Energy Storage Technology Advancement Partnership (ESTAP)

Energy Storage Update

NESEA
March 9, 2016

Todd Olinsky-Paul
Project Director
Clean Energy States Alliance

Clean Energy States Alliance

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

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

Energy Storage Technology Advancement Partnership (ESTAP)

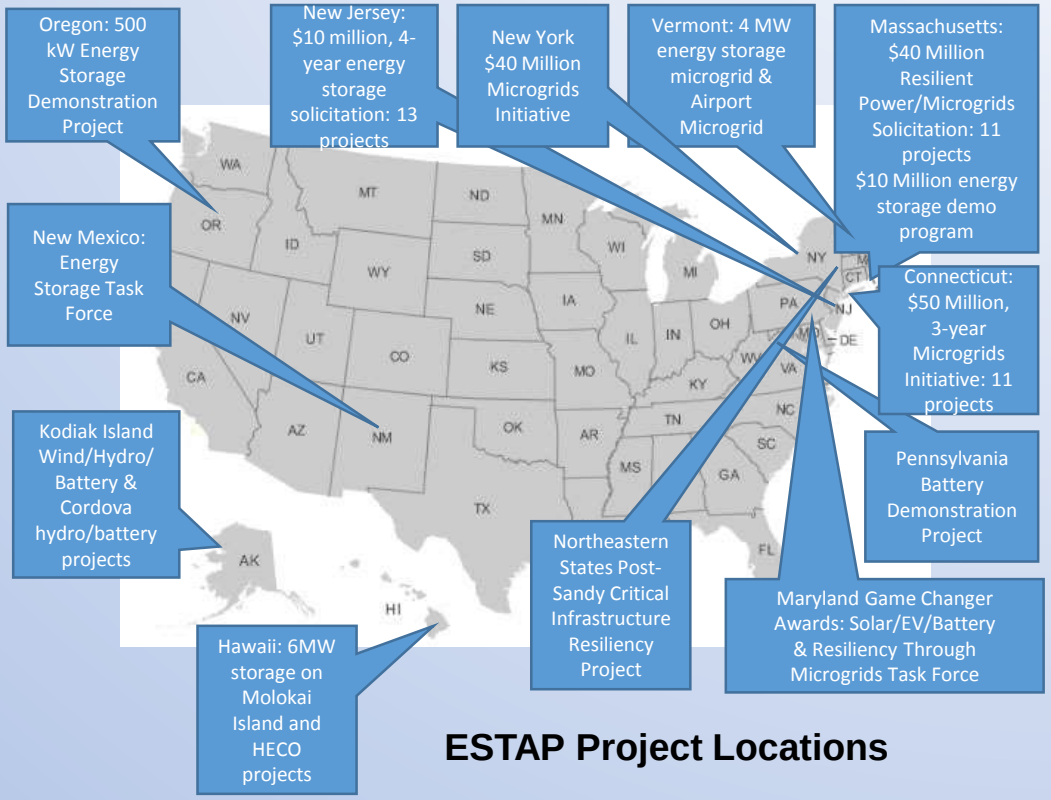
- A project of Clean Energy States Alliance (CESA), a non-profit organization providing a forum for states to work together to implement effective clean energy policies & programs
- Conducted under contract with Sandia National Laboratories, with funding from US DOE-OE

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

Clean Energy States Alliance

Sandia National Laboratories

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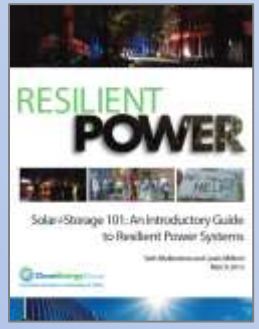
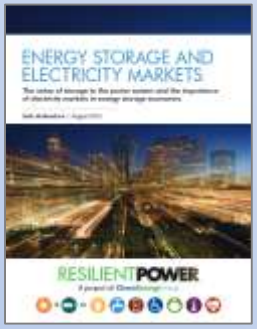
Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See www.resilient-power.org for reports, newsletters, webinar recordings

