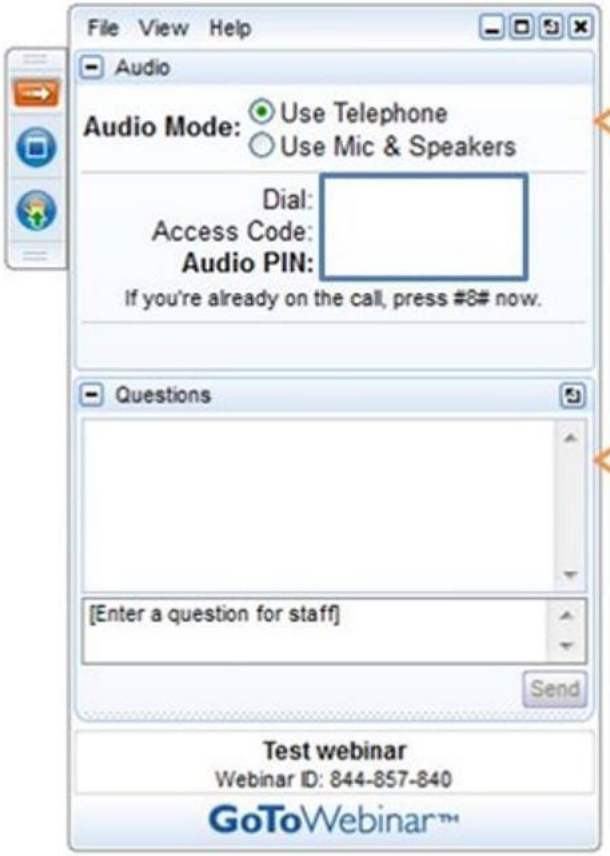
Energy Storage Technology Advancement Partnership (ESTAP) Webinar:

Energy Storage Market Updates

September 30, 2015

Hosted by Todd Olinsky-Paul
ESTAP Project Director, CESA

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:

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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:

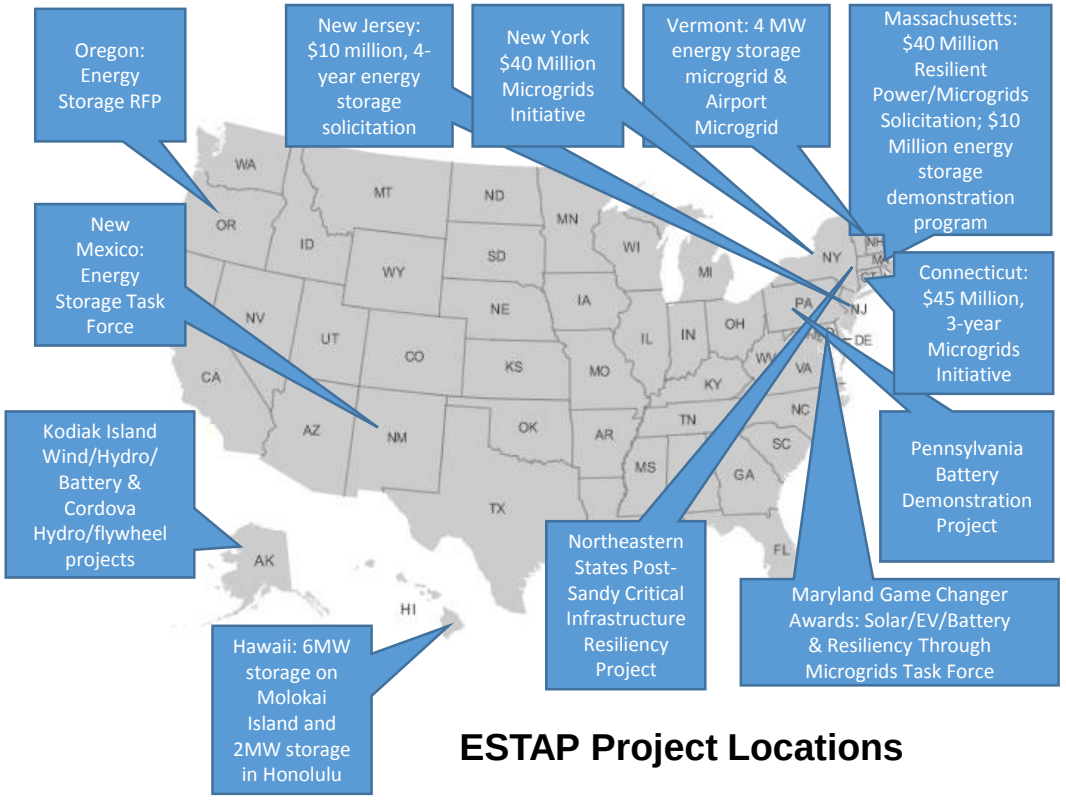
State & Federal Energy Storage Technology Advancement Partnership (ESTAP) is conducted under contract with Sandia National Laboratories, with funding from US DOE.

