Silicon Valley Energy Storage Symposium

May 30, 2012
Microsoft Auditorium
Mountain View, California

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LOCAL INDUSTRY BRIEFING

Eric Wesoff
Editor in Chief
Greentech Media
Silicon Valley
Energy Storage Symposium

May 30, 2012
Microsoft Auditorium
Mountain View, California
CalCharge
Energy Storage Innovation Catalyst

Doug Davenport, LBNL
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LBNL, CalCEF, and a few founding partners will launch CalCharge to accelerate the pace of battery innovation in California.

- In-Lab Collaboration
- Professional Development
- Market & Policy Intelligence
- Economic Resources
Our Goal: Form California’s “Center of Gravity” for battery innovation in Silicon Valley.

The critical ingredients are all here

- 30+ emerging battery technology companies
- World-class R&D resources and institutions
- 1st in CleanTech investment and patent filings
- Enlightened policy, early adopter culture
- Leadership in clean technology development

CalCharge strives to bring them together
A Platform for Energy Storage Innovation

- Collaboration with leading battery scientists
- Access lab-grade resources for development
- New development partnerships and collaborations
- Links to incubators, commercialization, and field trial partners
World Class Science & Engineering

- Largest group of battery development scientists, anywhere
- True experts in Li-ion cells, flow cells, and advanced batteries
- Lab-scale battery fabrication, testing, and development facilities
- World-class user facilities in materials development and microscopy
- Industry-oriented approach to collaboration
- Interdisciplinary materials, chemistry, systems, applications
Supporting the Energy Storage Industry

Bringing Technical, Market, and Policy matters into conversation with members

- Battery University
  - Advanced training in battery design & applications

- Informative webinars & networking
  - Core partner in SV Energy Storage Summit 2013
  - Local networking events and topical webinars
Joining CalCharge

- Collaboration mechanisms for members
  - Eliminates contracting delays, assures confidentiality

- New dedicated lab space and testing equipment for CalCharge collaboration

- Strategic agreements with other regional institutions in the works

- CalCharge will participate in proposed ANL/LBNL-led DOE Energy Storage Hub
Joining CalCharge

Initially reaching...
- Emerging Battery Companies: developing innovations for devices, transport, grid
- Large Battery Producers: interested to support development of technology and talent

Potential Additional Members
- Major Battery Users: transportation, grid, consumer sector companies that drive needs and opportunities
- Policy Makers: government leadership shaping the direction of energy storage applications
- Local Economic Development: business incubators and accelerators, workforce development
For membership, please contact:

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Paul Frankel at CalCEF
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PANEL DISCUSSION:
Grid-Level Storage

Edward Cazalet, MegaWatt Storage Farms
Haresh Kamath, EPRI
Jon Eric Thalman, Pacific Gas & Electric
Amy Guy Wagner, Energy & Environmental Economics
David Rummler (moderator), CleanTech Strategy Group and Stanford University Civil & Environmental Engineering
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Joint Venture
SILICON VALLEY
Steve Berberich
President and Chief Executive Officer
California Independent System Operator Corporation
CALIFORNIA ENERGY STORAGE POLICY BRIEFING

Janice Lin
Managing Partner, Strategen Consulting, LLC
Executive Director, California Energy Storage Alliance
Strategen Overview

We combine strategic thinking with deep industry expertise to create profitable businesses

Strategen Core Team

Partners

- Technology Specialists
- Structured Finance
- Controls & Smart Grid
- Project Developers
- Tariff and Rate Specialists

Clean Tech Manufacturers / Service Providers

Corporations Exploring Clean Energy Opportunities

Private Equity / VC Firms Investing in Clean Tech

A sampling of our clients:

- CESA
- Chevron Energy Solutions
- DMF
- FMC
- Hudson Clean Energy
- Fluidic Energy
- GAF
- Bosch
- Recurrent Energy
- Echo
- Rockport Capital
- 3M
- Walmart
- Sharp
- Redwood City Saltworks
- Satcon
- SunPower

U.S. Department of Energy
Why California?

**Energy Storage is fundamental to many key California policy initiatives**

» BIG: 13% of US GDP, 8th largest economy in the world, ahead of Canada and Spain.

