Executive Summary

- SCE's long-standing interest in energy storage continues today through engineering pilots and a comprehensive strategic planning effort.
- SCE approaches energy storage from the perspective of system needs and potential storage applications, and not technology capabilities.
- Energy storage is a broad and heterogeneous category, made up of numerous distinct operational uses and technologies.
- A primary challenge facing energy storage is to develop and evaluate **specific** and **practical** applications. Costs and benefits are situation-dependent, and will vary based on the nuances of each particular project.

SCE'S Approach To Energy Storage

Engineering Pilots and Demonstration Efforts

- ***Chino Battery Storage Project*** (1988-1996): demonstrated a 10 MW / 40 MWh lead acid battery
- ***Electric Vehicle Technical Center*** has tested a wide variety of battery chemistries, modules, and management systems since 1993 in a nationally recognized and certified research center
- ***Tehachapi Storage Project ****
- ***Irvine Smart Grid Demonstration ****

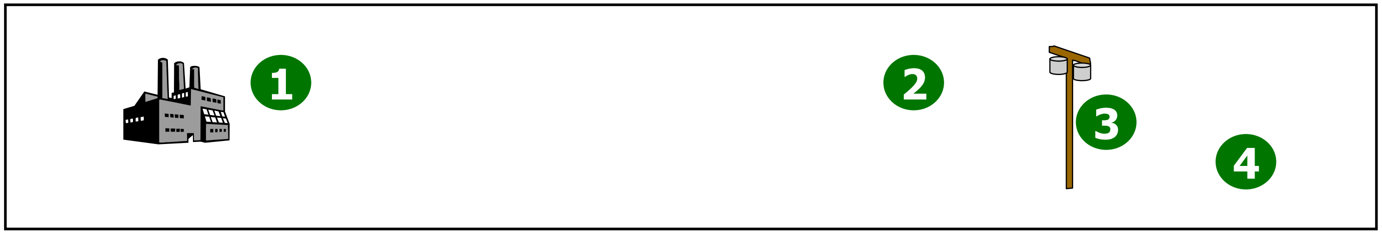
SCE has approached energy storage from two angles

Strategic Planning

- Deepen SCE's understanding on energy storage technologies
- Define potential energy storage applications to communicate preferred specifications internally and externally
- Engage energy storage stakeholders and regulatory agencies in key policy issues
- Create a strategic "roadmap" for SCE's future engagement with energy storage

** See next slide and appendix for more detail*

SCE's Current Primary Storage R&D Efforts



Tehachapi Storage Project

1 Large-Scale Battery Storage (8MW for 4 hours or 32MWh)

- Evaluate a utility scale lithium-ion battery's ability to increase grid performance & integrate wind generation

Irvine Smart Grid Demonstration

2 Large Transportable Battery System (Two 2MW/500kWh units)

- Evaluate transportable, containerized Li-ion battery systems in field and laboratory trials

3 Community Energy Storage (Distributed units: 25kW/50kWh)

- Enhance circuit efficiency, resilience, and reliability

4 Residential Home Energy Storage (4kW/10kWh)

- Evaluate home storage integration with customer HAN, EE, smart appliances, solar PV, PEV, etc.

See appendix for further details

Needs and Policy Goals Drive Solutions

System needs and clear regulatory and policy goals can frame the opportunities for storage or other solutions.

Define Objectives
System needs and policy goals highlight challenges in need of solutions.

Identify Potential Solutions
Industry/others identify potential solutions, e.g., storage. These solutions come with operational and technical uncertainties.

Test Proposed Solutions
R&D assesses technological potential, operational feasibility, and economic viability.

Communicate Findings
Results must be communicated back to stakeholders to inform next steps.

Stakeholders consider results and compare alternative solutions.

