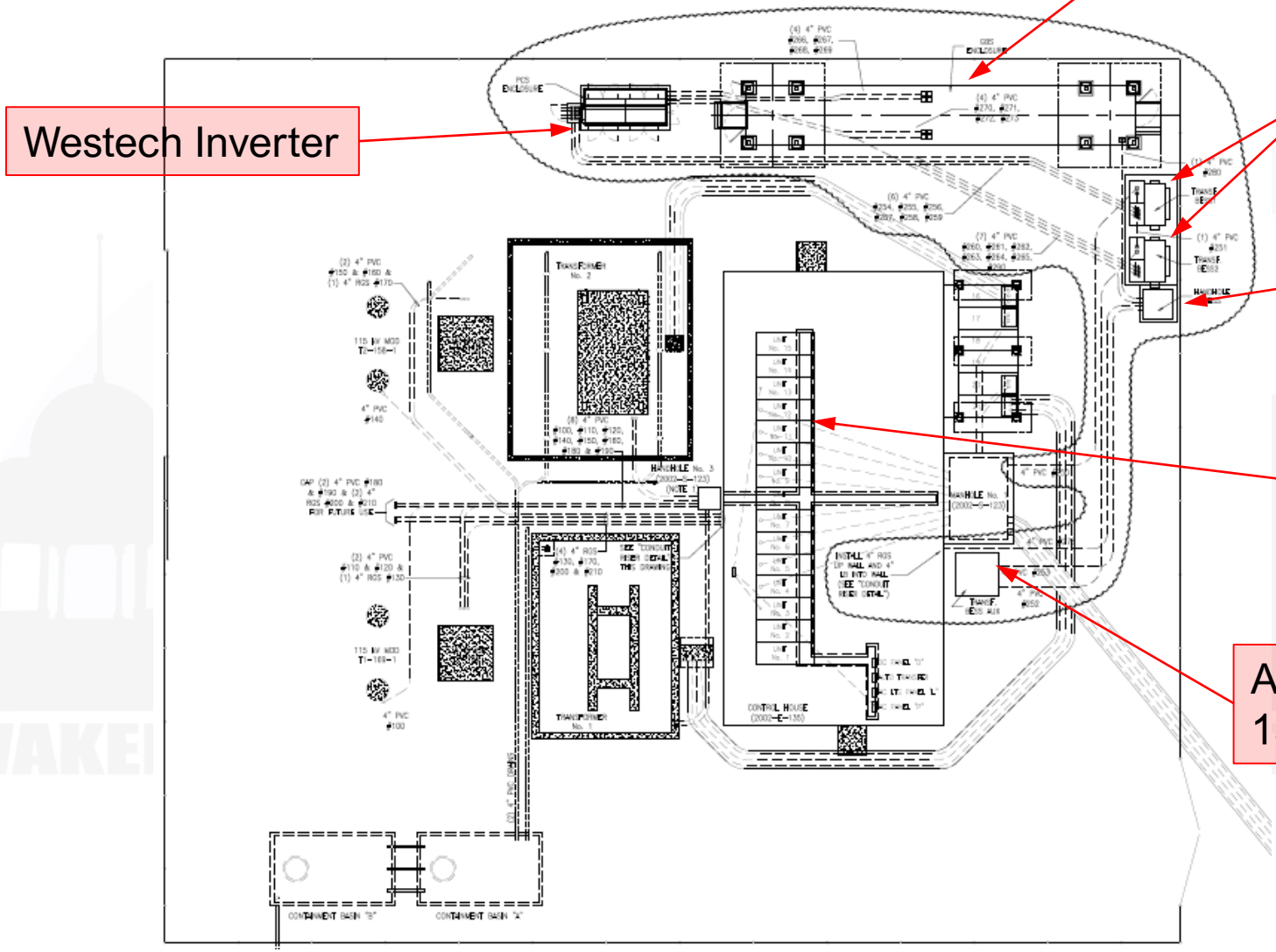


Project: Wakefield Timeline
Date: Mon 6/24/19

Task	Inactive Summary	Path Driving Predecessor Summary Task	
Split	Manual Task	Path Driving Predecessor Normal Task	
Milestone	Duration-only	Baseline	
Summary	Manual Summary Rollup	Baseline Milestone	
Project Summary	Manual Summary	Baseline Summary	
External Tasks	Start-only	Progress	
External Milestone	Finish-only	Manual Progress	
Inactive Task	Deadline		
Inactive Milestone	Path Driving Predecessor Milestone Task		

Page 1

Physical Layout



NEC 53’ x 8’
Battery Storage Container
48 DC racks

Step-up Transformers
(2) 1.5MVA 440v : 13.8kv

Westech Inverter

Communications Handhole

13.8KV Connection to the Existing Switchgear from the Battery system

Auxiliary Transformer
13.8kv:120/208v

Construction

Pre-Construction

1 or 2 Battery Container Foundations

Conduits to the Step-up Transformers

Conduits for DC Cables to the Battery Container

Actual Equipment

Westech Inverter

NEC Battery Storage Container
&
Step-up Transformers

Lessons Learned

- Material and equipment lead times when coming from another country
- Integration of site contractors and equipment providers
- Shipping, delivery and installation
- Actual battery installations
- Communications fiber optic system
- Battery system supplier overview and training before project starts
- Control software for BESS and SCADA integration
- Need complete and detailed design drawings and specs prior to bidding

Year-To-Date Savings

Battery Storage Value to Wakefield 2019 with MMWEC Operations										
Month	Peak Runs	Testing Runs	Reduce SOC	Transmision Peak Date	HE	Hit Peak	MW @ Peak	Arbitrage	RNS Reduction	Capacity reduction
Feb-19	3	5	-	2/1/19	19	Yes	1.220	$186.73	$11,388.42	-
Mar-19	2	-	-	3/6/19	19	Yes	2.465	$304.02	$22,682.57	-
Apr-19	5	-	1	4/9/19	20	Yes	3.152	$342.87	$29,421.95	-
May-19	1	-	-	5/20/19	19	Yes	2.536	$88.12	$23,668.77	-
Total	**11**	**5**	**1**					**$921.75**	**$87,161.70**	**$ -**
							Savings to date:		**$88,083.45**	

- June 27th is the forecasted peak for this month estimated savings of $25,000
- Estimated 6 month savings of $113,083 +/-

Thank you for attending our webinar

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Todd Olinsky-Paul
Project Director, CESA
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Upcoming Webinars

Building Resilient Home Health Care with Energy Storage
Thursday, June 27, 1-2pm ET

EVs and the Electricity System
Tuesday, July 2, 1-2pm ET

Maycroft Apartments: A Low-Income Solar+Storage Resiliency Center in DC
Wednesday, July 31, 1-2pm ET

Read more and register at: www.cesa.org/webinars