PANEL DISCUSSION: Interagency Coordination

Karen Edson, Vice President, Policy and Client Services, California Independent System Operator Corporation

Carla Peterman, Commissioner, California Public Utilities Commission

Jon Wellinghoff, Chairman, Federal Energy Regulatory Commission

Brian Orion (moderator), Principal, Lawyers for Clean Energy
4th ANNUAL
Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors
Assistant Secretary Patricia Hoffman

U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability
Grid Storage: A Key Component to our Nation’s Energy Future

Patricia Hoffman
Assistant Secretary
Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy
www.OE.energy.gov
Electric Delivery Infrastructure

- **Today’s grid**
  - One-way power flow
  - Limited capabilities in handling new energy resources

- **New demands are driving the need for additional grid flexibility**
  - Distributed generation, variable resources
  - Emerging electrification of transportation
  - Implementation of time-based rates and load management

- **Investment is needed to modernize the grid**
  - By 2020, $76 billion of investment will be needed every year in electric infrastructure\(^1\)
  - Power quality and momentary outages result in losses as high as $80 billion/year\(^2\)

*Sources: \(^1\) ASCE, *The Failure to Act, The Economic Impact of Current Investment Trends in Electricity Infrastructure*; \(^2\) LBNL*
# DOE - OE is Focused on Addressing Several Energy Storage Challenges

## Current challenges

- Cost of energy storage systems
- Cost/Benefit ratio
- Reliability of energy storage systems
- Regulatory treatment of energy storage

## DOE - OE priorities

- Improved materials and system integration
- Utility scale demonstrations to demonstrate reliability
- Identification of benefits and accruing multiple benefits from single system
- Educate regulators, PUCs, Congressional members

---

*Silicon Valley Energy Storage Symposium*
April 11, 2013
Mountain View, California
Government Role Tapers as Industry Investment Increases

- Basic research to improve performance and safety
- Development and scale-up of technologies
- In-grid MW demonstrations with industry partners
- Widespread grid integration

Tax Incentives
Loan Guarantee
State Mandates
FERC – Order 755
Cost shared projects
Venture Capital
Grants

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Levelized Total cost of Energy Storage Technologies Relative to Combustion Turbine

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Cost Competitive Technologies

Scenario LCC Estimates

Bars Denote 2020 Cost Assumptions for Resource:
- Capital
- O&M
- Emissions
- Fuel

2011 Cost for Resource

Note: Cost ranges include key uncertainties in the 2011 and 2020 cost assumptions.

DOE investment led to almost 2x improvement in vanadium redox flow battery energy density.

2007 – Based on existing technology, PNNL initiates internal research on mixed acid electrolyte to improve VRB.

2010 – PNNL initiates patent application.

Aug 2012 – PNNL demonstrates scaled-up stack (1kW/1 kWh), at 60% higher current density.

Pre-DOE Involvement → DOE Funded Research → DOE & Private Sector

2009 – PNNL demonstrates 70% larger energy density and 80% larger temperature window.

2012 – PNNL begins licensing technology; UniEnergy founded.

2012 – PNNL wins Tech Transfer award.

2013 – Planned prototype at 300+% current density.
**History**

**DOE resources provided catalyst for commercialization and demonstration of advanced lead-acid battery systems**

1997 – Research showed integrating a Carbon Ultracapacitor with a lead-acid battery increases performance and lifetime (CSIRO, Australia), leading to UltraBattery® creation

2007 – Sandia begins testing Ultrabattery®

2009 – East Penn attains rights to CSIRO UltraBattery®

2009 – East Penn receives DOE ARRA manufacturing grant

2011 – PNM grid-scale UltraBattery® and Advanced Lead Carbon PV ARRA project commissioned

2010 – SNL testing of UltraBattery® showed 5 to 10x cycle life improvement

2012 – East Penn/PJM grid-scale UltraBattery® and frequency response ARRA project commissioned

2011– PNM grid-scale UltraBattery® and Advanced Lead Carbon PV ARRA project commissioned

**Pre-DOE Involvement → DOE Funded Research → DOE & Private Sector**
Strong public-private partnerships were key in developing grid scale projects, including two 20 MW/15 min facilities.
Two demonstration projects are providing grid support while maintaining a high level of reliability and durability

- Led development of flywheel technology for grid storage, working closely with industry, regulators, and other stakeholders
- Multiple successful demonstration projects-
  - Nov 2008 - First grid-scale flywheel demonstration project
  - June 2011 - 20 MW demonstration project fully operational
    - >24 months of commercial operation (thru Jan 2013)
    - ~ 2,000,000 hours of operation (thru Jan 2013)
- $3.32MM OE SBIR & ARPA-E grant to develop “Gen 6” 1hr hubless flywheel
- U.S. Patent awarded for Beacon’s technology
US-Frequency Regulation Could Re-Emerge as a Lucrative Market

AVERAGE FREQUENCY REGULATION PRICES BY ISO/RTO AND HENRY HUB
NATURAL GAS PRICES, 2009-12

PJM FREQUENCY REGULATION CLEARING PRICES, SEPTEMBER AND OCTOBER 2012

FERC Order 755 (pay for performance) could boost storage regulation revenues by 2-3x

Source: ISOs/RTOs, Bloomberg New Energy Finance

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Southern California Edison: Tehachapi Wind Energy Storage Project

Overview

The Tehachapi Wind Energy Storage Project (TSP) Battery Energy Storage System (BESS) consists of an 8 MW-4 hour (32 MWh) lithium-ion battery and a smart inverter system that is cutting-edge in scale and application. SCE will test the BESS for 24 months to determine its capability and effectiveness to support 13 operational uses (see sidebar).

SCE’s Demonstration Project

The Tehachapi Wind Energy Storage project will test an 8 MW-4 hour (32 MWh) lithium-ion battery and smart inverter system. This will help store energy from the existing ~5,000 wind turbines and any future additions. The major equipment used includes the following:

- 8 MW 4 hour lithium ion battery array
- Power conversion system
- Transformers
- Communication gateway
- Phasor measurement unit

The project was sited at the Tehachapi Wind Resource Area because it is one of the largest wind resource areas in the world.

Project Benefits

Transmission
- Provides voltage support/grid stabilization
- Decreases transmission losses
- Diminishes transmission congestion
- Increases system reliability by load shed deferral
- Defers transmission investment
- Optimizes renewable-energy-related transmission

System
- Provides system capacity/resource adequacy
- Integrates renewable energy (smoothing)
- Shifts wind generation output

Grid
- Frequency regulation
- Spin/non-spin/replacement reserves
- Ramp management
- Energy price arbitrage

Budget

Total Project Value: $54,856,495
DOE/Non-DOE Share: $24,978,264/$29,878,231
Value of Energy Storage Will Vary by Location

U.S. Residential Average Price per kilowatthour is 11.51 Cents

Note: Data are displayed as 5 groups of 10 States and the District of Columbia.
Intra-Hour Balancing Power Requirements

Size Requirements for Storage Technologies to Meet Additional and Total Intra-Hour Balancing Requirements for a 2020 Grid with 20% RPS

<table>
<thead>
<tr>
<th>WECC totals</th>
<th>6.3 GW</th>
<th>1.95 GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Intra-hour Balancing Requirements</td>
<td>1.53 GW</td>
<td>0.56 GWh</td>
</tr>
<tr>
<td>Additional Intra-hour Balancing Requirements</td>
<td>0.28 GW</td>
<td>0.13 GWh</td>
</tr>
<tr>
<td>Total Intra-hour Balancing Requirements</td>
<td>2.0 GW</td>
<td>0.60 GWh</td>
</tr>
<tr>
<td>Additional Intra-hour Balancing Requirements</td>
<td>0.7 GW</td>
<td>0.22 GWh</td>
</tr>
<tr>
<td>Total Intra-hour Balancing Requirements</td>
<td>0.51 GW</td>
<td>0.19 GWh</td>
</tr>
<tr>
<td>Additional Intra-hour Balancing Requirements</td>
<td>1.2 GW</td>
<td>0.45 GWh</td>
</tr>
<tr>
<td>Total Intra-hour Balancing Requirements</td>
<td>0.53 GW</td>
<td>0.18 GWh</td>
</tr>
<tr>
<td>Additional Intra-hour Balancing Requirements</td>
<td>0.21 GW</td>
<td>0.08 GWh</td>
</tr>
</tbody>
</table>

