Southern California Edison
Energy Storage Activities
Brief Overview

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Engineer - Advanced Energy Storage
14 million customers - one of the largest utilities in US

50,000 square miles service territory

125+ years of service

23,000 MW Peak
Background

• California Public Utility Commission (CPUC) Energy Storage Decision
  – Requires SCE to procure 580MW of energy storage by 2020 and gives SCE the opportunity to own up to 290MW

• SCE Approach
  – Leverage RFO procurement process
    • Provide market services
    • Provide distribution capital deferral
  – Enhance learning and understanding through targeted pilot programs
    • Support distribution reliability
    • Facilitate preferred resources integration
    • Investigate microgrids
**Energy Storage Decision D 13-10-040**

Requires SCE to procure 580MW of energy storage by 2020 and gives SCE the opportunity to own up to 290MW

<table>
<thead>
<tr>
<th>Energy Storage Requirements (MW)</th>
<th>2014</th>
<th>2016</th>
<th>2018</th>
<th>2020</th>
<th>Total</th>
<th>Total Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Grid Domain (Point of Interconnection)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td>50</td>
<td>65</td>
<td>85</td>
<td>110</td>
<td>310</td>
<td>62 - 458</td>
</tr>
<tr>
<td>Distribution</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>65</td>
<td>185</td>
<td>37 - 433</td>
</tr>
<tr>
<td>Customer</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>85</td>
<td>85 - 170</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>90</td>
<td>120</td>
<td>160</td>
<td>210</td>
<td>580</td>
<td>580</td>
</tr>
</tbody>
</table>

**Flexibility:**

- Up to 50% of total procurement goal can be Utility Owned
- Up to 80% of target MWs can be:
  - Shifted between Transmission and Distribution domain (only)
  - Deferred (not past 2020) with a showing of unreasonableness
  - Up to 200% of target Customer domain MWs can be counted
- All projects must be installed and operational by 2024
2016 ES Procurement Status

SCE 2016 Storage Portfolio

- Transmission: 115 MW (Authorized to be counted towards 2016 targets)
- Distribution: 70 MW (Currently above targets)
- Customer: 25 MW (Excess customer domain capacity)

85 MW excess capacity

SCE Procurement Activities

<table>
<thead>
<tr>
<th></th>
<th>SCE LCR RFO</th>
<th>SCE 2014 ES RFO</th>
<th>Customer Service Programs</th>
<th>Other (e.g., Pilots &amp; Demos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>100 MW</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Distribution</td>
<td>-</td>
<td>16 MW</td>
<td>-</td>
<td>16 MW</td>
</tr>
<tr>
<td>Customer</td>
<td>161 MW</td>
<td>-</td>
<td>54 MW</td>
<td>11 MW</td>
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</tbody>
</table>

(All numbers rounded to the nearest Megawatt)
SCE Energy Storage Efforts

Technical Evaluation
- Laboratory Evaluation
- Demos & Pilots

Simulation & Modeling
- Where?
- What size?

Strategic Planning
- ES Business Cases
- Regulatory Compliance
SCE ES Technical Activities

• Storage Technology Laboratory Evaluation
  – Validate storage technology performance
  – Create degradation models to optimize system operation (extend life, improve business case)

• System or Sub-system Laboratory Testing
  – Validate system integration (from a safety and operational performance perspective)

• Field Demonstration and Pilots
  – Refine deployment, connection and operation processes
  – Validate system performance and reliability in the field
SCE ES Evaluation Philosophy

**Electrochemical Energy Storage Evaluation**
- Assess Various Chemistries for Performance and Potential Cost Reduction
- Determine Battery Operational Life
- Provide Input for Strategic Planning

**System Evaluation**
- Validate Full System Performance
- Validate Control System
- Prepare Documentation for Field Installation
- Train Field Personnel
- Engage Internal and External Stakeholders

**Field Evaluation**
- Demonstrate Functionality and Value in Actual Applications
- Engage Internal and External Stakeholders
SCE ES Field Evaluation

Demonstration Programs

Assess Technical Merit
- Demonstrate Functionality
- Demonstrate Potential Value Streams
- Demonstrate Reliability

Pilot Programs

Provide a System Function
- Provide Grid Function
- Increase Operational Excellence
- Capture Value Streams
- Pursue Standardization

Deployment

Mainstream Grid Device
LABORATORY EVALUATION
Energy Storage Laboratory Evaluation

• Evaluate top battery manufacturer technologies to establish operational life
  – Design appropriate test methodology
  – Model energy storage technologies degradation
    • Model allow to optimize operational life when used as a dual use asset (distribution and market applications)

• Evaluate sub-system or full energy storage systems and associated component performances prior to the field deployment
SCE’s ES Current and Past Demonstration and Pilot Activities

1. **Large-scale Energy Storage** (8MW/32MWh – Q3 2014)
   - Evaluate a utility scale lithium-ion battery’s ability to increase grid performance & integrate wind generation

2. **Distributed Energy Storage Integration 1 (DESI 1) Pilot Program** (2.4MW/3.9MWh – Q2 2015)
   - Deploy energy storage on the distribution system to solve a challenge or for economic benefit

3. **Large Commercial PLS Program** (100kW/500kWh – Q4 2014)
   - Evaluate Energy Storage for Large Commercial Customer Permanent Load Shifting

4. **Large Distributed Energy Storage** (2MW/500kWh unit – Q1 2014)
   - Evaluate containerized battery systems in field trials

5. **Community Energy Storage (CES)** (25kW/50kWh – Q3 2013)
   - Evaluate system ability to enhance circuit efficiency, resilience, and reliability

6. **Residential Home Energy Storage Unit (RESU)** (4kW/10kWh – Q3 2013)
   - Evaluate home storage integration with customer HAN, smart appliances, solar PV, PEV, etc.