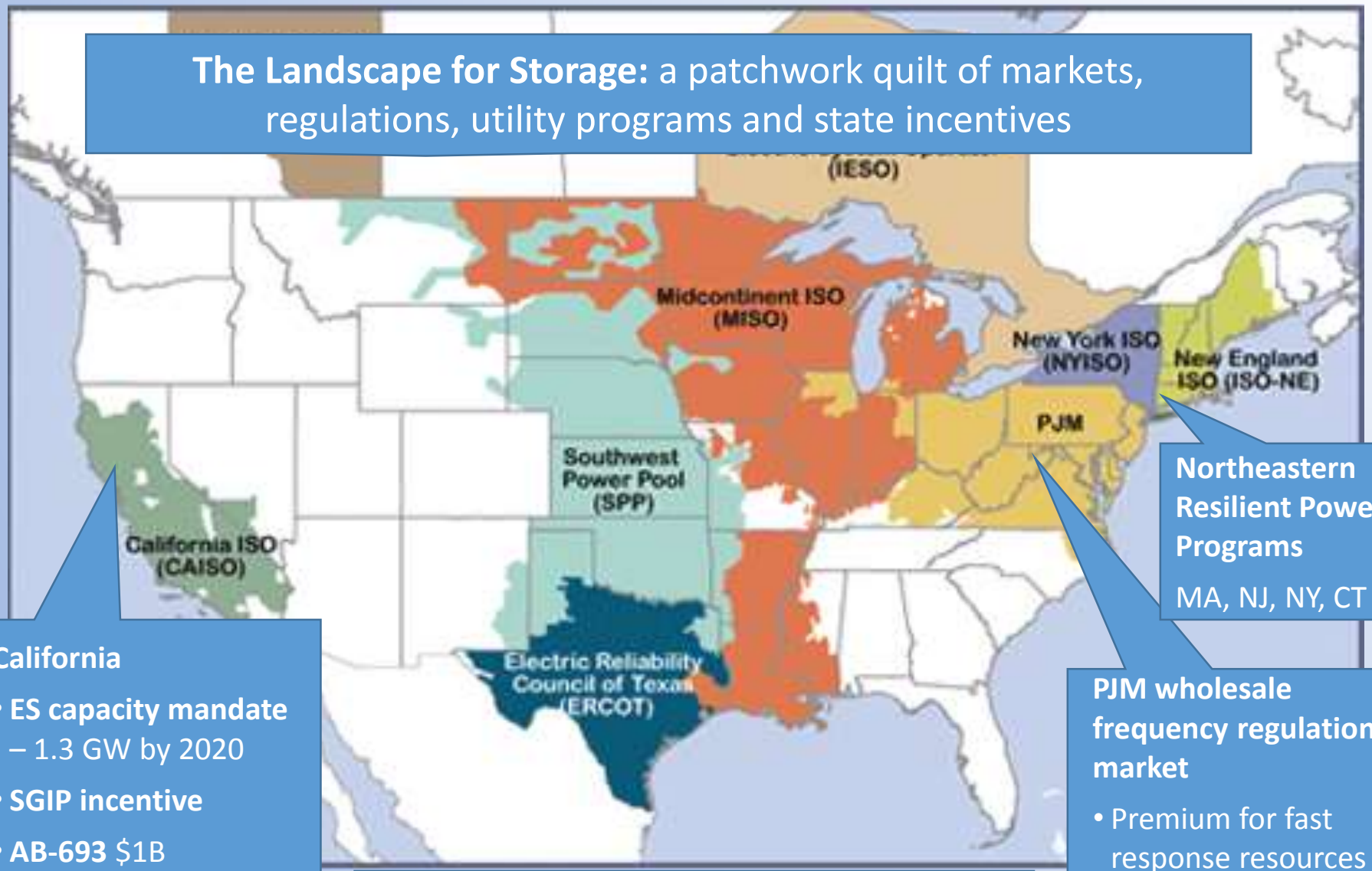




www.cleanegroup.org

www.resilient-power.org

The Landscape for Storage: a patchwork quilt of markets, regulations, utility programs and state incentives



California

- **ES capacity mandate** – 1.3 GW by 2020
- **SGIP incentive**
- **AB-693** $1B multifamily affordable housing solar roofs program

- **Demand charge management**
- **State incentives**
- **High electricity prices/net metering caps**

Northeastern Resilient Power Programs

MA, NJ, NY, CT

PJM wholesale frequency regulation market

- Premium for fast response resources
- Lowered barriers to entry for distributed resources