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
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ESTAP

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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 (>500 members)
- Webinars, conferences, information updates, surveys

2) Facilitate public/private partnerships at the state level to support energy storage demonstration

NEW RESOURCES

June 22, 2015
Clean Energy Champions - The Importance of State Programs and Policies
By Warren Leon, Executive Director, CESA

June 12, 2015
Solar+Storage News 6.12.15
By Clean Energy Group

April 7, 2015
ESTAP Webinar Slides: Upgrading Distribution Resilience - A DOE-OE

UPCOMING EVENTS

August 27, 2015
Webinar: Electricity Markets and the Economics of Energy Storage,

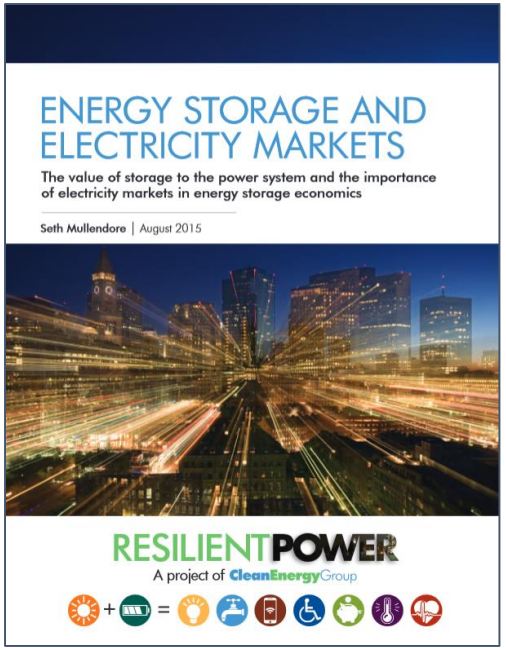
More Events

LATEST NEWS

May 21, 2015
ODOE to Offer Research and Development Funds for Energy Storage

Energy Storage and Electricity Markets

This report examines how emerging energy storage markets have developed and the potential for realizing additional value streams through new market mechanisms.



http://bit.ly/Energy-Storage-Electricity-Markets

Today's Guest Speakers

- **Jacqueline DeRosa**, Director of Emerging Technologies – US, Customized Energy Solutions
- **Michael Berlinski**, Senior Consultant – Emerging Technology, Customized Energy Solutions
- **Raj Chintapalli**, Director of Regulatory Affairs – Ontario, Customized Energy Solutions

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Webinar Archive: www.cesa.org/webinars

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

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

CleanEnergy States Alliance

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U.S. DEPARTMENT OF ENERGY

Customized Energy Solutions

CEG-CESA Webinar:

An Overview of

Energy Storage Markets

Jacqueline DeRosa

Mike Berlinski

Raj Chintapalli

Agenda

- Overview of CES
- Federal Overview
- Regional Markets
  - CA
  - PJM
  - ISO-NE
  - ERCOT
  - SPP
  - MISO
  - NY
  - Ontario

Customized Energy Solutions

CES Overview

Customized Energy Solutions Company Overview

- **Customized Energy Solutions is at the forefront of competitive energy markets. Through consulting services and financial analysis, we enable competitive suppliers, technology providers, marketers, and utilities to prosper through change.**

- Founded in 1998
- Self-Funded Corporation
- Main Office: Philadelphia, PA with Regional Offices in CA, IN, NY, TX, VA, International Offices in Canada and India
- 100+ staff with diverse educations and experience in regulatory, transmission, generation, risk management, trading, consulting, demand side, load serving, operations and planning.
- We have won several awards over the past few years : The Inc500 and the Philadelphia 100 Hall of Fame.

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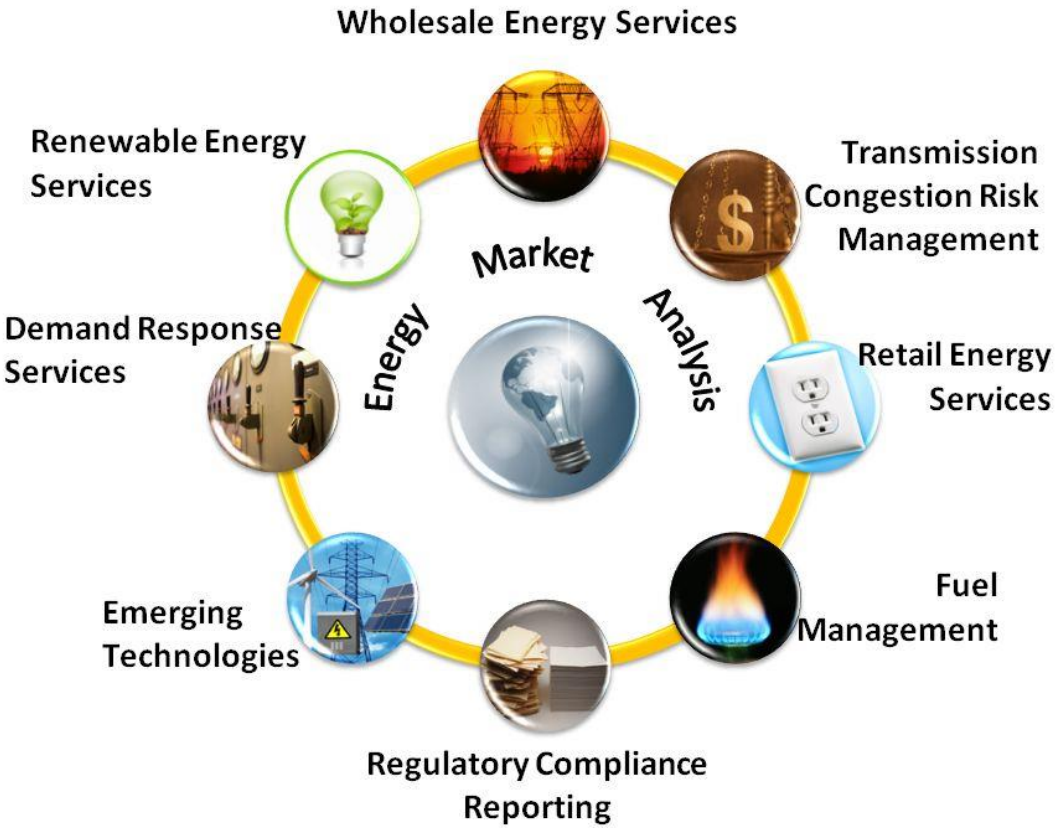
CES Core Service Offerings