Intra-Hour Balancing Power Requirements Caused by Wind Variability in the WECC Area

<table>
<thead>
<tr>
<th>20% Wind in WECC</th>
<th>Required MW “Storage”</th>
<th>Percentage of Installed Wind Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ-NM-SNV</td>
<td>174.08</td>
<td>12.8</td>
</tr>
<tr>
<td>CA-MX</td>
<td>943.65</td>
<td>14.4</td>
</tr>
<tr>
<td>NWPP</td>
<td>1,071.26</td>
<td>11.0</td>
</tr>
<tr>
<td>RMPA</td>
<td>504.89</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Microgrids and Storage

Hourly Operability on a Microgrid

- total efficiency savings
- PHEV/EV (charge)
- battery storage (charge)
- PHEV/EV (discharge)
- battery storage (discharge)
- distributed wind
- grid power
- rooftop solar
- local combined heat and power (CHP)

load to meet
post-dispatch load

demand response shifts load to correspond to output from local renewables

efficiency reduces demand (especially at peaks)

PHEVs and batteries charge when renewable supplies are abundant, and can return this energy to the grid later

Assumed grid outage
Assumed CHP outage

grid power is used for balancing

CHP ramps to accommodate variations in wind and solar output

local CHP is ramped up at non-heating demand hours to back up the grid during an outage

grid power can help meet demand when local resources (e.g. CHP) suddenly trip offline

Source: Rocky Mountain Institute 2011
UC San Diego Microgrid

• 42 MW microgrid
• Master controller & optimization system:
  • self generates 92% of annual load
  • 95% of heating and cooling load
• 2.8 MW fuel cell
• 1.5 MW of Photovoltaics
• 2 Concentrating PV Systems
• 30 kW/30 kWh PV fully integrated storage system
• 4 Million gallon thermal storage system
Duke Energy is getting charged up about batteries

Kathleen Wolf Davis | Mar 26, 2013

By Dan Sowder, Senior Project Manager, Duke Energy

Batteries are nothing new. They've been around for more than 100 years.

But over the past few years, utility-scale battery technology has been making great strides and will likely have useful applications for the utility industry.

Duke Energy is actively testing several different applications and battery systems to determine how energy storage can make the grid stronger and more efficient. One of our battery installations, at the Rankin Substation in Mount Holly, N.C., gives a glimpse into how energy storage may ensure grid reliability in a future with more distributed, intermittent generation.

At the Rankin substation, a 402-kilowatt/282-kilowatt-hour sodium nickel chloride battery system is smoothing out large minute by minute peaks and valleys in electricity production from a 1.2-megawatt solar facility at an industrial complex about three miles away.

The system is connected to a 12.47-kV distribution circuit and is designed to detect and respond to solar-induced intermittency from any source connected to the circuit. This could include hundreds of residential rooftop solar installations dispersed across a
Grid-scale Energy Storage: Lux Research Predicts $113.5 Billion in Global Demand by 2017

http://www.luxresearchinc.com/
“We’ve got to invest in a serious, sustained, all-of-the-above energy strategy that develops every resource available for the 21st century. We’ve got to choose between the past and the future. And that's a choice we shouldn’t be afraid to make because we’ve always bet on the future, and we’re good at it. America is good at the future. We are good at being ahead of the curve. We’re good at being on the cutting edge.”

– President Barack Obama, March 15, 2012
4th ANNUAL
Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors
California Energy Storage Policy Briefing

Joshua Bar-Lev
Joshua Bar-Lev

- Special Advisor on Regulatory Strategy to Primus Power

- VP Regulatory Affairs and Government Relations for BrightSource Energy (Retired)

- Chief Counsel for PG&E

- Founder and former Chair of the Coalition for Energy Efficiency and Renewable Technology

- Federal Energy Bar Association (FEBA)

- State Bar of California

- American Bar Association (ABA)
Our Mission: *Expand the role of storage technology to promote the growth of renewable energy and make California a model for a cleaner, more efficient, and reliable power system.*

» Core principles for a healthy market – diversity is important!

- Technology neutrality
- Ownership/business model neutrality

» No advocacy for ‘advocacy sake’. We are seeking tangible market results

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

» Philosophy of ‘coalition building’ with all stakeholders – strength in diversity

» We have limited resources, and so must be very focused in our efforts
Outline

1. The Grid Connected Energy Storage Market

2. Transforming the Energy Industry is a Complex Policy Challenge at both Federal and State Levels

3. Current Energy Storage Policy & Incentives

4. The Need for Long-Term Vision
Tremendous Potential: U.S. Market, by Benefit Stream

The U.S. market potential based on utility spending is promising at $238B over 10 years, but certain applications dominate.

Application Lifetime Value ($/kW for 10yr Project Life)

Electric Bill Cost Management $98.4B

Market Reference Size = $10,000 M

Ease of Deployment
Key Forces Encouraging the Adoption And Integration of ES

Rising Energy Prices

Variable Energy Consumption

Variable Generation from Renewables

Storage-friendly Policy

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Outline

1. The Grid Connected Energy Storage Market

2. Transforming the Energy Industry is a Complex Policy Challenge at both Federal and State Levels

3. Current Energy Storage Policy & Incentives

4. The Need for Long-Term Vision
Energy Technology: From R&D to Market Success

Policy Challenges for Utility Scale Solar Projects

Congress
- Investment Tax Credit / Grant
- Loan Guarantees
- Transmission
- RPS
- Climate Change
- Land Use Issues

FERC
- Interconnection Rules
- Transmission Funding
- Transmission rates & allocation
- Reliability
- Backstop sitting
- Transmission planning

DOE
- Loan Guarantees
- Backstop sitting
- Transmission corridors
- Solar development policy
- R&D Assistance

BLM
- 299 Applications
- Solar Energy Zones
- Land use planning
- Environmental / project permit (NEPA)
- Rent
- PEIS for Southwest
- Transmission Corridors

Investors
- PPA’s
- Project & Company Financing
- On time/budget Construction, O&M
- Access to transmission / market

Lenders
- PPA
- Transmission Construction
- Interconnection Agreements
- Procurement and cost recovery

State Legislatures
- RPS
- Climate
- Generation Permitting & Siting
- Transmission Permitting & Siting
- Property Tax
- Sales Tax

State Agencies
- Approval of PPA or Purchase/Sale
- Siting and permitting of Project
- Siting and permitting of Transmission
- RPS Compliance
- Standards for Pricing (TOD/MPR)
- Standards for Gas Use
- Resource adequacy

Stakeholders
- Communities
- Consumers
- Environmentalists

California
Arizona
Nevada
New Mexico
Utah
Colorado
Texas

BrightSourceEnergy
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE
Energy Technology: From R&D to Market Success

- R&D
- Incubation
- New Tariffs
- Regulatory Programs
- Utility Procurement
- Rate Base
- Competition
- Winners / Losers
- Return for Investors
- Achieve Legislative Goals
- Economic Benefits
Energy Storage Is Complex

The grid storage “market” is very different from many traditional industries

Key Differences between ESS and traditional markets

<table>
<thead>
<tr>
<th>Application Diversity</th>
<th>There are dozens of applications, each with its own value proposition, demand curves, and business structure. Each application can have 2-4 ownership models.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most applications have multiple benefit streams</td>
<td>The rules governing the benefit streams are different for each of the different users (utility types, states, ISOs), and are governed by vastly different groups.</td>
</tr>
<tr>
<td>Regulatory/Policy/Incentive Complexity</td>
<td>Many of the benefit streams are dependent upon regulation, policy, or incentives that are still be determined. New incentives, regulations, or policies could completely change the landscape.</td>
</tr>
<tr>
<td>Geographic Diversity</td>
<td>Benefits, regulations, and payment structures vary widely by state and region.</td>
</tr>
<tr>
<td>Immature Market/Growing Pains</td>
<td>Many of the companies are still unproven. Reliability and costs of new technologies is completely unknown, even to providers themselves. Markets are immature, requires turnkey ‘solution’ – systems integration skills, and regulatory intervention</td>
</tr>
</tbody>
</table>