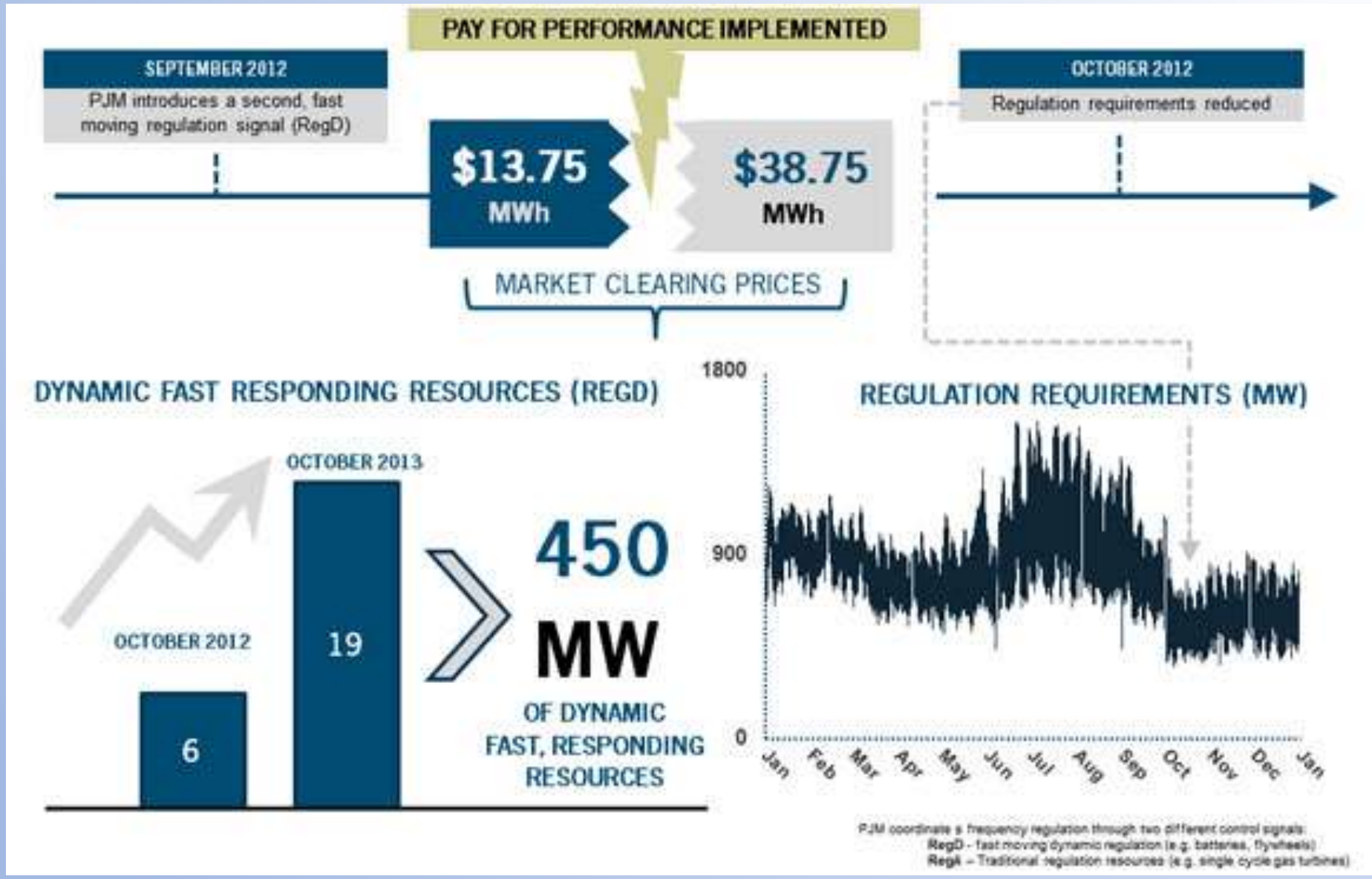
Frequency Regulation in PJM

PJM as Part of the Eastern Interconnection

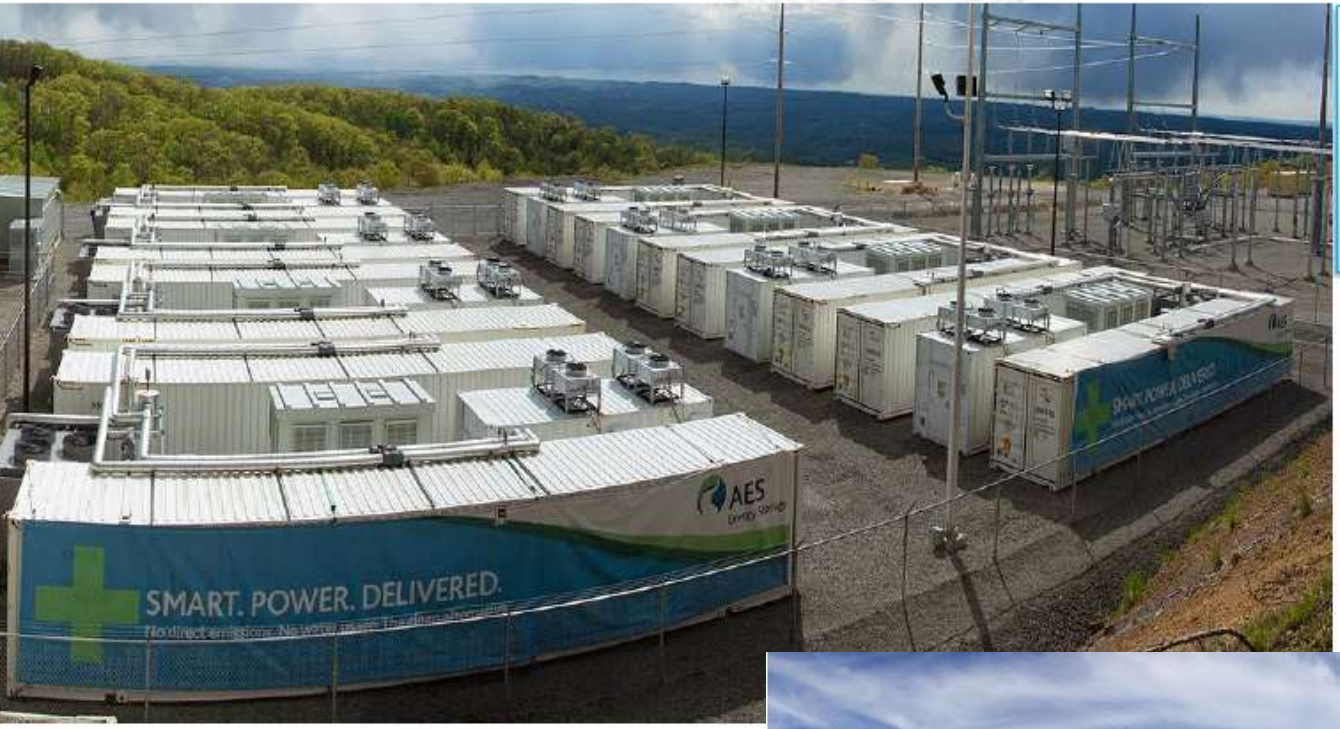
Key Statistics	
Member companies	960+
Millions of people served	61
Peak load in megawatts	165,492
MW of generating capacity	171,648
Miles of transmission lines	72,075
2014 GWh of annual energy	792,580
Generation sources	1,304
Square miles of territory	243,417
States served	13 + DC

21% of U.S. GDP produced in PJM

1/2016


PAY FOR PERFORMANCE IMPLEMENTED
SEPTEMBER 2012
PJM introduces a second, fast moving regulation signal (RegD)
$13.75 MWh
$38.75 MWh
OCTOBER 2012
Regulation requirements reduced
MARKET CLEARING PRICES