» ‘Foundational’ Legislation
  - Energy Storage Procurement Targets: (AB 2514)
  - RPS Legislation (SB X1-2)
  - Self-Generation Incentive Program: SGIP (SB 412, AB1150)
  - Smart Grid Systems (SB 17)
  - Global Warming Solutions Act of 2006 (AB 32)
  - Solar Energy System Incentives: CSI (SB 1)

» Pro-storage policy makers: Governor’s office, CPUC, CAISO, CEC & CARB

» Incentives available for customer sited applications via SGIP (~$450M) and PLS ($32M)

» Storage key to renewable integration – new wholesale products under development (CAISO)

» Many CA storage projects currently underway

**CESA is driving results-oriented change in all of these areas**
About CESA

Our Mission: *Expand the role of storage technology to promote the growth of renewable energy and create a cleaner, more affordable and reliable electric power system*

» Core principles for a healthy market – diversity is important!
  ▪ Technology neutrality
  ▪ Ownership/business model neutrality

» Explicit support of renewable energy in our mission...and our membership

» Philosophy of ‘coalition building’ with *all* stakeholders (especially utilities) – strength in diversity

» We have limited resources, and so must be very focused in our efforts
  ▪ California Legislature
  ▪ CPUC
  ▪ CAISO
  ▪ CEC
  ▪ CARB
  ▪ FERC
### Role for All Storage Technologies on the Grid

<table>
<thead>
<tr>
<th>Technology Classes</th>
<th>Energy Storage Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Storage</strong></td>
<td><strong>Sodium Sulfur Battery</strong></td>
</tr>
<tr>
<td></td>
<td>• Electrical energy is stored for later use in chemical form. Existing battery technologies are being improved, and new battery technologies are becoming available.</td>
</tr>
<tr>
<td></td>
<td>• Example: 34 MW Sodium Sulfur Battery — 51 MW wind farm, Japan (NGK)</td>
</tr>
<tr>
<td><strong>Thermal Storage</strong></td>
<td><strong>Chilled Water Storage</strong></td>
</tr>
<tr>
<td></td>
<td>• Combustion turbines’ efficiency is dependent upon the temperature of the air taken into the turbine. Water chilled during off-peak hours can greatly increase their efficiency by pre-cooling the air before intake.</td>
</tr>
<tr>
<td></td>
<td>• Example: 23,700 tons of chilled water for a 1300MW Warren County, Virginia CCCT</td>
</tr>
<tr>
<td><strong>Mechanical Storage</strong></td>
<td><strong>High Speed Flywheel</strong></td>
</tr>
<tr>
<td></td>
<td>• Flywheels convert electrical energy to kinetic energy, then back again very rapidly. Flywheels are ideal for power conditioning and short-term storage.</td>
</tr>
<tr>
<td></td>
<td>• Example: 3 MW Mechanical Storage for Ancillary Services — NE ISO (Beacon Power)</td>
</tr>
<tr>
<td><strong>Bulk Mechanical Storage</strong></td>
<td><strong>Below Ground Compressed Air</strong></td>
</tr>
<tr>
<td></td>
<td>• Electricity is used to compress air into small or large modular storage tanks or a large underground cavern. The compressed air is used to spin turbines when electricity is needed.</td>
</tr>
<tr>
<td></td>
<td>• Example: 115 MW Compressed Air Energy Storage — McIntosh, Alabama</td>
</tr>
<tr>
<td><strong>Bulk Gravitational Storage</strong></td>
<td><strong>Pumped Hydro</strong></td>
</tr>
<tr>
<td></td>
<td>• Excess electricity is used to pump water uphill into a reservoir. When power is needed, the water can run down through turbines, much like a traditional hydroelectric dam.</td>
</tr>
<tr>
<td></td>
<td>• Example: 1,532 MW Pumped Hydro — TVA’s Raccoon Mountain</td>
</tr>
</tbody>
</table>
CESA Vision for California

Storage creates a more efficient, cleaner, smarter grid!