Major Variables

» AB2514 implementation
» FITC implementation
» Storage system reliability
» Storage system cost
» FERC Rulemakings

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Energy storage is a broad asset class…

<table>
<thead>
<tr>
<th>Technology Classes</th>
<th>Energy Storage Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Storage</td>
<td><strong>Sodium Sulfur Battery</strong>&lt;br&gt;• Electrical energy is stored for later use in chemical form. Existing battery technologies are being improved, and new battery technologies are becoming available.&lt;br&gt;• Example: 34 MW Sodium Sulfur Battery — 51 MW wind farm, Japan (NGK)</td>
</tr>
<tr>
<td>Thermal Storage</td>
<td><strong>Ice Storage</strong>&lt;br&gt;• Air conditioners create ice at night, when power rates are low. This stored ice then runs a cooling system during the afternoon, when power costs are highest and the power grid is most stressed.&lt;br&gt;• Example: 12 kW Thermal Storage — Napa Community College (Ice Energy)</td>
</tr>
<tr>
<td>Mechanical Storage</td>
<td><strong>High Speed Flywheel</strong>&lt;br&gt;• Flywheels convert electrical energy to kinetic energy, then back again very rapidly. Flywheels are ideal for power conditioning and short-term storage.&lt;br&gt;• Example: 3 MW Mechanical Storage for Ancillary Services — NE ISO (Beacon Power)</td>
</tr>
<tr>
<td>Bulk Mechanical Storage</td>
<td><strong>Below Ground Compressed Air</strong>&lt;br&gt;• 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.&lt;br&gt;• Example: 115 MW Compressed Air Energy Storage — McIntosh, Alabama</td>
</tr>
<tr>
<td>Bulk Gravitational Storage</td>
<td><strong>Pumped Hydro</strong>&lt;br&gt;• 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.&lt;br&gt;• Example: 1,532 MW Pumped Hydro — TVA’s Raccoon Mountain</td>
</tr>
</tbody>
</table>
...with multiple applications...
...multiple revenue opportunities...

- Electric Energy Time-Shift (Arbitrage)
- Frequency Response (Inertia)
- Frequency Regulation Up
- Frequency Regulation Down
- Ramping
- Real-Time Energy Balancing
- Synchronous Reserve (Spin)
- Non-Synchronous Reserve (Non-Spin)
- Black Start
- System Electric Supply Capacity
- Local Electric Supply Capacity
- Resource Adequacy
- Intermittent Resource Integration (Ramp/Voltage Support)
- VER/PV Shifting, Voltage Sag, Rapid Demand Support
- Supply Firming
- Peak Shaving: Load Shift
- Transmission Peak Capacity Support (Deferral)
- Transmission Operation
- Transmission Congestion Relief
- Distribution Peak Capacity Support (Deferral)
- Distribution Operation (Voltage/VAR Support)
- TOU Electric Bill Management
- On-Site VER Supply Firming: Microgrid
- Outage Mitigation: Microgrid
- Power Quality
- Backup Power

...and multiple deployment options

### Siting
- Centralized
- Distributed
- Customer-Sited

### Ownership Model
- Utility
- Customer
- Third Party

### Benefit(s)
- Electric Bill Management
- Electric Supply
- Ancillary Services
- Grid Operations
Outline

1. The Grid Connected Energy Storage Market

2. Transforming the Energy Industry is a Complex Policy Challenge at both Federal and State Levels

3. Current Energy Storage Policy & Incentives

4. The Need for Long-Term Vision
Energy Storage is fundamental to many key California policy initiatives

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

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

» Pro-storage Governor, policy makers in Legislature, and at key agencies: CPUC, CAISO, CEC & CARB

» Incentives available for customer sited applications via SGIP and possibly PLS too

» Participation in Renewable Integration Stakeholder Process—California Independent System Operator (CAISO)

» Many CA storage projects currently underway
AB 2514 – Landmark New Storage Bill

AB 2514 provides the necessary focus on storage

  ▪ IF cost-effective AND 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
Recommended Process and Timeline

Step 1: Set Cost-Effectiveness Methodology
Stakeholders and Commission decide on which methodology is most appropriate for each application (example: KEMA model for peakers).

Step 2: Conduct Cost-Effectiveness Evaluation of Each Application Category
Commission and stakeholders conduct cost-effectiveness analysis.

Step 3a: Set-Targets
All application Categories that prove to be cost-effective proceed to discussion and analysis of procurement targets.

Step 3b: Pilot Evaluation
Application categories that do not pass the cost-effectiveness threshold are evaluated for potential pilot procurement based on key criteria such as market transformation, changing market dynamics that will affect future cost-effectiveness, and as yet unforeseen value to California.

Step 4 – Commission issues Proposed Decision outlining procurement recommendations
Commission adopts procurement recommendations based upon the results of Step 3a and Step 3b.

Step 5 – Commission issues Final Decision implementing procurement recommendations
Long Term Procurement Planning – Phase 1 Decision

In February 2013, California’s long term procurement process required Southern California Edison to purchase at least 50 MW of energy storage.

Key points from the decision:

» “At least 50 MW must be procured from energy storage resources.”

» “SCE is also authorized to procure up to an additional 600 MW of capacity from preferred resources and/or energy storage resources.”

Commissioner Michel Florio stated:

“We need to move beyond paralysis by analysis with respect to energy storage.”

Later phases are likely to increase procurement of energy storage in other utility areas.
# 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 • Waste Heat to Power • Pressure Reduction Turbine*</td>
<td>• Internal Combustion Engine – CHP • Microturbine – CHP • Gas Turbine – CHP</td>
<td>• Advanced Energy Storage • Biogas • Fuel Cell (CHP or Electric Only)</td>
</tr>
<tr>
<td>0-1 MW</td>
<td>100%</td>
<td>$1.19/W</td>
<td>$0.48/W</td>
<td>$1.80/W</td>
</tr>
<tr>
<td>1-2 MW</td>
<td>50%</td>
<td>$0.595/W</td>
<td>$0.24/W</td>
<td>$0.90/W</td>
</tr>
<tr>
<td>2-3 MW</td>
<td>25%</td>
<td>$0.2975/W</td>
<td>$0.12/W</td>
<td>$0.45/W</td>
</tr>
</tbody>
</table>

**Payment Details**

» 50% of the incentive is paid upfront; 50% is a performance-based-incentive (PBI) paid over 5 years for systems over 30 kW

» 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.


*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.
Energy Storage + PV Projects are Happening Using the SGIP!

### Program Administrator (PA) vs. Annual Budget ‘12-’14

<table>
<thead>
<tr>
<th>Program Administrator (PA)</th>
<th>Annual Budget ‘12-’14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Gas and Electric Company</td>
<td>$33,480,000</td>
</tr>
<tr>
<td>Southern California Edison</td>
<td>$26,040,000</td>
</tr>
<tr>
<td>California Center for Sustainable Energy</td>
<td>$10,230,000</td>
</tr>
<tr>
<td>Southern California Gas Company</td>
<td>$7,440,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$77,190,000</strong></td>
</tr>
</tbody>
</table>

** Each PA’s annual budget allocation is divided into two categories – 75% in Renewable and Emerging Technologies; 25% in Non-Renewable Technologies. Any remaining funds in each category at the end of the year are added to their respective annual budget allocations for the following year.