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**Irvine Smart Grid Demo**

*Decommissioned*
SCE’s ES Upcoming Pilot Activities

**Integrated Grid Project**

**Distributed Energy Storage Integration 2 & 3 (DESI 2 & 3) Pilot Program (2MW/4MWh & 1MW/1MWh – Q4 2017)**
- Evaluate aggregated energy storage units on the distribution system with optimized control

**Energy Storage Integration Program**

**Distribution Reliability Improvement (3 systems – 2017/2018)**
- Mitigate Duck Bank temperature violation
- Mitigate Planned Load Limit violation
- Mitigate N-1 contingency

**Preferred Resources Integration (3 systems – 2018)**
- Focus on circuit with high PV penetration
- Mitigate voltage fluctuation
- Increase PV dependability
- Minimize reverse power flow

**Strategic Applications (4 systems – 2018/2020)**
- Leverage storage fast response capabilities
- Increase grid resiliency for critical and/or remote loads
- Support micro grid developments
- Support projects that enable electrification and carbon reduction objectives

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DEMO PROGRAMS
Tehachapi Storage Project (TSP)

- Installed at an SCE substation
- 9 MVA / 32 MWh
- 6,300 sq. ft. building
- Connected at sub-transmission level through a 12/66kV transformer
- In operation since July 2014
- Evaluating 13 grid-reliability and market-function operational uses
## System Configuration

### How to get 32MWh from 60Wh battery cells

<table>
<thead>
<tr>
<th>Cell</th>
<th>Module</th>
<th>Rack</th>
<th>Section</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>608,832</td>
<td>10,872</td>
<td>604</td>
<td>4</td>
</tr>
<tr>
<td>Voltage</td>
<td>3.7 V</td>
<td>52 V</td>
<td>930 V</td>
<td>930 V</td>
</tr>
<tr>
<td>Energy</td>
<td>60 Wh</td>
<td>3.2 kWh</td>
<td>58 kWh</td>
<td>8.7 MWh</td>
</tr>
<tr>
<td>Weight</td>
<td>380 g</td>
<td>40 kg</td>
<td>950 kg</td>
<td>N/A</td>
</tr>
</tbody>
</table>

[Image of battery cell, module, rack, and system configuration]

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TSP Layout

12kV/66kV transformer

BESS Building

PCS units
TSP Facilities
TSP Power Conversion System
Irvine Smart Grid Demonstration (ISGD)
ISGD - Storage Elements

- Residential Energy Storage Unit (RESU)
  - 4kW / 10kWh
  - Installed in 13 homes
- Community Energy Storage (CES)
  - 25kW / 50kWh
  - One device serving 9 homes
- Electric Vehicle Charging Station with PV and Storage (BESS)
  - 100kW / 100 kWh
  - Paired with 20 EV charging stations & 48kW PV array
- Distribution Battery Energy Storage System (DBESS)
  - 2MW / 500kWh
  - Connected to 12kV distribution circuit

Note: decommissioning is in progress
Distributed Energy Storage Integration (DESI) Pilot 1

• Installed to support overloaded 12kV distribution circuit
• Rated at 2.5MVA / 3.9MWh
• Located in dense urban area environment
  – Sited on customer easement
• Extremely compact system
  – Entire system fit within 1,600 sq. ft. easement (including 12kV transformer, switchgear and protection)
• In operation since May 2015
DESI Site

BESS Building

Connection Point

PCS

12 kV/480 V Transformer

Switchgear
DESI 1 Key Components

• Battery System
• Power Conversion System (PCS)
• Medium Voltage Transformer
• Medium Voltage Switchgear and Protection
Modes of Operation

• Maintain distribution circuit current to a pre-defined threshold based on measurement made on the circuit or near/at substation [by discharging the battery system]
• Recharge the battery system during time of low line loading
• Optionally, provide reactive power to support local voltage or maintain zero reactive power at the substation
Remaining Challenges/Gaps

• Capturing promised value streams in actual applications & building positive business cases

• Availability of truly grid-ready integrated systems
  – Storage component may be mature, integration into complete turn-key system has not reached full maturity

• Siting, Siting, Siting
  – Land availability, system footprint

• Demonstrating required reliability at the system level

• Integrating with existing utility communication infrastructure & new Smart Grid technologies

• Validating large systems prior to deployment

• Availability of standard application definitions and test procedures
Distribution Benefits Analysis
Building Business Cases

• Many challenges still remain:
  – Defining practical use cases
  – Capturing sufficient value streams
  – Identifying appropriate circuit & location
  – Integrating seamlessly with company distribution planning practices
Benefits Overview

Identifying, quantifying, monetizing and capturing storage distribution values

<table>
<thead>
<tr>
<th>Identified, quantified, monetized Values</th>
<th>Identified, quantified Values</th>
<th>Identified Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Deferral value of distribution upgrades</td>
<td>• Equipment life extension</td>
<td>• DER integration enhancement</td>
</tr>
<tr>
<td>• Market services value (AS, RA, and energy arbitrage) ¹</td>
<td>• Voltage optimization</td>
<td>• Grid reliability (SAIDI/SAIFI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Power quality improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reactive power compensation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Phase balancing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other</td>
</tr>
</tbody>
</table>

¹ Market values
Thank you