SCE's Methodology For Assessing Energy Storage

Step 1: Identify operational uses & understand technologies

- Document the **discrete, individual uses of energy storage** along the electricity value chain from central generation to end user
- Assess technologies & their commercial viability

Step 2: Develop practical applications

- Combine operational uses into **practical applications**
- Applications are specific to SCE's system and market structure

Step 3: Match applications with technologies

- Define **primary application requirements** and preferences
- Identify & **assess "best fit" technologies**

Step 4: Evaluate applications

- Apply **cost / benefit analysis** to specific application & technology pairs
- Approach from both the **current environment** and **expected future** circumstances

SCE approaches energy storage from the perspective of potential applications, and not technology capabilities

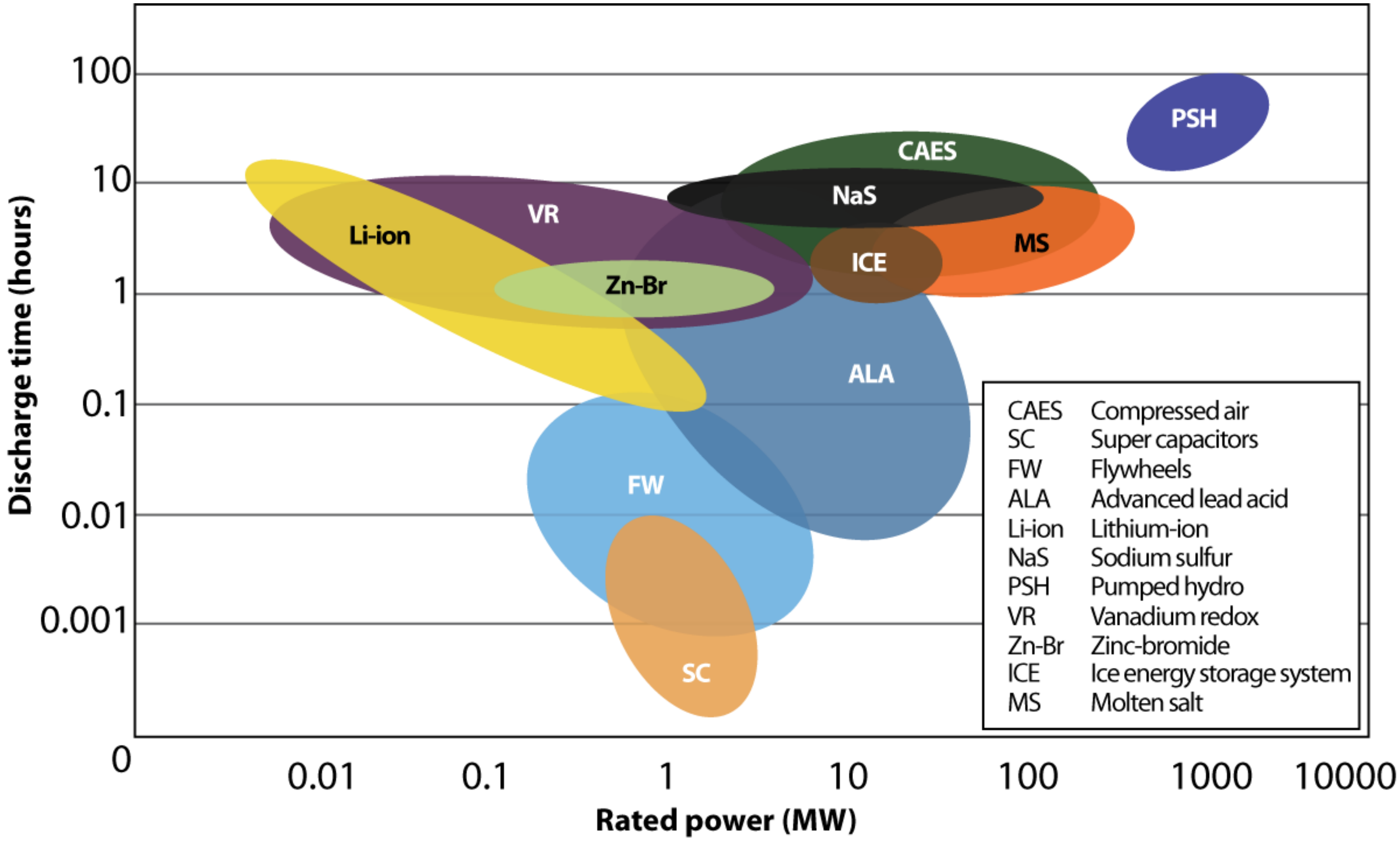
Potential Operational Uses For Storage Systems