DYNAMIC FAST RESPONDING RESOURCES (REGD)
OCTOBER 2013
OCTOBER 2012
6
19
450 MW
OF DYNAMIC FAST, RESPONDING RESOURCES
REGULATION REQUIREMENTS (MW)
1800
900
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
PJM coordinates s frequency regulation through two different control signals:
RegD - fast moving dynamic regulation (e.g. batteries, flywheels)
RegA – Traditional regulation resources (e.g. single cycle gas turbines)

Grid-Scale Energy Storage – 250+ MW in Operation



Total Advanced Storage

Grid Connected – 263 MW
Under Construction – 53 MW
Under Study – 674 MW*

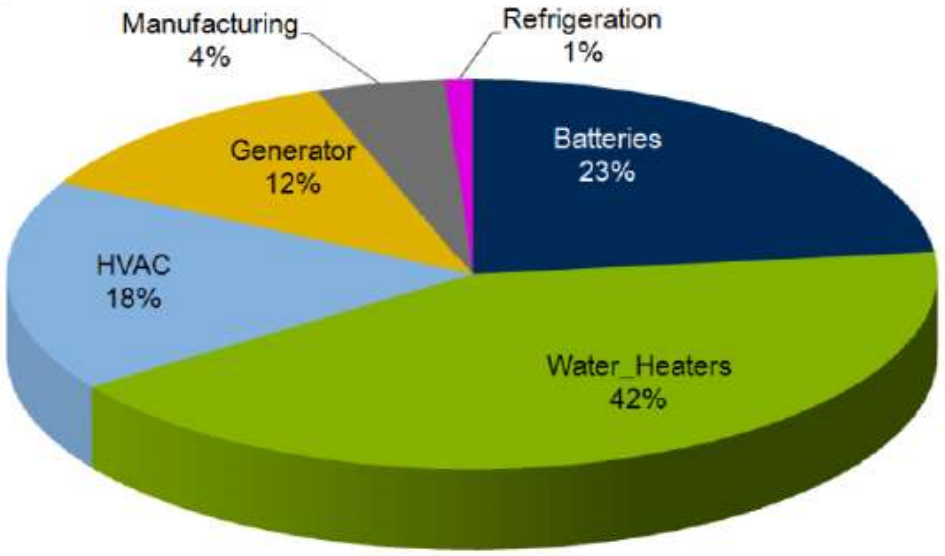
32 MW AES energy storage facility at 98 MW Laurel Mountain Wind Farm, WV
-Source: PJM