Current Grid Infrastructure
- Built for load and generation peaks that occur only a few times per year
- Massive fossil storage required

Future Grid Infrastructure
- Strategic buffers level generation and load, reducing unevenness (Mura) and overburden (Muri)
- Result: more efficient & reliable electrical system

1. The approach is similar to Heijunka in the Toyota Production System, which levels production schedules in order to reduce overall waste

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CESA’s Top 2012 Policy Priorities

» Build a Robust Market Foundation *(CPUC)*
  » Implement AB 2514 - Comprehensive Storage Rulemaking *(CPUC)*: appropriate procurement targets, applications, priorities, cost-effectiveness
  » Achieve multi-year procurement – Resource Adequacy Rulemaking

» Behind the Meter Incentives and Value Proposition *(CPUC)*
  » Implement Self-Generation Incentive Program ~$400M budget
  » Implement Permanent Load Shifting Program ~$32M budget
  » Access Ancillary Services markets *(with CAISO)*

» Comparable Treatment in Wholesale Markets *(CAISO)*
  » Implement Pay for Performance robust implementation of FERC Order 755
  » Various Flexible Dispatch Initiatives - REM, flexible dispatch, FERC Order 745 demand response

» Promote Energy Storage as a Mainstream Energy Resource *(all)*: educate policymakers and stakeholders in all relevant proceedings, legislation:
  - 33% RPS implementation
  - AB32 GHG rules
  - Federal ITC*
  - Calif. Loading Order
  - Flexible dispatch rules
  - FERC proceedings*

* with ESA Advocacy Council
AB 2514 – Landmark New Storage Bill

AB 2514 considers procurement targets for new storage capacity

» Considers establishing Energy Storage Procurement Targets for 2015 and 2020 (2016 and 2021 for POUs)
  » IF cost-effective
  » IF commercially available
» Sponsored by Jerry Brown, former California Attorney General, now Governor
» Authored by Assembly member Nancy Skinner, Chair, Assembly Rules Committee
» Directs CPUC to convene a proceeding to evaluate energy storage procurement targets:
  ▪ Technology neutral – but must be cost-effective
  ▪ Application neutral – key to implementation
  ▪ Utility-owned, customer-owned, and third party-owned are eligible
  ▪ Applies to systems installed after 1/1/10
  ▪ Requires CPUC to consider info from CAISO and integration of storage with other programs, including demand side management
  ▪ Electrical corporations with <60k customers are exempt
» Status – signed into law 9/29/10, implementation underway at CPUC!!

AB 2514 provides necessary focus on storage
How AB 2514 is being implemented...

The CPUC is has been very proactive in implementing the Storage Bill.

Key: Happened Legislative Milestone
Status of AB 2514 Implementation Right Now ...

1. Final Energy Storage Framework Staff Proposal issued 4/3/12

2. Informal collaboration meetings with CPUC staff and investor owned utilities underway
   - Achieve consensus terminology/definitions
   - Framework for identifying and prioritizing applications
   - Discuss approach to cost-effectiveness methodology/analysis
   - Brainstorm barriers/policy options

3. Next steps:
   - Expect Phase 1 Proposed Decision sometime this summer. Then on to Phase 2!
Incentives Are Critical to Align Current Costs & Benefits

Distributed storage has many value streams that can’t be directly monetized by the end user.

Market transformational incentives for distributed storage will enable the vision for California’s future clean energy supply.
Self-Generation Incentive Program History

Evolution of the SGIP

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>SGIP established to implement AB 970. Creates financial incentives for distributed generation technologies that provide “energy conservation demand-side management and other initiatives in order to reduce demand for electricity and reduce load during peak demand periods.”</td>
</tr>
<tr>
<td>2002</td>
<td>D. 01-03-073</td>
</tr>
<tr>
<td>2005</td>
<td>AB 2778 Extended SGIP through 1/1/12. Limited eligibility to wind and fuel cell DG technologies</td>
</tr>
<tr>
<td>2006</td>
<td>D.08-11-044 Energy storage systems eligible only when coupled with eligible wind or fuel cells, including pre-existing wind or fuel cell projects</td>
</tr>
<tr>
<td>2007</td>
<td>AB 1150 Clarifies intent of SGIP for energy storage, and extends funding by three years (2012-2014)</td>
</tr>
<tr>
<td>2008</td>
<td>Final Decision - SB 412 Implementation CPUC Final Decision Implementing SB412 Standalone storage and storage + PV is eligible!</td>
</tr>
<tr>
<td>2009</td>
<td>SB 412 Signed Extends program through 12/16 and restores CPUC authority to add new technologies to SGIP. Effective 1/1/10</td>
</tr>
<tr>
<td>2010</td>
<td>D.02-04-004 CPUC Opinion reveals that “Legislature expressed no guidance on the extent or scope of incentives for distributed generation.”</td>
</tr>
<tr>
<td>2011</td>
<td>D.06-01-047 California Solar Initiative Established Removes all PV incentives from SGIP and creates CSI program, also administered by the CPUC</td>
</tr>
</tbody>
</table>