Grid location	Minimum duration of output energy (continuous): Short (< 2 min)	Medium (2 min – 1 hour)	Long (1 hour +)
Generation	Provide frequency regulation services (in market)	Provide spin / non-spin Provide ramping Provide frequency regulation services (in market)	Provide capacity Energy shifting Provide black start In-basin generation
Generation / Transmission	Intermittent resource output smoothing	Intermittent resource output smoothing	
Transmission	Improve short-duration performance Provide system inertia	Improve system reliability	Congestion fee avoidance System upgrade deferral Improve system reliability
Distribution	Improve power quality	Outage mitigation	System upgrade deferral Outage mitigation
Distribution / End user		Intermittent DG integration	Intermittent DG integration
End user	Maintain power quality	Uninterruptible power supply (UPS)	Retail rate Optimization Uninterruptible power supply (UPS)

Dynamic response ⟷ Energy shifting

Energy storage could provide a variety of operational uses ("benefits") throughout the electric value chain

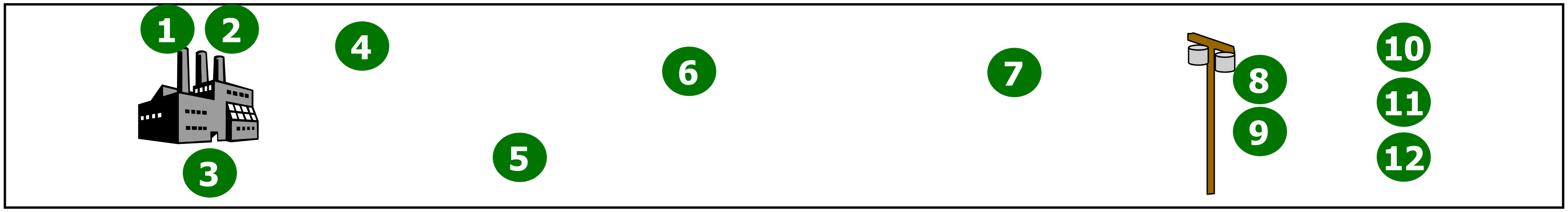
Technology Overview



Energy storage is a broad and heterogeneous category made up of many different technologies with a wide range of operational characteristics.

A technology's rated power and discharge duration help to define potential matching applications.

Developing Practical Storage Applications



EXAMPLES

1 Off-to-on peak intermittent energy firming for generator	Charge device at the site of off-peak renewable and/or intermittent energy sources – discharge "firmed and smoothed" energy onto grid during on-peak periods
8 "Peak shaving" downstream of the distribution system	Charge device off-peak downstream of the distribution system – discharge during 2-4 hour peak period daily
10 End user rate optimization	Charge device "behind the meter" when retail TOU prices are low – discharge when high (or during DR curtailment periods)

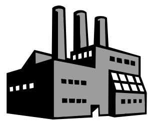
SCE has defined and evaluated twelve representative practical applications for energy storage by combining operational uses at specific locations on the grid

Conclusions

- Valuing energy storage requires a consistent methodology:
  - Developing specific and practical applications which potentially aggregate operational uses across the electric value chain
  - Identifying “best fit” technologies for each application
  - Evaluating specific application-technology pairs under both current and future circumstances
- Much work remains:
  - Testing/demonstrating the operational viability of storage on our grid
  - Calculating detailed monetary benefits of the various storage applications
  - Addressing the regulatory issues associated with energy storage