We maximize value of existing and emerging electric infrastructure through active resource management.

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CES Service Offerings

Consulting

- Feasibility Analysis
- Competitive Assessment
- Interconnection Studies
- Financial Analysis
- StorageIQ : Market Insights
- Project Finance Advisory

Data Acquisition & Scheduling

- Real-time Communication through SecureNet-RT
- UI Management
- Real-time Monitoring for energy and ancillary services
- Web-based reporting

Scheduling and Operations

- Registration / Accreditation
- Portfolio Management
- Bidding Strategies
- SOC management
- Settlements

CES assists clients from concept to market implementation

Comprehensive Emerging Technology Services

- Markets & Regulatory
  - US Market Report on Storage
  - ISO/RTO storage activity reporting
- Modeling and Consulting
  - Price forecasts
  - Economic analysis and valuation
  - Optimization of product configuration
- Financial Advisory
  - Help secure funding
- Project Development
  - Site selection, interconnection
- Market Operations
  - Wholesale, DR, and Telemetry

Customized assists clients from concept to market implementation

Integrating Energy Storage Into Energy Markets

- CES Schedules Energy Storage Resources into the RTOs
  - 20 MW flywheel facility in NYISO: 3 years
  - 4 MW battery facility in PJM: 1 Year
  - 2 MW battery Facility in PJM 6 Months
  - 4 MW battery facility in IESO 4 months
  - 2x 20 MWs Batteries in PJM – September 2015
  - 4 more projects totaling 32 MWs of battery facilities in PJM and ISO-NE in late 2015
- CES also provides telemetry to ~25 MWs of Telemetry for both in front and behind the meter storage resources in PJM

Also previously scheduled: 32 MW battery facility in PJM: 2 years and 8 MW battery facility in NYISO: 1.5 years

We offer bidding strategies, state of charge management, scheduling, and dispatch.

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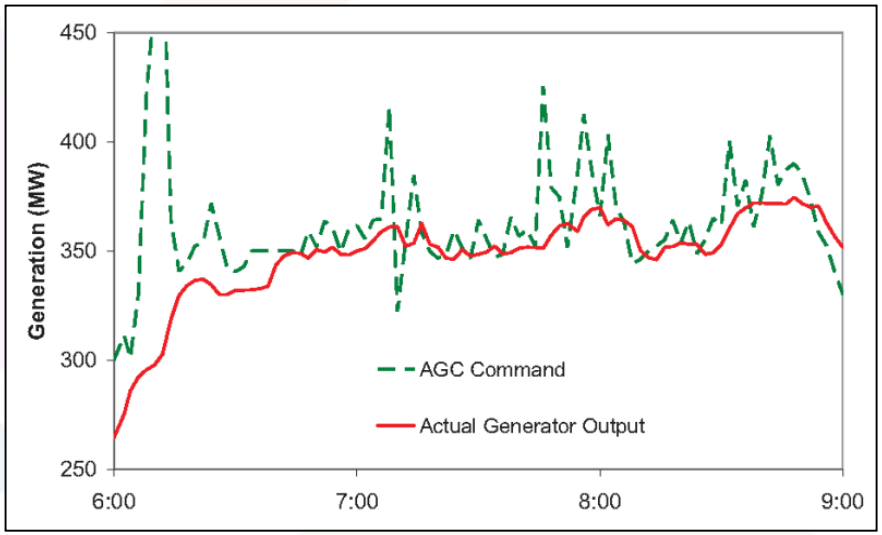
Federal Overview