The SGIP was the ‘birth-place’ of the CSI, and is equally important for storage (storage has no other incentives)
SGIP Incentive Program – 2012

**Funding Structure**

<table>
<thead>
<tr>
<th>System Size</th>
<th>Incentive Structure</th>
<th>Renewable and Waste Energy Recovery</th>
<th>Non-renewable Conventional CHP</th>
<th>Emerging Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Wind Turbine</td>
<td>• Internal Combustion Engine – CHP</td>
<td>• Advanced Energy Storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Waste Heat to Power</td>
<td>• Microturbine – CHP</td>
<td>• Biogas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pressure Reduction Turbine*</td>
<td>• Gas Turbine – CHP</td>
<td>• Fuel Cell (CHP or Electric Only)</td>
</tr>
<tr>
<td>0-1 MW</td>
<td>100%</td>
<td>$1.25</td>
<td>$0.50</td>
<td>$2.00</td>
</tr>
<tr>
<td>1-2 MW</td>
<td>50%</td>
<td>$0.63</td>
<td>$0.25</td>
<td>$1.00</td>
</tr>
<tr>
<td>2-3 MW</td>
<td>25%</td>
<td>$0.31</td>
<td>$0.13</td>
<td>$0.50</td>
</tr>
</tbody>
</table>

*Includes, but is not limited to any small turbine generator installed in an existing, man-made channel for delivery of water, steam or natural gas.

50% of the incentive is paid upfront, 50% is a performance-based-incentive (PBI) paid over 5 years. Systems under 30kW get all incentive payments upfront. For more program details, see:


- AES can participate in either bucket depending on if it is standalone or coupled with renewable or non-renewable generation!
- Any installation provided by a California supplier will receive an additional 20% incentive.
- Incentives in the “Emerging Technologies” category decline at 10% per year beginning 2013.
SB 412 Implementation: D.11-09-015

Current SGIP handbook is very favorable to Energy Storage.

<table>
<thead>
<tr>
<th>AES General Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size Restriction:</strong></td>
</tr>
<tr>
<td>» Maximum size: A standalone system can be no larger than the host customer’s previous 12-month annual peak demand at the proposed site. A generation-paired system can be no larger than the generation system it is paired with.</td>
</tr>
<tr>
<td>» Must meet onsite load – Max. 25% export to grid</td>
</tr>
<tr>
<td><strong>Discharge Capacity Criteria:</strong></td>
</tr>
<tr>
<td>» Rated Capacity = average discharge kW over 2 hours</td>
</tr>
<tr>
<td>» Standalone systems must be able to discharge once per day.</td>
</tr>
<tr>
<td>» Wind-coupled projects must be able to handle “hundreds” of partial discharge cycles per day.</td>
</tr>
<tr>
<td><strong>Incentive Payment Method:</strong></td>
</tr>
<tr>
<td>» Tech Based, 50 % up front, 50 % PBI (100% up front if &lt;30kW)</td>
</tr>
<tr>
<td>» Incentive calculations are separate for companion technologies</td>
</tr>
<tr>
<td><strong>Minimum Required Round Trip Efficiency (AC to AC)</strong></td>
</tr>
<tr>
<td>» 67.9%</td>
</tr>
<tr>
<td><strong>Capacity Factor (% total yearly capacity the system is in operation)</strong></td>
</tr>
<tr>
<td>» 10%</td>
</tr>
<tr>
<td><strong>Cost Cap</strong></td>
</tr>
<tr>
<td>» Applicants must pay a minimum of 40% of the eligible project cost</td>
</tr>
<tr>
<td>» $5 million maximum incentive amount per project</td>
</tr>
<tr>
<td><strong>Warranty Requirement</strong></td>
</tr>
<tr>
<td>» All SGIP-eligible systems must have a minimum 10 year warranty on all major components of the system that are eligible for the incentive which covers the cost of repair or replacement.</td>
</tr>
</tbody>
</table>

All systems must meet the Institute of Electrical and Electronics Engineers, Inc. interconnection standards and comply with all local environmental and air quality requirements.
Energy storage is doing well in the SGIP!