Invenergy's Beech Ridge 32 MW energy storage project paired with 100 MW wind energy in West Virginia

Source: PJM

DR Market Participation: Regulation Market

Regulation	Zone	January 2016
Locations	RTO	293
MW	RTO	22



Note: Percent of CSP Reported Load Reduction MWs

FY2015 Renewable Electric Storage Incentive Solicitation Results

October 22, 2014 - Board Approved Solicitation & Evaluation Process

December 08, 2014 - Applications Due; 22 Received => Evaluated

March 18, 2015 – Board Approved 13 Applications for Incentive Award

- 22 Applications Received
- $4,694,642 Requested
- $70,000 to $468,708 per
- $323,585 to $1.86 million
- 13,430 kW total capacity
- 250 kW to 1,500 kW
- 19 Li-ion & 3 Lead Carbon
- 18 public & critical, 4 not

- 13 Applications Approved
- $2,908,804 Awarded
- $70,000 to $468,708 per
- $330,766 to $1.855 million
- 8,750 kW total capacity
- 250 kW to 1,500 kW
- 13 Li-ion projects
- 13 public and critical

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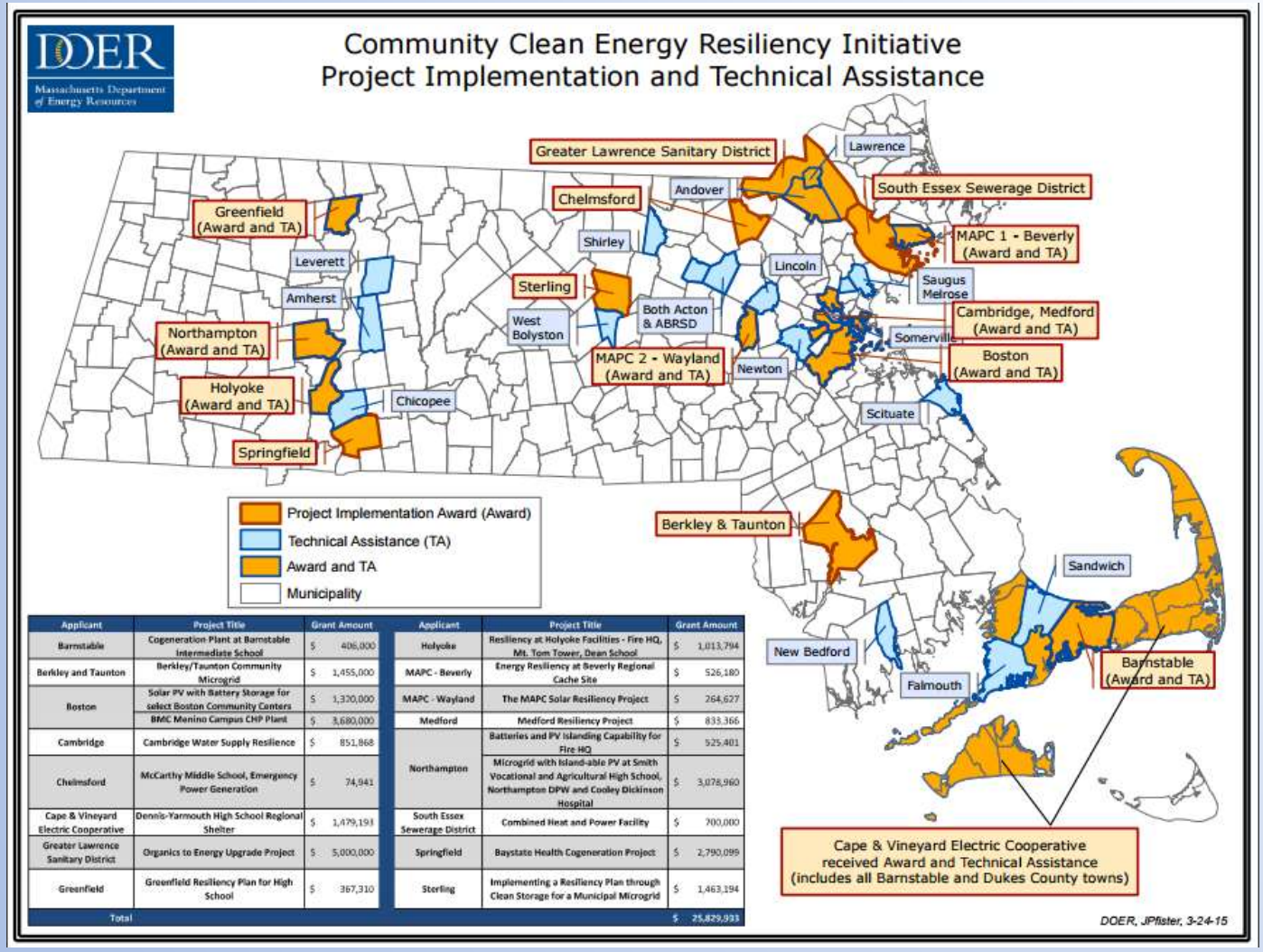
4 Projects Remain