### Remaining Budget 2012

<table>
<thead>
<tr>
<th>Category</th>
<th>Budget '12-’14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-R/E</td>
<td>$20 million</td>
</tr>
<tr>
<td>Renewable/ Emerging Technology</td>
<td>$56 million</td>
</tr>
</tbody>
</table>

### Renewable & Emerging Technologies SGIP Applications to Date

#### Applications
- Wast Heat to Power: 3
- Pressure Reduction Turbine: 8
- Wind Turbine: 27
- AES Plus PV: 216
- Fuel Cell: 176
- AES Standalone: 441

### Renewable & Emerging Technologies MW Pending

#### MW
- Waste Heat to Power: 10,000
- Pressure Reduction Turbine: 5,000
- AES Plus PV: 20,000
- AES Standalone: 3,000
- Wind Turbine: 4,000
- Fuel Cell: 40,000

SGIP Data for all program admins supplied by CCSE as of 3/08/2013

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Outline

1. The Grid Connected Energy Storage Market

2. Transforming the Energy Industry is a Complex Policy Challenge at both Federal and State Levels

3. Current Energy Storage Policy & Incentives

4. The Need for Long-Term Vision
Renewable Energy Costs vs. Traditional Generators

Energy storage charged by renewables will benefit from decreases in the cost of renewable energy.

Source: California Energy Commission
Over Time, Value Chain Cost Structure Will Change

There is tremendous opportunity for cost reduction in this space

- ‘Capable’ OEMs will vertically integrate to capture margin and further improve offering
- Optimized system design for specific applications will drive down system-level cost
- Competition, innovation, and scale will drive component price reductions to commodity levels

Today

2020

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
ES is a cleaner alternative to natural gas peakers

GHG & Air Quality Comparison

![Graph showing GHG and Air Quality Comparison]

1) Assumptions from CEC Cost of Generation Model for simple cycle peaker and standard combined cycle for off-peak base load; generation mix based on annual report of actual electricity purchases for Pacific Gas and Electric in 2008
BUILDING A PROFITABLE ECOSYSTEM
APPLICATIONS - CUSTOMERS - DEAL MAKING

CONFERENCE & EXHIBITION
- 3 Day Conference
- Three Application-Focused Parallel Session Tracks
- Over 70 speakers
- Online Community

PLATINUM SPONSORS
- Nextera Energy Resources
- Xcelsec Power
- Bosch

GOLD SPONSORS
- CalCharge
- CalCEF

SILVER SPONSORS
- Sumitomo Electric

EXPOSURE TO KEY MARKET STAKEHOLDERS
OUTREACH CAMPAIGN TO 200,000+ PROFESSIONALS THROUGH OUR NETWORK OF PARTNERS:
Thank you.

Joshua Bar-Lev
jblenergy@comcast.net
4th ANNUAL

Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors

Green VC
greenvc.org

Prescience International

Joint Venture
SILICON VALLEY
Building California’s Clean Energy Future:
Governor Brown’s Vision and Policy Priorities

Nick Chaset
Governor’s Special Advisor for Distributed Generation,
Energy Storage and Combined Heat and Power
Agenda

1) Vision: California’s Long-Term Energy Future

2) Policy Priorities: Focus on Distributed Generation and Energy Storage
   - Distributed Generation
   - Energy Storage
Our Long-term Energy Vision

Transition California’s energy system to a highly efficient, renewables-based system and electrify transportation.
Why prioritize this energy vision?

Transitioning our energy system means jobs.
- Clean tech jobs grew 53% between 1995 and 2010, compared with CA’s overall job growth of 12%.

This transition saves consumers money.
- Ratepayers have saved $65 billion since 1978 through energy efficiency, and will save an additional $23 billion through 2013.

It is needed to meet our long term climate goals:
- 80% reduction in GHG pollution by 2050 requires fundamental changes.
Elements of energy transformation

1. Improve energy efficiency and reduce energy demand
2. Develop a cleaner, more responsive energy supply
3. Implement an efficient and responsive energy infrastructure
4. Reduce emissions from the transportation sector

(Source: California Clean Energy Future)
Developing a cleaner energy supply: Renewables of all sizes are needed

- Electricity demand will increase: population growth and electrified transportation.
- Along with energy demand programs, we will need more power.
  - A recent report estimated the state’s solar energy capacity must increase 12% and its wind capacity 7.5% every year between now and 2050 to meet electricity demand increases while meeting our long-term climate goal.
- Governor Brown has called for expansion of both large-scale and small-scale energy (aka “Distributed Generation”)
Changing Energy System is Presenting New Challenges

1. Intermittent resources are a growing part of our energy mix
   - 12 GW of DG by 2020
   - 33% RPS by 2020

2. Electrification of transportation sector if approaching
   - 1.5 million zero emission vehicles by 2025

3. Aging Distribution Infrastructure That Requires Investment
   - In next five years, SCE alone plans to spend over $20 billion on its transmission and distribution system
New Solutions are Needed

• There are three operating constraints that need to be accounted for when considering solutions to our energy systems challenges:
  – System Reliability – “keeping the lights on”
  – Cost Effectiveness – “safeguarding California’s economy’
  – GHG Reductions – “protecting our resources and climate”

• Distributed Generation and Energy Storage have the potential to do all three
Why Distributed Generation?

- **DG provides consumer benefits**
  - An added consumer option
  - Stable renewable prices over time as fossil fuel costs spike

- **DG provides jobs across California**
  - Distributes clean energy employment across communities

- **DG enhances the energy grid**
  - Reduces transmission congestion
  - Increases reliability of energy delivery
Governor Brown’s 12 GW Goal

June 2010:
Jerry Brown calls for 12,000 MW of localized renewable energy as part of his clean energy and jobs plan.

July 2011:
Governor convenes energy leaders to discuss the DG goal and how it can be achieved.
What’s Distributed Generation?

Energy systems that:

1. Are renewable (technologies and fuels accepted as renewable in state’s RPS)
2. Are sized up to 20 MW
3. Are located within the low-voltage distribution grid; or if outside of the distribution grid, supply power directly to the consumer.
DG enhances resiliency of the grid

Hurricane Sandy’s affect on East Coast transmission lines
Important elements of our DG portfolio

The state’s DG portfolio should achieve the following:

• Increase the **flexibility** and **reliability** of utilities’ distribution grids and the state’s overall energy system.

• **Work in conjunction with** other key state energy initiatives, including energy storage, demand response and electrified transportation.

• Include a **range of renewable technologies**, including both intermittent and base-load energy sources.

• Is delivered in a **cost-effective** manner that provides long term benefits to energy consumers and ratepayers.

• Develops renewable energy resources in **communities across the state**.
# DG Authorized in Current Programs (MW)

<table>
<thead>
<tr>
<th>Program</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total MW</td>
<td>3,000</td>
</tr>
<tr>
<td>CSI (IOU, POU, NSHP)</td>
<td>3,000</td>
</tr>
<tr>
<td>Renewable Auction Mechanism</td>
<td>1,299</td>
</tr>
<tr>
<td>SB32 FIT</td>
<td>750</td>
</tr>
<tr>
<td>IOU Solar PV programs</td>
<td>775</td>
</tr>
<tr>
<td>SGIP</td>
<td>270</td>
</tr>
<tr>
<td>SB1122 FIT (Bioenergy)</td>
<td>250</td>
</tr>
<tr>
<td>Post CSI NEM*</td>
<td>3,000</td>
</tr>
</tbody>
</table>

*This is an estimate based on current CPUC definition of the NEM cap.
How should the rest of the 12,000 MW goal be achieved?

1. Keep current programs on-track. Maintain consistency of policy and programs that are delivering DG.

2. Proceed thoughtfully in considering new programs or expansion of current programs:
   - monitor progress of current and emerging programs
   - emphasize productive efforts across the state
   - determine how DG portfolio is the characteristics of an effective DG portfolio
   - when necessary, expanding or change programs and policies.

3. Remove barriers constraining DG: Change elements of current system, both at statewide and localized level.
DG Potential in CA

- CA has technical potential of 15 GW of DG by 2020
- Study found that 15 GW can be achieved without major infrastructure investments or forced curtailments
  - 15 GW assumes average interconnection costs of $15,000 per MW
Why Energy Storage?