FERC Orders

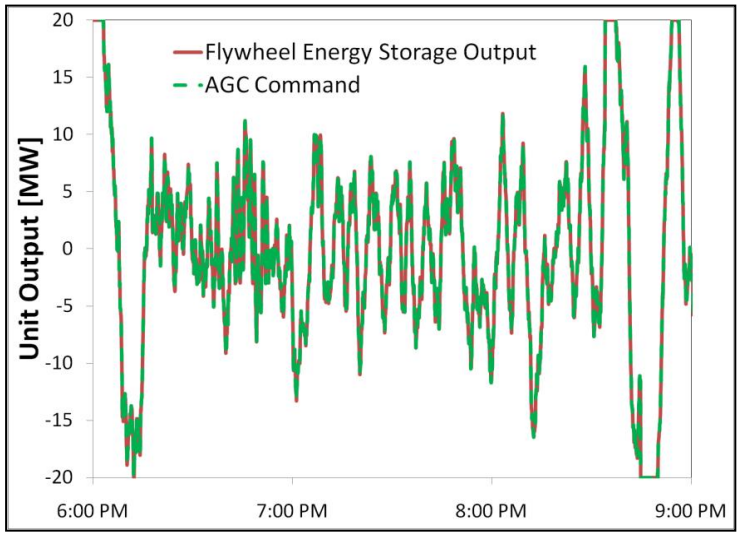
- FERC Order 890
  - Participation by non-generator resources in the RTO/ISO Ancillary Services markets, including Regulation.
  - Preventing Undue Discrimination and Preference in Transmission Service
- FERC Orders 719 and 745
  - Improve DR in the wholesale power markets
- FERC Order 755
  - Pay for Performance Regulation
- FERC Order 784
  - Third-party provision of ancillary services and the accounting and financial reporting for new electric storage facilities”
- FERC Order 794
  - Frequency Response

FERC ORDERS

- FERC Order 755 – “Pay for Performance”
  - Created new compensation rules for frequency regulation
  - Recognizes value of speed and accuracy



Slow-ramping Generator*



Fast-ramping Storage**

Superior speed and accuracy provides more value to the grid and should be compensated

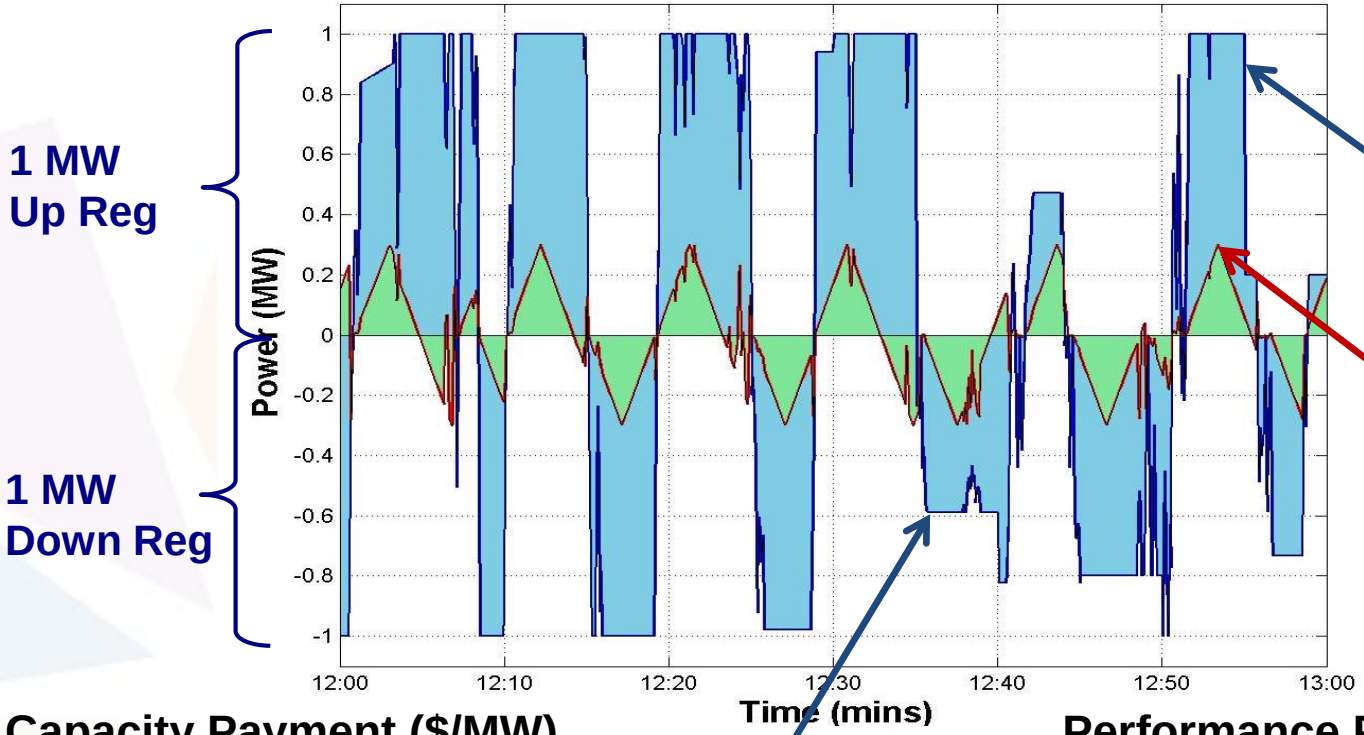
Source:

* Kirby, B. “Ancillary Services: Technical and Commercial Insights.” Wartsilla, July, 2007. pg. 13

** Beacon Power

FERC ORDERS

- FERC Order 755 – Created two-part payment



Capacity Payment ($/MW)

- Amount set-aside (MW)
- Includes Opportunity Cost
- *May be adjusted based on state-of-charge*

Performance Payment ($/ΔMW)

- Sum of up and down movement "mileage" (ΔMW)
- Adjusted by accuracy

National Trends
What's Next….