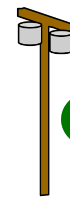
Appendix

SCE's Current Primary Storage R&D Efforts



1

2



3

4

1 Large-Scale Battery Storage

Name	Tehachapi Storage Project (TSP)
Objective	Evaluate a utility scale lithium-ion battery's ability to increase grid performance & integrate wind generation
Size	8 MW for 4 hours or 32 MWh
Cost	$53.5 million ~50% ARRA
Timeline	2010-2014

2 Large Transportable Battery System

Name	Distributed Generation Storage Services Evaluation
Objective	Evaluate transportable, containerized Li-Ion battery systems in field & laboratory trials
Size	Two 2 MW / 500 kWh units
Cost	~ $3 million Part of ISGD* (sub-project 3)
Timeline	2010-2013

3 Community Energy Storage

Name	Community Energy Storage System Research
Objective	Enhance circuit efficiency, resilience and reliability
Size	Distributed units (25kW / 50kWh)
Cost	Part of ISGD* (sub-project 4)
Timeline	2011-2013

4 Residential Home Energy Storage

Name	Home Battery Pilot (HBP)
Objective	Evaluate home storage integration with customer HAN, EE, smart appliances, solar PV, PEV, etc.
Size	4kW / 10 kWh
Cost	~ $3 million Part of ISGD* (sub-project 1)
Timeline	2010-2013

** Irvine SmartGrid Demonstration: $80.2 million project ~ 50% ARRA funded*

Application Example:

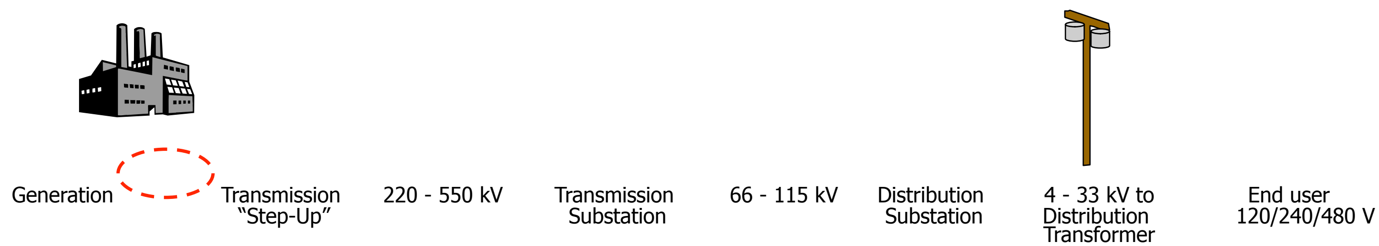
EXAMPLE

Off-to-on peak intermittent energy shifting & firming at or near generation

Application description

Charge at the site of off-peak renewable and/or intermittent energy sources (storage device should be sized to absorb several hours of energy); discharge "firmed" energy to grid during on-peak periods.

Physical Location on Grid



Primary Drivers and Definite Operational Uses

Operational use ("benefits")	**Potential value metric**	**Comments**
Resource Adequacy / dependable operating capacity	Peak capacity avoided cost	Valuation is roughly modeled from the cost of a new peaking unit
Intermittent energy firming	Specific renewable integration costs attributed to firming off-peak energy	Avoided integration cost of firmed on-peak gen instead of intermittent off-peak
Wholesale price energy shifting (arbitrage)	Price differential between charge and discharge less efficiency losses	On-off peak spreads decrease with increasing penetrations of storage
Intermittent energy smoothing	Specific renewable integration costs attributed to off-peak energy smoothing	This integration cost varies by technology and grid/portfolio circumstance, but may include avoided A/S procurement