Applicant	Project Title	Grant Amount
Barnstable	Cogeneration Plant at Barnstable Intermediate School	$ 406,000
Berkley and Taunton	Berkley/Taunton Community Microgrid	$ 1,455,000
Boston	Solar PV with Battery Storage for select Boston Community Centers	$ 1,320,000
	BMC Menino Campus CHP Plant	$ 3,680,000
Cambridge	Cambridge Water Supply Resilience	$ 851,868
Chelmsford	McCarthy Middle School, Emergency Power Generation	$ 74,941
Cape & Vineyard Electric Cooperative	Dennis-Yarmouth High School Regional Shelter	$ 1,479,191
Greater Lawrence Sanitary District	Organics to Energy Upgrade Project	$ 5,000,000
Greenfield	Greenfield Resiliency Plan for High School	$ 367,310

Applicant	Project Title	Grant Amount
Holyoke	Resiliency at Holyoke Facilities - Fire HQ, Mt. Tom Tower, Dean School	$ 1,013,794
MAPC - Beverly	Energy Resiliency at Beverly Regional Cache Site	$ 526,180
MAPC - Wayland	The MAPC Solar Resiliency Project	$ 264,627
Medford	Medford Resiliency Project	$ 833,366
Northampton	Batteries and PV Islanding Capability for Fire HQ	$ 525,401
	Microgrid with Island-able PV at Smith Vocational and Agricultural High School, Northampton DPW and Cooley Dickinson Hospital	$ 3,078,960
South Essex Sewerage District	Combined Heat and Power Facility	$ 700,000
Springfield	Baystate Health Cogeneration Project	$ 2,790,099
Sterling	Implementing a Resiliency Plan through Clean Storage for a Municipal Microgrid	$ 1,463,194
Total		$ 25,829,933

With federal and foundation support, CESA is providing free technical assistance to the DOER awardees whose resiliency projects include an energy storage component

- Sandia National Laboratories
- Pacific Northwest National Laboratories
- Contractors

Municipal Utility Analysis - Massachusetts

- Analysis conducted by Sandia National Laboratories
- Based on 1 MW/1MWh lithium ion battery installed on distribution grid, with 3 MW solar PV
- System to be owned and operated by a MA municipal utility
- Potential value streams:
  - **Energy arbitrage** revenues (buy low, sell high)
  - **Reduction in transmission obligation** to ISO-NE (cost savings based on monthly peak hour)
  - **Reduction in capacity obligation** to ISO-NE (cost savngs based on annual peak hour)
  - **Resilient power provision** to critical emergency facilities (non-monetizable benefit)

Arbitrage basis

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	553.12	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

Energy Arbitrage

- Analyzed 33 months of data (January 2013-September 2015)
- Optimization using perfect foresight
- Cycling limitations were not included

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

Reduction in Transmission Obligation (Regional Network Service (RNS) payments) to ISO-NE