- Additional Ancillary Services and Compensation:
  - Frequency Response
    - FERC ORDER 794
      - Approves NERC BAL-003
    - FERC NOPR: Frequency Response Market Based Product NOPR
  - Reactive Power
    - FERC Docket AD14-7

- Distributed Energy Resources
  - Wholesale market participation
  - Aggregations, Metering, Telemetry

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California

Energy Storage Opportunities in CA

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California ISO

- CAISO Non Generator Resource and Proxy Demand Response: Ancillary Services: Spin, Non Spin, Regulation (although PDR cannot provide Regulation)
    - .5 MWs Minimum Size
- CAISO Transmission Planning
- CAISO Stakeholder Initiatives – Energy Storage, Flexible Ramping Product, Reactive Power, and Frequency Response

California Public Utilities Commission:

- CPUC / CAISO: Resource Adequacy (RA) for Storage and DR
- CPUC: Storage procurement targets, authorizations, RFOs
- CPUC: Long Term Procurement Authorizations, Energy Storage Procurement Authorizations, RFOs
- CPUC: DRAM
- CPUC: SGIP

California Energy Commission

- EPIC

CAISO "Performance-Based Regulation" Market – FERC Order 755 (Pay for Performance)

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- Product: Regulation Up and Regulation Down
  - For load following, frequency response, Demand forecast inaccuracies, and market imbalance inaccuracies that occur between one Real Time Dispatch (RTD) period to the next.
- Pay for Performance (Mileage) Implemented in 2013
- Market Size ~350 Mws Reg Up and ~ 350 MWs Reg Down
- Duration Requirement:
  - 1 Hour Duration
  - 15 Minute for Regulation Energy Management (15 minute resources)
- AGC: 8 second round trip (AGC)
- Prices continue to be ~$10 – 12/MW
  - Reasons include: $0 mileage bids, low accuracy

CAISO Transmission Planning - Energy storage

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- **Options in Transmission Planning Process**
  - **Participating Transmission Owner**
  - **Reliability, Economic, Policy**
  - **FERC regulated rate of return**.
- *Eliminate the overload conditions during contingency situation, Stabilize voltage during contingency, Power oscillation damping, Tie line control, Circuit break reclosing, Subsynchronous resonance damping, Power quality*

Distributed Resources Gaining Importance

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- CAISO Developing Market Rules:
  - The Distributed Energy Resource Provider (DERP) will offer energy and ancillary services into the ISO market through a Scheduling Coordinator (SC) from distribution connected resources.
  - Use of the “data concentrator” model for distributed resources. This involves collecting metering and telemetry data from multiple resources within a central data center and communicating with the ISO.
  - “homogenous” aggregations, must move in same direction, limit to 20 MWs per SubLap, .5 MW aggregation minimum
  - Additional Clarifications Being Made in the Energy Storage and Distributed Energy Resource Stakeholder (ESDER) Initiative
  - CAISO Developing Market Rules
- New CPUC Distributed Resource Proceeding

CA State Initiatives - Resource Adequacy

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CPUC

- 1-year forward bilateral market
- Prices: $1.50 to $3.50 / kW-month
- System, Local and Flexible
  - System / Local – Four Hour requirement
  - Flexible –Three-hour ramping requirement
- Storage - Can be both charging and discharging
- Minimum value is capable of charging for 1.5 or more uninterrupted hours

CAISO

- Must Offer Obligation
- Availability Incentive Mechanism
- Outage Replacement and Substitution

CA State Initiatives -Continued

- Long Term Procurement
  - CPUC: CA Storage Procurement
  - CPUC: LTPP Authorizations
- Demand Response (CPUC in coordination w/CAISO)
- Self Generation Incentive Program (CPUC)
  - SGIP: Incentive up to 1 MW = $1.46/W
  - Incentive for 1 MW to 2 MW = 50%
  - Incentive for 1 MW to 3 MW = 25%
- Research/ Grants - Electric Program Investment Charge (CEC)
  - Applied research and development, Technology demonstration and deployment, and Market research, regulatory permitting, and workforce development activities

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PJM

Energy Storage Initiatives in PJM

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- Advanced Technology Pilot Program
- Asset class – Energy Storage Resource; Capacity Storage Resource
- Regulation signal – fast-ramping, energy-neutral (“RegD”)
- Ability to adjust Regulation midpoint to manage state of charge
- Net Energy Settlement – hourly, at LMP; excluded from station power charges
- Low minimum resource size: 0.1 MW
- Next frontier: Regulation Market review

PJM "Performance-Based Regulation" Market – FERC Order 755 (Pay for Performance)

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- Payments to accurate, fast ("RegD") resources have been ~ $40/MW/hr
  - Capability Price that includes Lost Opportunity Cost (LOC) of Energy plus Performance Price times the "Mileage Ratio"
    - Ratio of Fast (16-17 miles/MW/hr) to Slow ("RegA") (6-7) Signals ~ 3:1
  - Performance Score: 10-second sampling; Expected value = ???
- Market Size – 650 - 700 Effective MW*; Will grow with more wind
- Existing Supply – 176 MW of grid-connected storage + ~5 MW behind-the-meter storage (classified as Demand Response)