- Energy Storage is a key enabler of the transformation of the electric grid

  - Energy Storage can defer distribution system upgrades caused growing quantities of DG
  - Energy Storage can replace polluting ‘peaker’ power plants
  - Energy Storage can integrate intermittent renewables into the electricity system
  - Energy Storage can improve the efficiency of existing gas fired power plants
  - Energy Storage can help customers manage their electricity usage
Energy Storage Uses: Distribution Deferral

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Defers distribution upgrades for 1 to 4 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Substation or downstream from overloaded equipment</td>
</tr>
<tr>
<td>Technology</td>
<td>Batteries: &gt;1 MW, 4 hours discharge</td>
</tr>
<tr>
<td>Example</td>
<td>SDG&amp;E Borrego Springs substation-level Li-ion battery: 500 kW/1,500 kWh</td>
</tr>
</tbody>
</table>
## Energy Storage Uses: Community Energy Storage

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Improve local reliability; integrate distributed renewable generation; provide voltage control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Adjacent to load, on utility or customer property</td>
</tr>
<tr>
<td>Technology</td>
<td>Batteries: &gt;25 kW, 2 hours</td>
</tr>
<tr>
<td>Example</td>
<td>SMUD “Smart Solar” in Anatolia neighborhood. Li-ion batteries: 15 units, 8.7 kW/8.8 kWh (residential) 3 units, 30 kW/30kWh (pad-mount transformers, distribution feeders)</td>
</tr>
</tbody>
</table>

![Residential Energy Storage](image)
## Energy Storage Uses: Distributed Peaker

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Energy cycling to meet peak load requirements and ancillary services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Sub-transmission level or at substation</td>
</tr>
<tr>
<td>Technology</td>
<td>Large batteries, compressed air, or turbine inlet cooling/thermal storage: &gt;25 MW, &gt;3 hours</td>
</tr>
<tr>
<td>Example</td>
<td>Modesto Irrigation District/Primus Power Flow battery: 25 MW/75 MWh</td>
</tr>
</tbody>
</table>

![Energy Storage System Diagram](image)
## Energy Storage Uses: Generation Sited

<table>
<thead>
<tr>
<th>Purpose</th>
<th>On-site firming or shaping variable energy; ramping; voltage support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>With or near renewable energy generation, or elsewhere</td>
</tr>
<tr>
<td>Technology</td>
<td>Concentrating Solar Power w/molten salt or other; generation sited thermal storage; batteries: &gt;25 MW, &gt;5 hours</td>
</tr>
<tr>
<td>Example</td>
<td>AES Laurel Mountain</td>
</tr>
<tr>
<td></td>
<td>BrightSource CSP with molten salt, 3 units, 200 MW, 6 hours</td>
</tr>
</tbody>
</table>
### Energy Storage Uses: Bulk Generation

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Capacity, energy and ancillary services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>At generator site or on transmission grid</td>
</tr>
<tr>
<td>Technology</td>
<td>Pumped hydro storage, CAES, generation-sited thermal storage: &gt;50 MW, 6 hours</td>
</tr>
<tr>
<td>Example</td>
<td>TAS Energy turbine inlet cooling with storage 45 MW incremental capacity on a 300 MW CCGT</td>
</tr>
</tbody>
</table>
### Energy Storage Uses: Demand-Side Management

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Peak shaving/load shifting; customer bill management; reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Customer site or district energy facility</td>
</tr>
<tr>
<td>Technology</td>
<td>Batteries, thermal energy storage</td>
</tr>
</tbody>
</table>
| Example  | Santa Rita Jail microgrid  
|          | Li-ion battery: 2 MW/4 MWh backup for wind, fuel cell generation |
|          | Tesla-Solar City. Li-Ion battery to support rooftop PVs      |
|          | Ice Energy, thermal energy storage cooling                   |
How Do We Unleash Energy Storage’s Potential?

• Remove Market Barriers to Energy Storage
  – CPUC and CEC are looking at everything from metering rules to Resource Adequacy requirements to determine how to better facilitate the deployment of Energy Storage

• Support Investment in Energy Storage
  – SDG&E intends to spend tens of millions on Energy Storage through its General Rate Case
  – CPUC is considering a requirement that SCE procure 50 MWs of Energy Storage
  – CPUC is also evaluating broader Energy Storage Procurement options

• Transform the Market to Unlock Energy Storage’s Potential
  – Continued support for wide variety of Energy Storage deployments
  – Encourage key stakeholders like CAISO to take deep dive into Energy Storage potential
  – On-going attention to role of procurement targets for Energy Storage
Joint Venture Silicon Valley

Smart Energy Enterprise Development Zone

Uniting Performance and Sustainability in the Power Network of the Future
In 2012, Joint Venture convened local energy customers and stakeholders, to form the ‘Smart Energy Enterprise Development Zone’ initiative.

**SEEDZ Initiative**

- A collaboration involving local energy customers, municipalities, institutions, solution providers, and utility interests

- Demonstrate and deliver improved performance and sustainability in the power network, on a commercially-based, community-wide scale

- Feature latest local developments in efficiency, clean energy, grid performance and business model integration
What inter-related Smart Energy elements does SEEDZ address, and how?

**Integrated Building Systems**
- advanced HVAC/lighting, energy management systems, automated load shifting, continuous commissioning

**Demand Programs**
- scaled adoption of DR & ADR, advancement of new dynamic pricing models

**Grid Infrastructure**
- power quality monitoring, advanced distribution automation, self-healing

**Interoperability Standards**
- building energy management and utility integration standards, DG & storage integration, NIST smart grid standards

**Distributed Generation**
- onsite (potentially shared) solar PV, fuel cells, biogas, SWH; DG/grid integration, district heat/cooling

**Electric Transport**
- EV charging infrastructure, smart charging programs, EV grid impacts/integration

**Storage and Backup**
- thermal & electric storage, back-up, DG/islanding integration, rate arbitrage

**Incentives and Financing**
- development incentives and standards, availability and piloting of PACE, on-bill financing, other commercial structures
Work has begun on several key Smart Energy elements.

- **Grid Infrastructure:**
  Power Quality Management and Zone Data Sharing

- **Distributed Generation**
  Analysis of Development Potential for Municipal/Community Renewables Assets

- **Integrated Building Systems:**
  Model Specification for Integrated Building Energy Management System

- **Storage and Backup:**
  Customer-side Pilot Application
For more information and to download our SEEDZ Blueprint Report, please visit:

www.jointventure.org/seedz
The Los Angeles AFB Vehicle-to-Grid Demonstration

CHRIS MARNAY
Staff Scientist, Berkeley Lab
ChrisMarnay@LBL.gov - +1.510.486.7028
INTRODUCTION TO DER-CAM
- concept and data flow

LOS ANGELES AIR FORCE BASE PROJECT
- CAISO ancillary services markets
- introduction to L.A. AFB
- V2G technology required
- bidding results

WHAT ARE MICROGRIDS?
- a definition
- Santiago 2013 Symposium on Microgrids
Introduction to the Distributed Energy Resources Customer Adoption Model (DER-CAM)
DER-CAM Concept
**DER-CAM Data Flow**

**Inputs:**
- Building energy service data
- Electricity & gas tariff data
- DER technology data
- Site weather data

**DER-CAM**

**Objectives:**
- Minimize total cost
- Minimize CO₂ emissions

**Outputs:**
- Optimal DER capacities
- Optimal DER operations schedule

**Investment & Planning:**
determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs

**Operations:**
determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather, and tariffs
Los Angeles Air Force Base
V2G Pilot
Project Overview

- 6 DoD bases with 500 PEVs announced, including China Lake CA. Third phase will be 1000 additional vehicles of total non-tactical fleet of ~200,000 (mostly low usage medium duty vehicles).
- About half L.A. AFB fleet will bid into CAISO Regulation (Aug 13).
- Three funding sources:
  - DOD ~2+ M$ for vehicles, charging stations, and construction.
  - ESTCP ~1.75 M$ for fleet management, communications, & optimization.
  - CEC ~1 M$ for 10-15 sedans and building integration capability.
- Hoping for two+ year project through mid-2014, first vehicles + EVSEs mid-2013.
- Key research question: can regulation market revenue close PEV cost gap.
AGC: Automated Generation Control
DER-CAM: Distributed Energy Resources-Customer Adoption Model
EM{C}S: Energy Management and {Control} System
SCE: Southern California Edison

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Regulation rectifies tiny discrepancies between load and 5-minute real time dispatch.