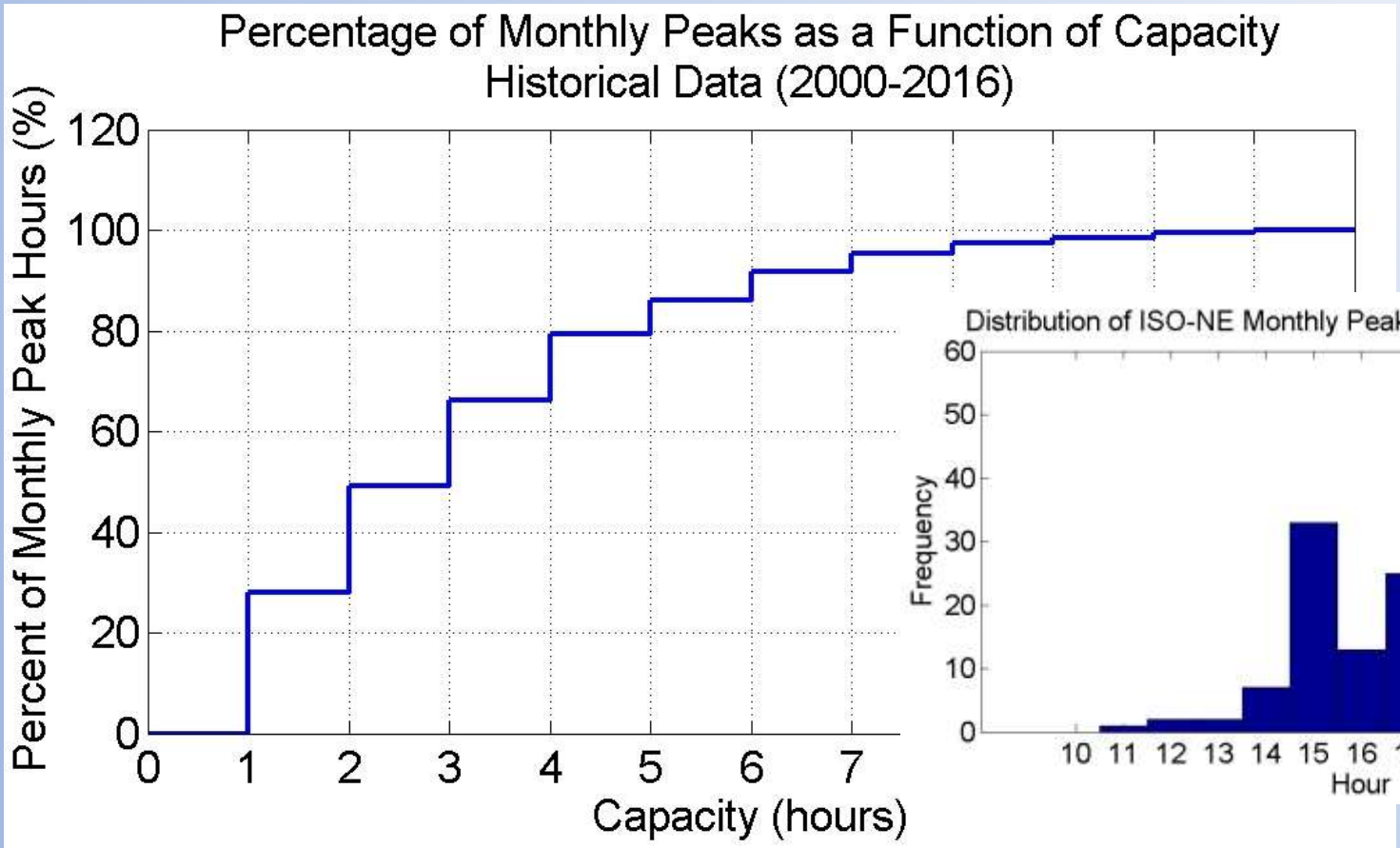
- Monthly payment based on maximum load
- Payment for using transmission facilities to move electricity into or within New England
- Current pool rate, effective June 1, 2015: $98.70147/kW-yr
- Need to “hit the hour” to reduce load, or else no benefit
- Having a multi-hour battery (more capacity) provides no increase in benefit, but increases the odds of “hitting the hour”

RNS Savings for 1 Hour Energy Storage System.

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

Impact of Energy Storage Capacity on Transmission Savings

Increased energy storage capacity increases the likelihood of hitting monthly peaks



Reduction in Capacity Obligation to ISO-NE

- Each load serving entity is responsible for a fraction of the Forward Capacity Market obligations
- Based on one annual peak hour
- Rates due to triple in three years
- Increasing capacity does not increase revenue, just increases the odds of "hitting the hour"

Capacity Clearing Price, ISO-NE.