- Summer 2015, PJM proposed to limit RegD volume to 200-300 MW
- PJM has formed a new stakeholder group to discuss Regulation Market design, including: benefits factor curve, Regulation requirement, dispatch signals, performance thresholds, compensation formulas

* "Effective MWs" are adjusted for Performance Score and Benefits Factor

Storage in PJM Capacity Market – Reliability Pricing Model ("RPM")

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- 3-year forward market, annual bidding process
- Market Size: ~167,000 MW
- Prices: $150-200/MW-d in most recent ('18-'19) auction
- Historically, storage participation by hydro pumped storage only
- In 2014, "Energy Storage in RPM" effort subsumed into "Capacity Performance" initiative
  - New resource type: Capacity Storage Resources
    - No minimum duration requirement; but check for reasonableness
  - If cleared, obligation to provide Energy during certain hours
  - Penalties for non-performance
  - Collected penalties are distributed to over-performing resources
  - May aggregate storage with intermittent renewables, demand response, and energy efficiency to offer as a single resource
- Next auction – May 2016 (for '19-'20)

State Activities in the PJM Region

- **New Jersey** – Renewable Electric Storage Program – FY2015: 13 Behind The Meter projects totaling 9 MW awarded $3 million; FY2016: $6 million
  - Energy Resilience Bank
- **Maryland** – Game Changer Competitive Grant Program
  - General Assembly (legislature) hearing on energy storage
- **District of Columbia** – Distribution System Planning Proceeding – party comments say storage has benefits that can help
- Some states with **Renewable Portfolio Standards** include energy storage as an eligible technology

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ISO-NE

Energy Storage Initiatives in ISO-NE

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- Alternative Technology Regulation Pilot Program
  - Traditionally, only hydro pumped storage resources could provide Regulation
  - Pilot for new advanced storage and other technologies began Nov. 2008, expected to last 18 months
  - 6 ½ years later, concluded with Order 755 implementation (March 31, 2015)
    - ISO-NE created testing environment for new technologies
- New asset class: Alternative Technology Regulation Resource (ATRR)
  - Minimum ATRR size: 1 MW
- Net energy settlement options – can settle net energy at wholesale price and avoid station power charges
- New Regulation dispatch signals: 3 to choose from: Traditional, Energy-neutral trinary, Energy-neutral continuous

ISO-NE Regulation Market

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- Regulation market size: ~60 MW; Expected to grow with more intermittent resources
- Paid for mileage since 2005, but not fully Order 755-compliant. Key changes:
  - Opportunity cost of marginal unit in Capacity price (July 2013)
  - Change to two-part bid: Capacity and Mileage
  - Mileage price now market-based; Previously, mileage prices set as 1/10 of capacity prices
- Resource revenue depends on accuracy and amount of mileage
  - Accuracy is determined by the ability to stay within “envelopes” around signal;
    expected value = ???
  - Mileage volume: ???

State Activities in New England

- **Massachusetts**: Energy Storage Initiative; Grid Modernization; Energy Resiliency Grants (several battery projects); Alternative Energy Portfolio Standard (APS) credit for flywheels
- **Connecticut**: Microgrid Program (several battery projects); Green Bank
- **Maine**: Non-transmission alternative pilot (0.5 MW storage)
- **Vermont**: Green Mountain Power – Stafford Hill Solar Farm + 4 MW storage project, Tesla Powerwall program

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ERCOT

Energy Storage Initiatives in Texas

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- **Nodal Protocol Revision Request (NPRR) 461 - Energy Storage Settlements Consistent with Public Utility Commission of Texas (PUCT) Project 39917 (December 2012)**
  - Storage resources can settle energy withdrawals at the wholesale nodal energy price
  - Wholesale Storage Load (WSL) is the "Energy that is *separately metered* from all other Facilities and withdrawn from the ERCOT System to charge [storage]"
    - Note – Not all loads at a storage plant are considered WSL, multiple meters may be required
  - Note – Storage load is not exempt from Station Power, as is done in FERC-jurisdictional markets
- **PUCT Project 40150 - Pilot Project Authority (June 2012)**
  - Granted ERCOT the authority to conduct pilot projects to provide a temporary platform to evaluate resources, technologies, and processes
- **Fast-Responding Regulation Service (FRRS) pilot**: 1 year, February 2013 – February 2014
  - Objectives: to gather and analyze data to determine potential improvements in ERCOT's frequency control, and to explore using new technologies for such.