- receive an operating point instruction and respond within 4 sec.
- continuous response during the award period
- requires capability to sustain output for 1 h

Operating Reserves, Spin and Non-Spin, respond when a contingency event occurs to restore balance.

- respond within 10 minutes
- most events 10-30 mins. long
- able to sustain output for 2 h or award length
History of Reg. Up Prices

CAISO-S - Up Regulation

Average hourly MCP [$/MWh]

- Average
- Percentile = 90
- Minimum

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Aerial View of L.A. AFB
L.A. AFB Views

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
3 Required Technologies

Project Singapore

BOSCH
Invented for life

Participating Load Pilot

Santa Rita Jail

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Data Machinery

- **BOSCH (eMobility)**
  - Vehicle data & status
  - Availability & SOC Targets
  - Charge – Discharge Instructions
  - Charge-Discharge Schedules
- **Berkeley Lab (DER-CAM)**
  - Day Ahead and Hour ahead bids
  - Bids
  - Schedules
- **Akuacom (DRAS)**
  - Bids
  - Availability & Req.
  - Awards, Instructions, Settlements, Prices
  - RTP - 2 Prices
  - 5-Day ahead RTP-2 Prices
  - Awards, Instructions, & Settlement
- **SCE (S. C.)**
  - Bids
  - Plug-In Vehicles
  - CAISO

**Phases**

- **Phase 1 – Static Test**
- **Phase 2 – Daily Cycle**
  (Bids at 10:00, Schedule at 20:00 etc)
- **Phase 3 – Continuous Optimization**
  (actual reg up/down participation)
# 18 Vehicle Test Fleet

## EV1-EV6
- **Model:** Nissan LEAF
- **Number:** 6
- **Energy Capacity:** 24 kWh
- **Max Charge Power:** 15 kW
- **Max Discharge Power:** 15 kW

## EV7-EV12
- **Model:** Auto Port Van
- **Number:** 6
- **Energy Capacity:** 35 kWh
- **Max Charge Power:** 15 kW
- **Max Discharge Power:** 15 kW

## EV13-EV18
- **Model:** Smith Electric Truck
- **Number:** 6
- **Energy Capacity:** 120 kWh
- **Max Charge Power:** 60 kW
- **Max Discharge Power:** 60 kW

<table>
<thead>
<tr>
<th>Model</th>
<th>Nissan LEAF</th>
<th>Auto Port Van</th>
<th>Smith Electric Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Energy Capacity</td>
<td>24 kWh</td>
<td>35 kWh</td>
<td>120 kWh</td>
</tr>
<tr>
<td>Max Charge Power</td>
<td>15 kW</td>
<td>15 kW</td>
<td>60 kW</td>
</tr>
<tr>
<td>Max Discharge Power</td>
<td>15 kW</td>
<td>15 kW</td>
<td>60 kW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Energy Capacity</th>
<th>1074 kWh</th>
<th>Minimum Resource Size</th>
<th>500 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Charge Power</td>
<td>540 kW</td>
<td>Minimum Bid</td>
<td>100 kW</td>
</tr>
<tr>
<td>Total Discharge Power</td>
<td>540 kW</td>
<td>Minimum Bid Increment</td>
<td>10 kW</td>
</tr>
</tbody>
</table>
EV Fleet Availability

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Prices and Availability

![Graph showing regulation price over time](graph1)

![Graph showing available energy in EVs over time](graph2)
Bids and Schedules

Regulation Bids - Day 1

EV Charging Profiles - Day 1

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
EV Charging and Base Load

![Graph of EV Charging Profiles - Day 1](image)

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California

20
# EV Results Summary

<table>
<thead>
<tr>
<th>Energy Costs ($)</th>
<th>22.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Costs ($)</td>
<td>0</td>
</tr>
<tr>
<td>Reg Revenue ($)</td>
<td></td>
</tr>
<tr>
<td>Up D1</td>
<td>83.01</td>
</tr>
<tr>
<td>Dn D1</td>
<td>24.53</td>
</tr>
<tr>
<td>Up D2</td>
<td>85.37</td>
</tr>
<tr>
<td>Dn D2</td>
<td>24.55</td>
</tr>
<tr>
<td>Energy limit (kWh)</td>
<td></td>
</tr>
<tr>
<td>High D1</td>
<td>1039</td>
</tr>
<tr>
<td>Low D1</td>
<td>214.8</td>
</tr>
<tr>
<td>High D2</td>
<td>1039</td>
</tr>
<tr>
<td>Low D2</td>
<td>214.8</td>
</tr>
</tbody>
</table>

### Available Energy in EVs - Day 1

- Upper Capacity
- Lower Capacity
- Upper Limit
- Lower Limit

### Regulation Bids - Day 1

- Up regulation
- Down regulation

### EV Charging Profiles - Day 1

- EV 1
- EV 2
- EV 3
- EV 4
- EV 5
- EV 6
- EV 7
- EV 8
- EV 9
- EV 10
- EV 11
- EV 12
- EV 13
- EV 14
- EV 15
- EV 16
- EV 17
- EV 18

### Regulation Price

- 0.01 - 0.02
What are microgrids?
What is a “Microgrid?”

U.S. Dept. of Energy Microgrid Exchange Group:

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.
Santiago 2013 Symposium on Microgrids

- the 9th in our series of microgrid symposiums
- dates:
  - 11 and 12 of September 2013
- optional technical tours after the symposium
- Chilecon beforehand
- information to be posted on

http://microgrid.lbl.gov/

(look in "microgrid symposiums")
Thank you!

http://microgrid.lbl.gov

http://www.youtube.com/watch?v=3XuCJBvq6Sk
4th ANNUAL
Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners
Exhibitors
Energy Storage Pilot Projects

Jon Eric Thalman
Director, Regulatory Strategy
Electric Operations
Pacific Gas and Electric Company
Building a Safe, Reliable and Affordable Electric System

Power Plants
- Nuclear Power Plants
- Natural Gas Generators
- Wind Farms
- Solar Farms / Power Plants
- Hydro Power Plants

Electric Grid
- Transmission Lines
- Distribution Substations
- Utility-scale Storage

Customers
- Rooftop Solar
- Plug-in Electric Vehicles
- Distributed Storage
PG&E’s Storage Project Portfolio

Established
- Pumped Hydro

Pilot
- Sodium-Sulfur (NAS) Battery

Exploratory
- Compressed Air

Objectives:
- Develop technology neutral environment for grid services while maintaining cost-effective investments for customers.
- Continually evolve PG&E’s understanding and evaluation methods to be inclusive of all technologies.
Battery Pilot Projects Objective:
Demonstrate implementation of energy storage for proposed applications

Vaca-Dixon Substation
2 MW / 14 MWh NAS Battery
Operational – August 2012
Renewable Integration
Load shaping
Ancillary services

Office Complex
4 MW / 28 MWh NAS Battery
Operational – Q2 2013
Reliability
Power quality
Islanding
Load shaping
Ancillary services
## Operating Plan

<table>
<thead>
<tr>
<th>Test/Activity</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I - System Evaluation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Thermal Boundaries</td>
<td>Q4</td>
<td>Q1</td>
</tr>
<tr>
<td>2. Efficiency</td>
<td>Q2</td>
<td>Q4</td>
</tr>
<tr>
<td>3. Power Quality</td>
<td>Q1</td>
<td></td>
</tr>
<tr>
<td>4. Telemetry Testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase II - Basic Performance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. CAISO Market Assessment</td>
<td>Q4</td>
<td>Q1</td>
</tr>
<tr>
<td>2. Peak Shaving and Load Shaping Performance</td>
<td>Q2</td>
<td>Q4</td>
</tr>
<tr>
<td>3. Test of Fully Automated and Remote Operation</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>4. Renewable Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase III - Advanced Performance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ancillary Services Assessment</td>
<td>Q4</td>
<td>Q1</td>
</tr>
<tr>
<td>2. Optimize Self-Schedule/Bidding Strategies</td>
<td>Q2</td>
<td>Q4</td>
</tr>
<tr>
<td>3. Dual-Mode Operation</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>4. Multi-Mode Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Island Customer Site</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall - Communications Application</strong></td>
<td>Q3</td>
<td>Q4</td>
</tr>
</tbody>
</table>
2 MW Vaca-Dixon NaS