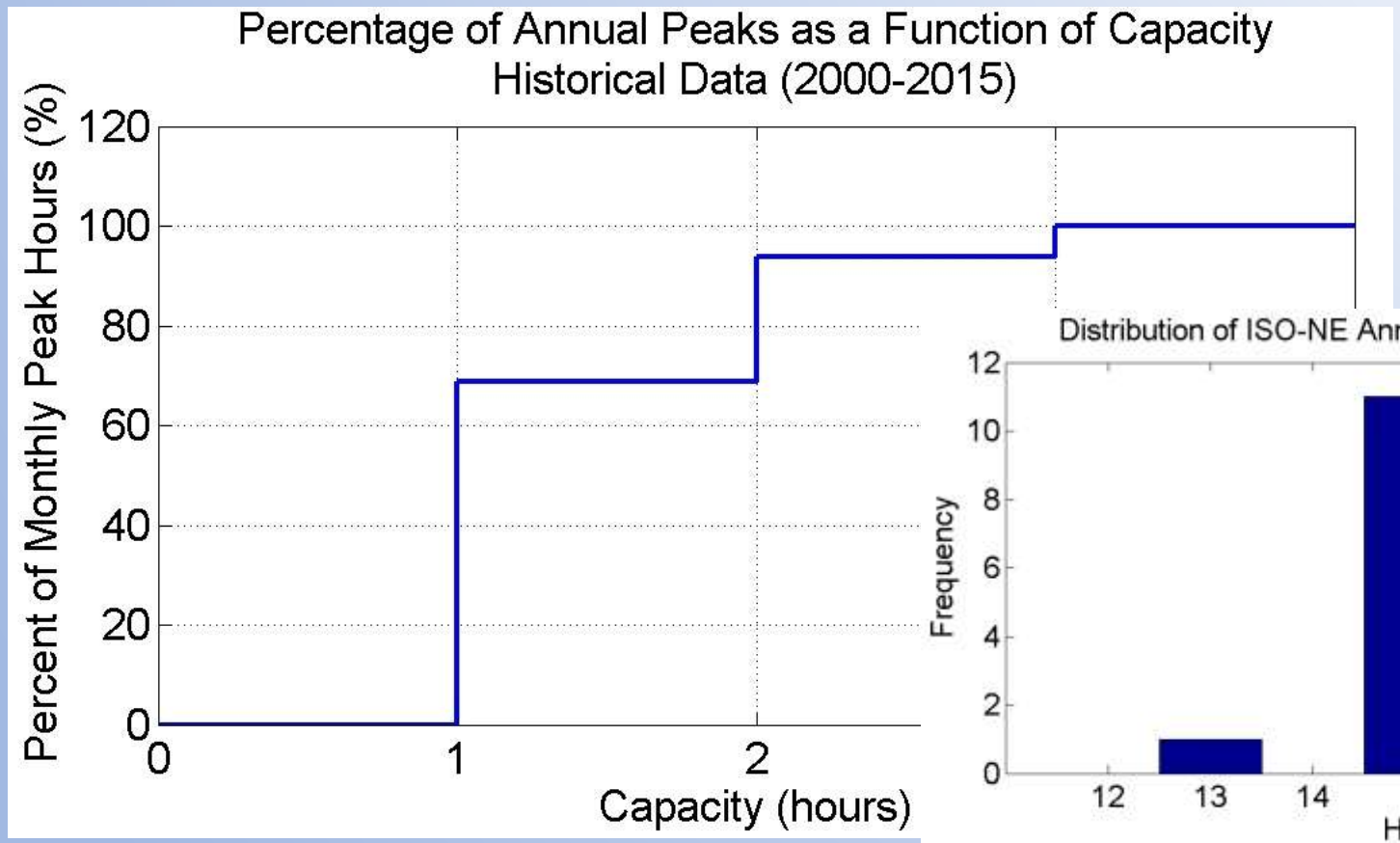
Year	Price ($/kW-Month)
2010-2011	$4.254
2011-2012	$3.119
2012-2013	$2.535
2013-2014	$2.516
2014-2015	$2.855
2015-2016	$3.129
2016-2017	$3.150
2017-2018	$7.025
2018-2019	$9.551

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

Impact of Storage Capacity on Capacity Savings

Increased energy storage capacity of limited benefit, due to distribution of annual peaks



Grid Resilience

- Municipality has identified 10kW as the critical load at community critical emergency facilities
- Resilience is not monetizable but is valued highly by the community and the state

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

Summary of Monetizable Benefits

- Total potential revenue, 1MW, 1MWh system

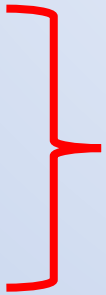
Description	Total	Percent
Arbitrage	$40,738	16.0%
RNS payment	$98,707	38.7%
FCM obligation*	$115,572	45.3%
Total	$255,017	100%

- For a capital cost of ~1.7M, the simple payback is 6.67 years

*2017-2018 data. Rates will be higher in 2018-2019, resulting in additional savings.

Take-Aways

- Energy storage is installed and operational in many states
  - Utility scale
  - Behind the meter
- Energy storage can provide many valuable benefits
  - Demand charge management
  - Demand response
  - Frequency regulation
  - Renewables integration
  - Resilience
  - T&D investment displacement/deferral



Stacking benefits can be challenging from behind the meter

- It is possible to provide resilience to critical facilities AND generate revenues/cost savings, so that storage systems will pay for themselves
- Energy storage can compete today in open markets under pay-for-performance conditions
- As prices continue to fall, energy storage will find new markets and applications

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

SIGN UP FOR THIS e-MAILING LIST

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

Thank You

Todd Olinsky-Paul

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ESTAP Website: http://bit.ly/CESA-ESTAP

ESTAP Listserv: http://bit.ly/EnergyStorageList

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