Potential Other Operational Uses

Operational use ("benefits")	**Potential value metric**	**Comments**
Avoid dump energy / minimum load issues	Price differential between charge and discharge less efficiency losses	Value only if and when operational and/or economic over gen situations occur
Transmission short duration performance improvement (voltage, frequency, fault duty)	Avoided cost of deferred/replaced infrastructure	But for storage, what costs would be incurred on the T system (if any) to counteract short-duration issues
Transmission system reliability (longer-duration outages)	Avoided cost of deferred/replaced infrastructure	But for storage, what costs would be incurred on the T system (if any) to counteract long-duration issues
Transmission fee avoidance	Transmission fees avoided	But for storage, what would have been paid for un-utilized reserved transmission

Tehachapi Energy Storage Project (TSP)

- **Objective**
  - Evaluate utility scale lithium-ion battery technology in improving grid performance and integrating wind generation.

- **Project Specifics**
  - **Size:** The project team will design and build an 8 MW – 4 hour (32 MWh) lithium-ion battery system and smart inverter, and connect it to SCE's Monolith substation near the Tehachapi Wind Resource Area (TWRA). SCE and the project participants will baseline the project by collecting data about the Antelope-Bailey 66kV system using existing and new measurement equipment.
  - **Cost:** $53.5 million, with SCE and partners providing $27.5 million, CEC match of $1 million with $25 million in matching funds from the Department of Energy.
  - **Team:** California Independent System Operator (CAISO) and A123 Systems as project participants, while Quanta Technology and California State Polytechnic University, Pomona will provide engineering support, measurement and reporting services.

- **Expected Results**
  - This project will demonstrate the ability of lithium-ion energy storage to enhance grid operations and wind power integration by measuring performance under 13 specific operational uses. These functions will help achieve the Department of Energy's (DOE) stated goals in this Funding Opportunity Announcement of utility load shifting, increasing the dispatchability of wind generation, and enhancing ramp rate control to minimize the need for fossil fuel-powered back-up generator operation. SCE also intends to use this demonstration project to advance core battery technology for use throughout the electric energy industry.

Irvine Smart Grid Demonstration (ISGD)

- **Objective**
  - The ISGD project will allow SCE, its partners and the DOE to verify, quantify, and validate the feasibility of integrating Smart Grid technologies. The ISGD project will verify the viability of Smart Grid energy technologies and cyber security when deployed in an integrated framework. Further, it will provide a means to quantify the costs and benefits of Smart Grid technologies in terms of overall energy consumption, operational efficiencies, and societal/ environmental benefits. Finally, the ISGD project will allow SCE, its partners and the DOE to test and validate the scalability of tested Smart Grid elements including customer energy storage applications.

- **Project Specifics**
  - SCE's ISGD project starts with CAISO operator deep distribution situational awareness using phasor measurement and then extends beyond the substation to evaluate the latest generation of distribution automation, including: universal remote circuit interrupters (URCI), looped 12 kV distribution circuit topology, and advanced voltage control sensing and self-healing technologies. The ISGD scope continues into the home, by demonstrating the integration, monitoring, control and efficacy of the home area network (HAN) and consumer devices such as smart appliances, electric vehicles, energy storage and photovoltaic solar generation. Tying all this together is the Secure Energy Network (SENet) which will enable end-to-end interoperability and cyber security.
  - **Cost:** Total project cost is $80.2 million, with SCE and partners providing $39.1 million, CEC match of $1 million and seeking $40.1 million in match from the Department of Energy.
  - **Team:** Boeing, General Electric, SunPower Corporation, Electric Power Research Institute (EPRI), ITRON, University of Southern California Information Sciences Institute, California State Polytechnic University at Pomona, and University of California at Irvine.

- **Expected Results**
  - This project will demonstrate a scalable model of a Smart Grid System that can be used to validate the interoperability of emerging NIST and NERC standards for future Smart Grid systems and applications, including standards for implementation, integration, communications, cyber-security and interoperability. This project will also produce measured results on all benefits as outlined by the DOE in Appendix A of the FOA, and will help provide a blueprint to build the Smart Grid workforce of the future.