Phase I: System Evaluation (12/25/12 – 3/9/13)
• Initial test plan (thermal boundaries) successfully completed

Eleven week test for max temperature and temperature creep
  – Independently varied discharge power and discharge duration
  – Repeated same profile 5 days (Tuesday – Saturday)
  – Data collected from NGK system, PG&E revenue meter, CAISO OASIS (pricing). PG&E SCADA data currently unreliable

<table>
<thead>
<tr>
<th>Weeks 1 -4</th>
<th>Weeks 5 -7</th>
<th>Weeks 8 -10</th>
<th>Week 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge 2MW for 3.6, 4.6, 5.6, and 6.6 hours</td>
<td>Discharge 1.75MW for varying durations</td>
<td>Discharge 1.5MW for varying durations</td>
<td>Discharge 1.25MW for 10.6 hours</td>
</tr>
</tbody>
</table>

• Second test series (system efficiency) has begun
• CAISO meter certified
• End-to-end telemetry test with CAISO to certify system for spin and frequency regulation a success
Typical 24 hour Test Cycle

Maximum Internal Temp (°C)

- **MW (DC), measured at battery**
- **MW (AC), measured at meter**

350°C: system shutdown
340°C: system curtailment

<table>
<thead>
<tr>
<th>kW</th>
<th>DC kW in</th>
<th>DC kW out</th>
<th>DC kW Net</th>
<th>AC kW in</th>
<th>AC kW out</th>
<th>AC kW Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>kW</td>
<td>(7,937)</td>
<td>7,340</td>
<td>(597)</td>
<td>(10,885)</td>
<td>6,872</td>
<td>(4,013)</td>
</tr>
</tbody>
</table>
Discharge Duration vs. Temperature

3.5 hour discharge
Max temp: 316°C

4.5 hour discharge
Max temp: 319°C

5.5 hour discharge
Max temp: 326°C

6.5 hour discharge
Max Temp: 333.9°C
Vaca NaS – Initial Technical Test Plan Results

• System temperature does not appear to be a constraint to operations
  – Can discharge at full power up to 6.95 hours/day (max per NGK)
  – Have tested 6.6 hrs., with 10% SOC remaining
  – System did not exhibit temperature creep:
    • Returned to idle temperature (305°C) within 2 hours of end of discharge
  – Don’t need “rest” days

• Caveats
  – Exterior ambient temperature could affect this result
    • Will re-run thermal tests in summertime to assess impact of exterior temperature on system operating temperature
  – As system ages, more electrical resistance builds up in cells, creating more heat which could affect this result
Limited Opportunities for price-arbitrage
But short price spikes can be significant
And negative prices can enhance revenues
‘Rest’ periods may be uneconomical
How to measure efficiency?

**Goal:** measure round-trip AC to AC efficiency:
- KWh(out) / KWh(in), measured at meter
- Compare at different charge and discharge power levels
- Exclude “rest” periods

**Plan:**
- Charge will follow immediately upon completion of 6 hour discharge
- Measurement period from start of discharge to end of charge
- First vary discharge power and hold charge power constant
- Then vary charge power holding discharge power constant
- Then vary both

Period to measure

Disregard “rest”
# Key Lessons Learned & Gaps

<table>
<thead>
<tr>
<th>Area</th>
<th>Issue</th>
<th>Lessons Learned</th>
<th>Current Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory/Business Case</td>
<td>Market &amp; Costs</td>
<td>High capital costs and limited market ability to provide value for unique capabilities</td>
<td>Valuation of revenue streams is insufficient to justify investment costs</td>
</tr>
<tr>
<td>Market Integration</td>
<td>Market models suitability to functionality</td>
<td>Provide CAISO with a testing platform and jointly develop NGR Model to address:</td>
<td>Current Hydro Pump Storage models limit load flexibility</td>
</tr>
<tr>
<td></td>
<td>• Resource Adequacy (RA)</td>
<td>• Fast Response - Market not yet active</td>
<td>• Currently energy storage not considered for RA</td>
</tr>
<tr>
<td></td>
<td>• Fast Response</td>
<td>• Resource Adequacy - Not currently applicable to storage</td>
<td>• Create Fast Response, Voltage control and smoothing ancillary markets</td>
</tr>
<tr>
<td></td>
<td>• Renewable applications:</td>
<td>• Renewable applications – voltage &amp; smoothing - No market exists</td>
<td>• Provide CAISO with test bed for further market simulation</td>
</tr>
<tr>
<td></td>
<td>• Voltage control &amp; smoothing</td>
<td>• Multi-mode operation – untested, not clear is CAISO metering will allow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Multi-mode operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td>• Internal PG&amp;E</td>
<td>Cross-cutting Roles and Responsibilities for Operational Excellence</td>
<td>Teams learning roles and responsibilities</td>
</tr>
<tr>
<td></td>
<td>• CAISO</td>
<td>• Alignment with</td>
<td>• Bidding strategy to be refined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bids</td>
<td>• Inability to provide a negative (load/charge) signal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Settlements</td>
<td>• Changes require significant upgrades to CAISO process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In process to demonstrate ability to respond to CAISO signals</td>
<td></td>
</tr>
<tr>
<td>Control &amp; Visibility</td>
<td>SCADA compatibility</td>
<td>PCS software designed to rely on utility SCADA and controls</td>
<td>Currently requires manual input</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCADA functionality is specialized</td>
<td>• Control application in testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standardization needed in the future</td>
<td></td>
</tr>
</tbody>
</table>

➢ Pilots are appropriate to learn from emerging technologies and avoid high costs to ratepayers
# Indication of Future Capital Costs for 3rd Party

<table>
<thead>
<tr>
<th>Project Costs</th>
<th>Vaca (2MW)</th>
<th>Vaca ($ per kW)</th>
<th>Yerba Buena (4MW)</th>
<th>Yerba Buena ($ per kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>4,000,000</td>
<td>2,000</td>
<td>8,000,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Power Control System (PCS)</td>
<td>1,916,364</td>
<td>958</td>
<td>2,448,427</td>
<td>612</td>
</tr>
<tr>
<td>Communications Application</td>
<td>150,000</td>
<td>75</td>
<td>150,000</td>
<td>38</td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upfront*</td>
<td>3,981,603</td>
<td>1,991</td>
<td>6,051,573</td>
<td>1,513</td>
</tr>
<tr>
<td>Removal</td>
<td>200,000</td>
<td>100</td>
<td>600,000</td>
<td>150</td>
</tr>
<tr>
<td><strong>Financing Costs</strong></td>
<td>264,681</td>
<td>132</td>
<td>850,000</td>
<td>213</td>
</tr>
<tr>
<td><strong>Total Project Costs</strong></td>
<td>$10,512,648</td>
<td></td>
<td><strong>$18,100,000</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Costs per kW</strong></td>
<td>$5,256/kW</td>
<td></td>
<td><strong>$4,525</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Upfront installation cost is approximately 2/3 third party and 1/3 PG&E

**Adjusted to remove delay costs
4 MW NaS BESS at HGST, San Jose

- Construction on schedule to begin commissioning and 5-cycle conditioning in mid April
- Ribbon cutting ceremony – May 23rd
4th ANNUAL
Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners
Exhibitors

4th ANNUAL
Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners
Exhibitors
The Opportunity to Revitalize the Battery Industry... in CA

Venkat Srinivasan¹, Jeff Anderson², and Doug Davenport¹

¹Lawrence Berkeley National Lab
²CalCEF
EVs require 2-5 x energy density improvements

- Li-ion batteries possess the energy density needed to power 40 mile PHEVs
- Significant improvements needed for EVs

Source: Product data sheets
...and cost remains very high

What about mass manufacturing?
Mass manufacturing not enough

Battery costs need to decrease by a factor of 3-5 for cost parity with competing technologies
Battery 101 - How do we make a better battery?