ERCOT Regulation Market

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- Market Size: ~500 MW
- Not bi-directional, so separate Reg Up and Reg Down markets
- Min resource size = 0.1 MW
- ERCOT not FERC-jurisdictional so no Order 755 / “Pay for Performance”
- Fast-Responding Regulation Service (FRRS) pilot -> subset of Regulation
  - Limited to 65 MW FRRS Up and 35 MW FRRS Down
  - FRRS is meant to complement current Regulation Service, by responding first and fast, and helping slow down the frequency decay as other resources start to respond.
  - Resource Performance Criteria
    - Automatically detect frequency deviations of .09 Hz from 60 Hz and provide full response within 1 second
    - Respond to control signals and provide at least 95% and no more than 110% of the obligated MW
    - Able to deploy for up to 8 minutes

ERCOT Future Ancillary Services (FAS)

- Since late 2013, ERCOT has been re-evaluating its Ancillary Services markets
- Motivation for Change:
  - Current framework is based on characteristics of steam generators
  - Several, distinct operational requirements are currently bundled as a single service (e.g. Responsive Reserve Service)
  - Awkward to fit capabilities of new technologies (e.g. storage, Combined Cycles with duct firing, wind turbines) that could provide services efficiently
- Held weekly meetings in 2014, workshops continued in 2015
- Plan to implement three years after Board approval (ie 2018-2019)
- Recent discussion on how to procure and price Frequency Response
- Working on Cost Benefit Analysis
- Also working on intertial response service

SPP

Energy Storage Initiatives in SPP

- SPP has not created rules for energy storage resources like other ISOs have
- A stakeholder recently submitted a request to add rules for energy storage, will be discussed this fall

SPP Regulation Market

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- SPP started full ISO market operations ("Integrated Marketplace") on March 1, 2014
  - Regulation not bi-directional, so separate Reg Up and Reg Down markets
    - Regulation market size: ~330 MW
- Minimum resource size = 0.1 MW
- Implemented Order 755 Regulation market March 1, 2015; Design like MISO
- Regulation Prices:
  - Capacity: Includes one average dispatch of mileage (~4 miles/MW/hr)
  - Mileage: Paid for mileage above ave., charged for mileage below ave.
- Resource revenue depends on accuracy and amount of mileage
  - Accuracy: actual mileage vs instructed mileage (sum of 4-second values); expected value = ???
  - Mileage volume: ???

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MISO

Energy Storage Initiatives in MISO

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- MISO Energy Storage Study 2011
- IOWA Stored Energy Park Agency (ISEPA)
- MISO Stored Energy Resource(SER)
- Indianapolis Power & Light (IPL) (owned by AES) has 20 MW battery in development
- MISO to implement Ramping Product in March 2016

MISO Stored Energy Resource

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- Created resource type: Stored Energy Resource (SER)
  - Short term storage devices, one hour or less duration
  - Eligible to offer Regulation (Regulating Reserve) only
  - Method for dispatching SERs, which maximizes the resource's capability to provide Regulation
    - MISO manages the state of charge, on 5 minute basis
      - "Effective capacity" will be less than nameplate capacity
      - Market Size: ~400 MW
      - Market Clearing – single part – add two offers and ISO-calculated LOC to get total cost
      - Regulation Prices (Capacity Price, Mileage Price)
      - Resource revenue depends on accuracy and amount of mileage
- Settle net energy at wholesale price; excluded from station power charges
- Minimum Regulation resource size: 1 MW

MISO Regulation Market Dispatch

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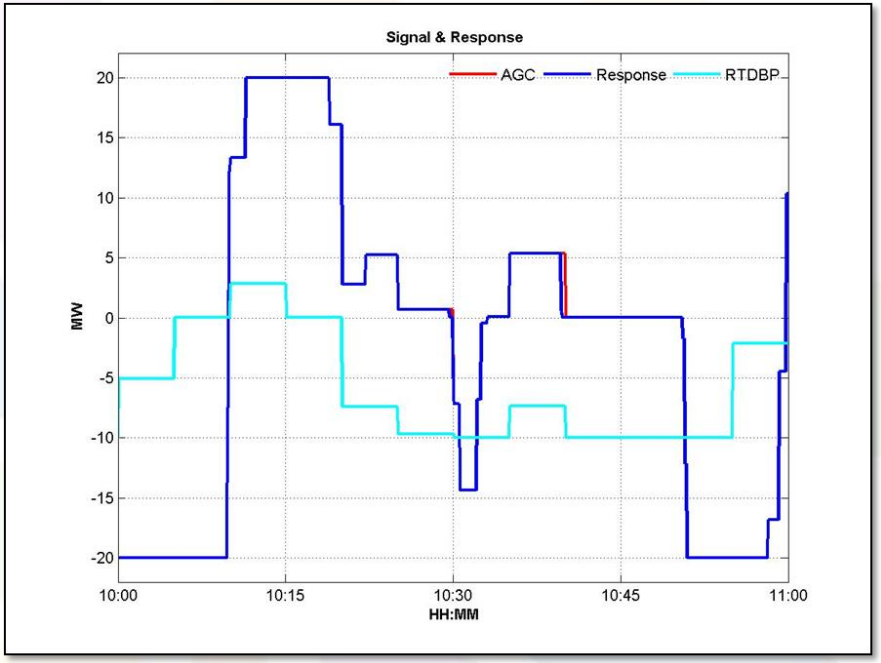
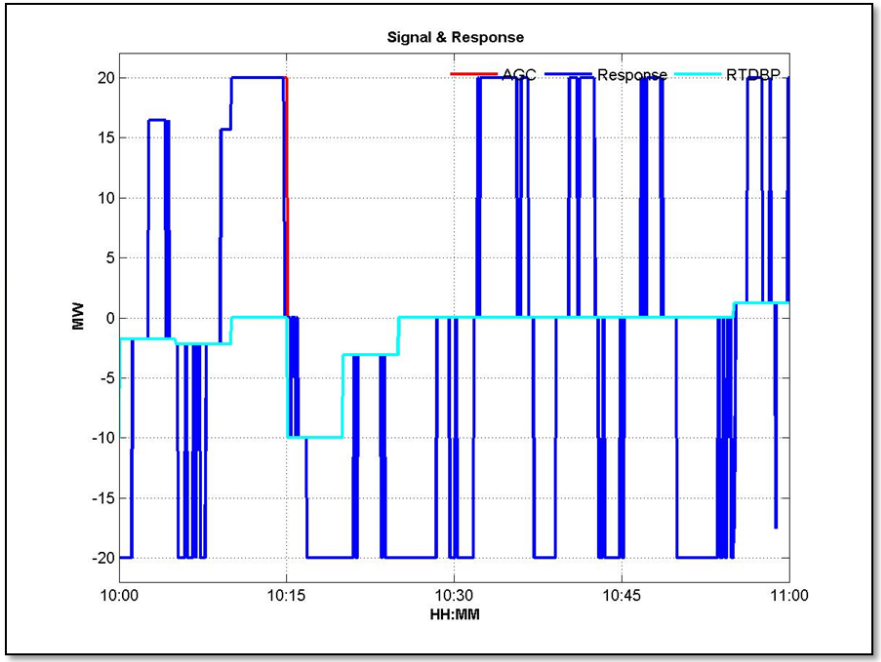
- Regulation Dispatch - Divided into 5 equal groups, based on number of resources
  - First group (fastest ramp rates) moved first, once maxed out, then move subsequent groups, sequentially