**Program Administrator (PA) | Annual Budget**
--- | ---
Pacific Gas and Electric Company | $33,480,000
Southern California Edison | $26,040,000
California Center for Sustainable Energy | $10,230,000
Southern California Gas Company | $7,440,000
Total | **$77,190,000**

**Remaining CCSE Funding $**
- AES Standalone, $1,003,200
- AES Plus PV, $2,055,640
- Pressure Reduction Turbine, $1,037,500
- Fuel Cell, $729,000
- Remaining Renewable, $7,729,412
- Remaining Non-Renewable, $5,416,484

**Number of CCSE SGIP Applications**

- Pressure Reduction Turbine
- Fuel Cell
- AES Plus PV
- AES Standalone

**CCSE kW to be Installed**

- Pressure Reduction Turbine
- Fuel Cell
- AES Plus PV
- AES Standalone

* CCSE data as of 4/30/12

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SGIP’s Future is Assured: AB 1150 (Perez)

**AB 1150** authorized new funding and extend the SGIP beyond 2012

» Signed into law by Governor Brown September 22, 2011

» Authorizes the extension $83M/year of rate-payer based funding through December 31, 2014 ($249 million, total)

» Statutorily clarifies eligibility of energy storage (Section 1. 379.6 a(1)):

*It is the intent of the Legislature that the self-generation incentive program increase deployment of distributed generation and energy storage systems to facilitate the integration of those resources into the electrical grid, improve efficiency and reliability of the distribution and transmission system, and reduce emissions of greenhouse gases, peak demand, and ratepayer costs.*
$32 million program: Permanent Load Shifting (PLS)

- New category created by CPUC in 2006 recognizing that storage (particularly thermal storage) is similar to DR but has different benefits, costs, markets and performance.*
- PLS programs reauthorized and significantly increased by IOUs and CPUC 4/19/12 to $32 million for 2012-2014 (rough doubling of current annual budgets).
  - Nearly all $ are directly for incentives of $250-$500(-$1000?)/kW to end users investing in qualifying PLS
  - Recognition that “not all of the benefits of PLS are accurately captured in the [current] cost-effectiveness protocols.”
  - New directive to IOUs to standardize PLS programs statewide; CESA will be at the center of that process over coming 2-3 months
  - IOUs authorized to transfer money into PLS from other programs if/as needed, but not vice versa (economic recovery, SONGS shutdown underscores need for additional PLS resources)
- PLS category and incentives may get folded into broader storage category/incentives when comprehensive AB 2514-authorized storage rulemaking is completed.

<table>
<thead>
<tr>
<th>IOU</th>
<th>2012-14 Budgets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Gas and Electric</td>
<td>$15,000,000.</td>
</tr>
<tr>
<td>Southern California Edison</td>
<td>$14,000,000.</td>
</tr>
<tr>
<td>San Diego Gas &amp; Electric</td>
<td>$3,000,000.</td>
</tr>
<tr>
<td>Total</td>
<td>$32,000,000.</td>
</tr>
</tbody>
</table>

* “…PLS involves [on a recurring basis] storing electricity produced during off peak hours and using the stored energy during peak hours to support loads.”

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Lots going on at CAISO!

» **Regulation Energy Management** – V2.1 implementation underway (Plan published 3/11/12)

» **Pay for Performance** (FERC Order 755 implementation) – capacity and performance payments expected Spring 2013

» **Flexible Ramping Product** – ramping procurement for 5 min RTD imbalances. Technical conference 5/29/12

» **Flexible Capacity Procurement** – Proposal introduced 1/12 – will be part of 2013 RA proceeding at CPUC

» **Demand Response** – (FERC Order 745 implementation) - on hold for now; FERC rejected CAISO tariff filing as non-compliant; new proposal in the works

» **DG Deliverability** – Board of Governors approved new proposed RA assessment and deliverability methodology for DG 5/16/12
California Applications: Compensation Timeline

Top California storage applications will become increasingly attractive as economic incentives and markets come online

- **Now**
  - SGIP: $2/W Incentive Program

- **2013**
  - FITC: 30% Investment Tax Credit if ESS Paired with PV

- **2014**
  --wholesale Energy MKT.: ESS Retail Participation in CAISO A/S Market (Proxy Demand Response)

- **2015**

- **2016**
  - Utility Side of the Meter
    - *Resource Adequacy contracts are procured on an annual basis. All other wholesale markets are day ahead.*

- **2017**
  --wholesale CAPACITY MKT.: Utility/IPP ESS Peakers bid into CAISO Capacity Markets

- **2018**
  - RPS: T/D and imbalance penalties associated with 33% RPS

- **2019**
  - Resource Adequacy: ESS owners/developers sell R.A. via bi-lateral contracts with utilities

- **2020**
  - FERC Accounting Standards: FERC creates accounting standards for storage to facilitate ratebasing

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Shaping our future in California....