- Anode:
  - Carbon-based
  - Alloys and intermetallics
  - Oxides
  - Vanadium, iron
  - Zinc
  - Hydrogen

- Electrolyte:
  - Liquid organic solvents
  - Polymers
  - Gels
  - Liquid electrolyte
  - Proton exchange membranes

- Cathode:
  - Layered oxides
  - Spinel-based compositions
  - Olivine-based compositions
  - Vanadium, chromium
  - Halogens (chlorine, bromine)

- A battery consisting of a set of materials that make up the anode, cathode, and electrolyte.

Can we find something much better?
A New Opportunity to Change the Paradigm-"Hub"

Team lead by Argonne National Lab (Chicago) with Berkeley Lab and other partners have formed the Joint Center for Energy Storage Research (JCESR)

"Moonshot" for Batteries: Make a Lab-scale battery with 5 times energy density at 1/5 the cost in 5 years

But is a Lab-scale battery enough?
Collaboration as an Accelerator

70 mile  ➔  350 miles

$500/kWh  ➔  $125-$100/kWh

Multifaceted Approach

Revolutionary new materials and storage concepts
Process and manufacturing R&D
Markets for batteries (Vehicles, grid, vehicle-to-grid, second life)

Innovation will occur by co-locating R&D, manufacturing, and markets
CA offers an Unique Ecosystem

- We have an existing cluster of 40+ venture-funded battery companies
- Berkeley Lab has teamed with CalCEF and SLAC to form a regional battery innovation consortium.
CalCharge will revitalize the CA Battery Ecosystem

- Technology acceleration
- Commercialization support
- Workforce development
- Ecosystem facilitation

*Partnering with San Jose State for training and workforce development: CalCharge University*

**May 3 event at Berkeley Lab focused on technology acceleration**
Accelerating Battery Development
Across the Spectrum of Technologies and Applications

Materials
Analysis
Fabrication
Testing
Modeling

MATERIALS PROJECT
A Materials Genome Approach
Accelerating materials discovery through advanced scientific computing and innovative design tools.
“Best Imaginable” Business Terms

Unique Process and Terms for a DOE CRADA:

• Members of CalCharge are afforded access to the CRADA
• Unique “Task Order” approach allows fast-response projects
• Option to an exclusive license on project inventions
• Sequester project information generated by LBNL
• Restrict publication of critical project data or results

Our Goal

Project Scope to Start in weeks not months.
4th ANNUAL

Silicon Valley
ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors
Simulation Modeling to Assess the Role of Storage Under Uncertainty

Thomas Edmunds, Ph.D.
Associate Program Leader, Energy Systems Analysis
Lawrence Livermore National Laboratory

edmunds2@llnl.gov  925-423-8982
LLNL-PRES-633375

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Silicon Valley Energy Storage Symposium
April 11, 2013
Mountain View, California
Outline

• Objectives of study
• Modeling approach
  – Weather/renewables model
  – Production simulation model
  – Stability model
• How we model storage
• Summary
Our study: Will storage and demand response (DR) be cost effective for managing 33% renewables in CA?

- 33% renewable generation will add operational challenges to system
  - Greater uncertainty about day ahead net loads
  - Higher variability due to renewable variations
  - Steeper, longer ramps

- Cost effectiveness of storage/DR depends on:
  - How system is operated: unit commitment, economic dispatch
  - Which units operating, what will storage/DR displace?
  - The demands placed on storage and DR for capacity and energy

- Demand curves for storage and DR
Goal: Identify tradeoffs among demand response, storage, and conventional resources

- Can hydro and gas generation follow load under 33% RPS?
  - Assess need for additional combustion turbines
- Identify DR resources that could substitute for some generation investments such as:
  - Scheduled charging of plug-in electric vehicles
  - Direct load control of air conditioners
- Estimate value of grid-scale storage
  - How much of what type would be most cost effective?
  - Include stochastic optimization methods that help manage variability and uncertainty in renewable generation
Our analysis couples weather/renewables, power production simulation, and grid stability models

New contributions:
- Ensemble weather forecasts to capture uncertainty
- Stochastic unit commitment (UC) optimization
- Coupled hourly UC and 5 minute economic dispatch (ED)
We utilize a model of Western Interconnect developed with Weather Research and Forecasting (WRF) code

- WRF fluid dynamics calculations
  - Wind speed, direction, and stability class
  - Surface solar insolation
  - Temperature (load effects)
- Ensemble forecast
  - 30 different weather trajectories
  - Different combinations of 6 physics submodels
We modified CAISO’s production simulation model (Plexos) to conduct the analysis

- States: 11 (across Western Interconnect)
- Generators: ~ 2400
- Transmission lines: 120 (zonal model)
- Renewables: 7 types
  - wind, geothermal, hydro, biomass, biogas, solar (thermal and PV)
- Demand response: 3 tiers, modeled as additional generators
- Multi-time scale - hourly unit commitment and 5 minute economic dispatch
- Stochastic unit commitment that minimizes expected cost over possible weather scenarios
We have made preliminary runs of selected days – tool for visualization

- Regions in Plexos production simulation model of WECC
- Power flow among regions (widths of arrows)
- Generation by source in each region (pie charts)
- Animation for April 6, 2020
A “demand curve” for energy storage can help set State targets

Value of storage (revenue)

Break-even revenue

MW goal

Quantity (MW storage)

Atmospheric models → Stochastic renewable generation scenarios

Historical loads → Net load scenarios → Scenario aggregation

Stochastic day ahead UC → 5 min. UC & ED to actual load

Modify DR & storage capacities

System operations

• Load and generation at 5 min. time steps
• Value of storage & DR
• Storage & DR used

Check system stability
EPRI and California Energy Storage Alliance provided data to analyze storage technologies

<table>
<thead>
<tr>
<th>Storage technology</th>
<th>2020 Capital cost ($M)</th>
<th>Plant life (years)</th>
<th>Cycles at 80% DOD</th>
<th>Round trip efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li-ion battery (15 min)</td>
<td>2</td>
<td>1.75</td>
<td>15</td>
<td>10,000</td>
</tr>
<tr>
<td>Li-ion battery (4 hr)</td>
<td>1</td>
<td>2.52</td>
<td>15</td>
<td>5,000</td>
</tr>
<tr>
<td>Flow battery (5 hr)</td>
<td>50</td>
<td>93</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Flywheel (15 min)</td>
<td>20</td>
<td>38</td>
<td>25</td>
<td>Infinite</td>
</tr>
<tr>
<td>Compressed air above ground (5 hr)</td>
<td>50</td>
<td>100</td>
<td>35</td>
<td>Infinite</td>
</tr>
<tr>
<td>Compressed air below ground (10 hr)</td>
<td>200</td>
<td>300</td>
<td>35</td>
<td>Infinite</td>
</tr>
</tbody>
</table>

*PUC data sheet
We are collaborating with other organizations and leveraging previous work

- **Team:**
  - Subcontract California Institute for Energy and Environment
  - Subcontract with KEMA Corp. - Kermit software, consulting
  - Demand Response Research Center

- **Collaborators**
  - CAISO – Data, models, requirements
  - National Center for Atmospheric Research - WRF/DART

- **Tools**
  - IBM - CPLEX optimizer implementation on HPC
  - Energy Exemplar - Plexos implementation on HPC
  - NREL – System Analysis Model
Summary: High fidelity analysis platform to estimate the value of storage

- Coupled high fidelity models
  - High resolution weather/renewables model with ensemble forecast, 15 minute temporal resolution, 3 km spatial
  - Plexos production simulation model with multiple timescales and stochastic optimization
  - Kema’s Kermit code for stability analysis

- Value of storage in system
  - Value as a function of penetration level (demand curve)
  - Inform policy makers seeking to establish State goals for storage deployment
4th ANNUAL Silicon Valley ENERGY STORAGE SYMPOSIUM

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors
Assemblymember Nancy Skinner
California State Assembly, 15th District
Silicon Valley Energy Storage Symposium

April 11, 2013
Microsoft Auditorium
Mountain View, California

Event Partners

Exhibitors