Currently: Slow, infrequently moving signal for Fast Storage, ~10-12 miles/MW/hr



In Development: Fast, frequently moving signal, could be many more miles/MW/hr



Drivers for Storage in MISO

- MISO AGC Fast Signal For Regulation Resources
- Renewable Integration
- State Initiatives
  - Ex. Minnesota Energy Storage Study

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New York

Energy Storage Initiatives in NYISO

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- Created asset type: Limited Energy Storage Resource (LESR)
  - Short duration, can provide Regulation only
- NYISO does 5 minute State of Charge management (similar to MISO)
  - Results in “effective capacity” less than nameplate
- Modified Regulation dispatch to take advantage of high speed response
  - Regulation resources provide their ramp rate
  - Dispatch signal takes that into account, resource-specific signals
- Settle net energy at wholesale nodal price; excluded from station power charges
- Minimum Regulation resource size: 1 MW

NYISO Regulation Market

- Market Size: ~215 MW
- Market Clearing – single part – add two offers and ISO-calculated LOC
- Regulation Prices: Single, marginal resource sets both prices
- Resource revenue depends on accuracy and amount of mileage
  - Accuracy: 30 second sampling of signal and response, expected value = ???
  - Mileage volume: ???
    - Dispatch is pro rated based on ramp rate

Drivers for Storage in NY

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- Funding
  - New York State Energy Research and Development Authority (NYSERDA)
  - NY Prize – Microgrids
  - NY Green Bank
- Utility tariffs / incentives
  - Customer bill management – demand charges
  - Con Edison Demand Management Program – storage incentives
- NY Public Service Commission (PSC) "Reforming the Energy Vision" (REV) initiative
  - REV: Re-invention of the grid, create competitive distribution services market
    - Enhanced customer knowledge and tools, reduce bills, market animation, system reliability and resiliency, reduce carbon emissions
    - Distributed Energy Resource (DER) demonstrations, non-wires T&D projects, microgrids, et al.
- NYISO rules?? –Behind The Meter (BTM) Net Generation initiative, DER integration

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Ontario

Energy Storage initiatives in Ontario

- Regulation Pilot RFP 2012
  - 10 MW (4 MW Battery, 4 MW Demand Response, 2 MW Flywheel)
- Ontario Long Term Energy Plan(LTEP 2013)
  - Target: 50 MW procurement
  - Phase 1: 33.5 MW (procurement complete)
  - Five companies
  - Projects include battery, flywheel, hydrogen and thermal storage technologies
  - Phase 2: 16.5 MW (ongoing: results Fall 2015)

Ontario Storage Initiatives

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- Ontario Smart Grid Fund
  - 17 projects were offered support ($23.7 million)
  - Six projects with storage, 3 microgrids)
    - 3 Energy storage: Peak management, grid reliability, and increased renewable energy penetration, electric vehicle integration and improve grid stability /reliability, system congestion and sudden connect/disconnect of electric vehicles
    - 3 Microgrids: integrating renewable energy,backup power during a utility power outage,smart metering technology, energy storage, renewable distributed generation and electric vehicles

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Drivers for Storage in Ontario

- Renewable Integration(RI)
- Surplus Baseload Generation(SBG)
- Conservation and Demand Management (CDM) initiatives
- Cap-and-Trade
- Regulatory mandate
  - LTEP 2013 (remove barriers, 50 MW procurement, opportunities to integration energy storage with renewable energy projects larger than 500 kW)
  - Minister of Energy Directive, April 22,2015 (review outcomes of 50 MW storage, options to integrate storage in Ontario electricity market place)

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