California’s regulatory framework is rapidly evolving to accelerate deployment of grid storage

» CAISO Flexibility Implementation, REM, Flexible Ramping, Flexible Capacity
» CAISO Pay for Performance Implementation regulation (FERC Order 755)
» CPUC Storage Rulemaking pursuant to AB 2514
» CPUC Long Term Procurement Planning (LTPP), Renewable Integration
» CPUC Resource Adequacy (RA)
» CPUC Self-Generation Incentive Program (SGIP)
» CPUC Standard Offer for Permanent Load Shifting (PLS)
» CPUC Smart Grid Deployment
» CPUC General Rate Cases – Storage friendly tariffs
» CEC Integrated Energy Policy Report – includes storage

Be the master of your own destiny, get involved!
Questions?

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For more information about CESA membership, public filings, and other energy storage educational documents, please visit us online at:

www.storagealliance.org
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Imre Gyuk

U.S. Department of Energy
Energy Storage Research Program Manager
Progress in Grid Energy Storage

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE

Si-Valley 05– 30-12
Energy Storage provides Energy when it is needed just as Transmission provides Energy where it is needed
29 U.S. States have Renewable Portfolio Standards (RPS) Requiring 10-40% Renewables

On Peak Wind - the Reality!

Cost effective Energy Storage yields better Asset Utilization
Some Large Energy Storage Projects:

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Year</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>27MW / 7MWh</td>
<td>1995</td>
<td>Fairbanks, AL</td>
</tr>
<tr>
<td>34MW / 245MWh</td>
<td>2008</td>
<td>Rokkasho, Japan</td>
</tr>
<tr>
<td>20MW / 5MWh</td>
<td>2011</td>
<td>Stephentown, NY</td>
</tr>
<tr>
<td>32MW / 8MWh</td>
<td>2011</td>
<td>Laurel Mountain, WV</td>
</tr>
<tr>
<td>14MW / 63 MWh</td>
<td>2011</td>
<td>Hebei, China</td>
</tr>
<tr>
<td>8MW / 32MWh</td>
<td>2012</td>
<td>Tehachapi, CA</td>
</tr>
<tr>
<td>25MW / 75MWh</td>
<td>2013</td>
<td>Modesto, CA</td>
</tr>
</tbody>
</table>

Worldwide – CNESA

<table>
<thead>
<tr>
<th>Year</th>
<th>Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 May</td>
<td>370MW</td>
</tr>
<tr>
<td>2011 Aug.</td>
<td>455MW</td>
</tr>
<tr>
<td>2011 Nov.</td>
<td>545MW</td>
</tr>
<tr>
<td>2012 Feb.</td>
<td>580MW</td>
</tr>
<tr>
<td>2012 Apr.</td>
<td>590MW</td>
</tr>
</tbody>
</table>

Annual new Deployment

2011 : 121MW

→ 2021 : 2,353MW

(Pike Research)
ARRA Stimulus Funding for Storage Demonstration Projects ($185M)

A ten-fold Increase in Power Scale!

Large Battery System (3 projects, 53MW)
Compressed Air (2 projects, 450MW)
Frequency Regulation (20MW)
Distributed Projects (5 projects, 9MW)
Technology Development (5 projects)

533MW - $585M Costshare!
Large Batteries for Wind Integration

Coincident BPA Wind Ramps

Feb. 24, 2007: 500MW / 2.5hr; 30x Spotprices
NREL: $\Delta = 25\%$ @ 2 days, $\Delta = 50\%$ @ 1 week

3 Large Battery + Wind Projects = 53MW in Stimulus Package!
Installing a 25 MW / 3hr battery plant for the Modesto Irrigation District in CA, providing equivalent flex capacity to 50 MW of natural gas engines costing $73M.
ARRA - Southern California Edison / A123 – Li-Ion:

8 MW / 4 hr battery plant for wind integration at Tehachapi, CA.

A Tehachapi Wind Field

8MW Storage Plant under Construction
ARRA – Duke Energy / Xtreme Power

36MW / 40 min battery plant

Ramp control, wind smoothing

Linked to 153MW Wind farm at No-Trees, TX
**Xtreme Power, Kahuku Wind Project**

Largest North American Installation with Wind

<table>
<thead>
<tr>
<th>Location</th>
<th>Oahu, HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Wind</td>
</tr>
<tr>
<td>DPR™</td>
<td>15 MW / 10 MWh</td>
</tr>
<tr>
<td>COD</td>
<td>Q1 2011</td>
</tr>
<tr>
<td>Services</td>
<td>Ramp Control, Voltage Regulation</td>
</tr>
</tbody>
</table>

This DPR™ will operate on a 30 MW wind farm on the island of Oahu to meet PPA ramp control and smoothing requirements.
Current method to balance constantly shifting load fluctuation is to vary the frequency and periodically adjust generation in response to an ISO signal. Fast storage can respond instantaneously!
Key Outcomes (PNNL Study, 2012)

When additional renewables are planned, a certain amount of storage or fast-ramping generation is also needed to firm the variable renewable power.

- For every unit of wind capacity power, approximately 0.08 to 0.15 units of intra-hour balancing (minute-to-minute variability) need to be added.

<table>
<thead>
<tr>
<th>Intra-hour balancing power requirements caused by wind variability only</th>
<th>MW storage</th>
<th>as a percentage of average demand</th>
<th>as a percentage of peak demand</th>
<th>as a percentage of installed wind capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ-NM-SNV</td>
<td>174.08</td>
<td>1.0</td>
<td>0.5</td>
<td>12.8</td>
</tr>
<tr>
<td>CA-MX</td>
<td>943.65</td>
<td>2.5</td>
<td>1.4</td>
<td>14.4</td>
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<tr>
<td>NWPP</td>
<td>1,071.26</td>
<td>2.1</td>
<td>1.5</td>
<td>11.0</td>
</tr>
<tr>
<td>RMPA</td>
<td>504.89</td>
<td>5.6</td>
<td>3.6</td>
<td>8.0</td>
</tr>
</tbody>
</table>
FREQUENCY REGULATION

DOE Loan Guarantee – Beacon:
20MW Flywheel Storage for Frequency Regulation in NY-ISO
20MW commissioned July 2011

DOE Loan Guarantee – AES / A123:
20MW Lithium Ion Battery for Frequency Regulation in NY-ISO
8MW on Line!
AES, Laurel Mountain, WV - 32 MW Storage
less than 1 acre, no emissions
Integrated with 98MW Wind Farm
Compressed Air Energy Storage
2 CAES Projects

Inexpensive Off-Peak Power to Compress Air for Storage in Aquifers, Salt Domes, Caverns, or abandoned Gas Wells. On-Peak, Compressed Air is used as Input for Gas Turbine Compressor, increasing Efficiency

McIntosh, Alabama, 1991, 110 MW
Huntdorf, Germany, 1978, 290 MW
ARRA – PG&E:

300 MW / 10hr Compressed Air Energy Storage Facility in Tehachapi, CA

Depleted Gas Wells

Gas Pipe Line

Existing 500kV Transmission Line

4 500 MW New Wind in 4-5 Years

Location of Wind Resources

Location of Depleted Gas Fields
ARRA – Public Service NM:
500kW, 2.5MWh for smoothing of 500kW PV installation; Using EastPenn Lead-Carbon Technology

Commissioned Sep. 24, 2011
Integrator: Ecoult

ARRA – EastPenn, PA:
3MW Frequency Reg for PJM
1MW 1-4hrs Load Management during Peak Periods

Commissioning June 2012

PbC Testing at Sandia
Detroit Edison, ARRA Community Energy Storage Project

20 Units
each 25kW / 2hr
Coupled with 500kW PV
and 500kW / 30min Storage

Monrovia County Community College

Dow Kokam Battery
S&C Inverter
ARRA - Enervault:
250kW/4hr Fe-Cr Flow Battery for PV

PV: 300 kW
Storage: 250 KW
Peak output: 450kW
Storage Cost: +16%
Storage Value: +84%

Tracking PV in Almond Grove

Flow Battery Prototype

Leveraging PV with Storage
ARRA Distributed Project:

Installation of 5 Transflow 2000 500kW ZnBr Battery Systems at locations within SMUD and National Grid Utility Districts:

- 2 units at a substation in Syracuse
- 1 unit at Syracuse University
- 1 unit at SMUD HQ microgrid
- 1 unit at SMUD Solar Smart Homes Project
ARRA - Aquion Energy: Aqueous Sodium Ion Battery

- Cost Goal: <$200/kWh
- Lifetime cost: <$0.10/kWh
- Ubiquitous, low cost precursors
- Inexpensive manufacture
- Roundtrip Efficiency >85%
- 5000 cycles demonstrated
ARRA - SustainX: Totally green Isothermal CAES

Awards: GE Ecomagination, Clean Tech 100 in 2010 / 11

A site-anywhere solution – eliminates lengthy siting and risk associated with geologic storage

Superior thermodynamics – eliminates reliance on natural gas

Isothermal efficiency of 95% compared with 54% for adiabatic technique

Higher pressure and efficiency make pipe-type storage cost effective

A patented and demonstrated, low-cost, long lifetime energy storage solution
Energy Storage Project Database

A publicly accessible database of energy storage projects world-wide, as well as state and federal legislation/policies

http://www.energystorageexchange.org/

DOE/EPRI Energy Storage Handbook

Partnership with EPRI and NRECA to develop a definitive energy storage handbook:
• Details the current state of commercially available energy storage technologies.
• Matches applications to technologies
• Info on sizing, siting, interconnecting
• Includes a cost database
ES-Select: Energy Storage Selection Tool

- A tool for high-level decision makers to facilitate planning for ESS infrastructure:
  - High-level technical and economic review of storage technologies
  - Determine and size applicable energy storage resources
  - Develop a preliminary business case
- Educate potential owners, electric system stakeholders and the general public on energy storage technologies
- Developed by KEMA

Storage Guidebook for Regulatory Officials

- Inform regulators about Storage benefits
- Provide information on technical aspects of Energy Storage Systems
- Identify regulatory challenges to increased Storage System deployment
- Suggest possible responses/solutions to challenges
- Develop model PUC submissions requesting approval of rate base addition
- Advisory Committee comprised of industry and government experts
Development of a Protocol to Measure and Report Performance of Energy Storage technology

• We need a common language for technology providers and prospective users
• No uniform acceptable criteria exist for comparable statements of performance
• This causes confusion in the market and adversely affects technology acceptance
• DOE is leading an effort to develop an initial protocol (pre-standard)
  • Formation of representative stakeholder group
  • Clarification of anticipated application and use of the protocol by industry
  • Develop a pre-standard with reasonable consensus
  • Ongoing support as technology evolves

Collaboration with Clean Energy States Alliance

• Webinar Series on Policy Issues related to Energy Storage
• Provide information on technical aspects of Energy Storage Systems
• Identify regulatory challenges to increased Storage System deployment
• Suggest possible responses/solutions to challenges
• Develop model PUC submissions requesting approval of rate base addition
• Advisory Committee comprised of industry and government experts
SNL Energy Storage System Analysis Laboratory

Reliable, independent, third party testing and verification of advanced energy technologies from cell to MW scale systems

Expertise to design test plans for technologies and their potential applications

Cell, Battery and Module Testing

• Testers to accommodate a wide range of testing applications including:
  – 14 channels from 36 V, 25 A to 72 V, 1000 A for battery to module-scale tests
  – Over 125 channels; 0 V to 10 V, 3 A to 100+ A for cell tests

Energy Storage Test Pad (ESTP)

System Testing

• Scalable from 5 KW to 1 MW, 480 VAC, 3 phase
• 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
• Subcycle metering in feeder breakers for system identification and transient analysis
• Can test for both power and energy use cases

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DOE Energy Storage Program
Aggressively Furthers
Market Pull and Technology Push:
Demonstrations and Research
Silicon Valley Energy Storage Symposium

May 30, 2012
Microsoft Auditorium
Mountain View, California
PANEL DISCUSSION: Enterprise-Level Storage

Jeff Byron, NRG Energy
Giovanni Damato, Strategen Consulting LLC
Matt Muniz, Alameda County
Kenneth Munson, Sunverge Energy
Evan Goldman (moderator), Prescience International
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SILICON VALLEY
Commissioner Cheryl A. LaFleur
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