Energy Storage Overview
Peninsula Clean Energy Board Meeting

January 24, 2019
Energy Storage Topics

- What is Energy Storage?
- Services and Applications
- What Does It Look Like?
- How Much Does They Cost?
- PCE Goals and Energy Storage
What is Energy Storage?
What is Energy Storage?

• Technologies to store electricity when it is not needed so that it is ready to use when there is demand for electricity

• This is increasingly important with high % of renewable energy sources
How is Energy Storage Described?

*Storage is like a bucket of water…*

<table>
<thead>
<tr>
<th>Term</th>
<th>Energy Storage</th>
<th>Bucket of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Capacity</td>
<td>Amount of energy stored (kWh or MWh)</td>
<td>How much water the bucket can hold</td>
</tr>
<tr>
<td>Power Capacity</td>
<td>Rate at which energy is charged or discharged (kW or MW)</td>
<td>How fast the bucket can filled/emptied</td>
</tr>
<tr>
<td>Duration</td>
<td>Ratio of energy and power capacity (hours)</td>
<td>How long it takes to fill/empty the bucket</td>
</tr>
<tr>
<td>Efficiency</td>
<td>The amount of energy lost during charging/discharging (%)</td>
<td>Water splashes when filling/emptying</td>
</tr>
<tr>
<td>Cycle Life</td>
<td>The number of charges/discharges before energy capacity falls below a certain level</td>
<td>Holes in the bucket form over time</td>
</tr>
</tbody>
</table>
What Types of Storage Exist?

- Scale: utility, commercial and industrial, residential
- Type of service
  - front of the meter (FTM): grid services, ancillary services
  - behind the meter (BTM): customer services
- Stand-alone or coupled with generator
- Stationary or mobile (trailer, electric vehicles)
Duck Curve - CAISO

Services and Applications
# FTM Services Relevant to PCE

<table>
<thead>
<tr>
<th>Grid Infrastructure Service</th>
<th>Resource Adequacy</th>
<th>Supply capacity to meet peak electricity demands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancillary Services</td>
<td>Energy Arbitrage</td>
<td>Store excess energy and dispatch when valuable</td>
</tr>
<tr>
<td></td>
<td>Reserves</td>
<td>Standby capacity for unplanned capacity losses occur</td>
</tr>
<tr>
<td></td>
<td>Frequency Regulation</td>
<td>Regulate frequency of grid to maintain power quality</td>
</tr>
</tbody>
</table>
# BTM Services Relevant to PCE

## Customer Energy Management

### TOU Bill Management
- **Application:** TOU Bill Management
- **Description:** Reduce energy purchases during peak consumption hours

### Demand Charge Reduction
- **Application:** Demand Charge Reduction
- **Description:** Reduce consumption when demand charges high

### PV Self-Consumption
- **Application:** PV Self-Consumption
- **Description:** Store PV generation for use later

### Backup Power
- **Application:** Backup Power
- **Description:** Provides energy during power outages
Stacking Services

*Storage owner can combine (stack) various applications to increase revenue opportunity*
Renewable Specific Applications - Wind
Renewable Specific Applications - Solar

Springerville AZ, One Day at 10 Second Resolution
Renewable Load Matching

Storage can shape the output of renewable energy to match load

Very Large ESS

Typical ESS
What Does It Look Like?
Many Types of Energy Storage

Flywheel Energy Storage System

Li-ion Battery

Compressed Air

Pumped Hydro
What Technology is Relevant?

Flywheel Energy Storage System

Li-ion Battery

Compressed Air

Pumped Hydro

1/24/2019
Why?

• Battery storage is:
  o Compact
  o Limited infrastructure requirements
  o Scalable

• Lithium-ion is the clear front runner
  o Cost
  o Flexible
  o Mature

• Others have promise but: expensive, limited services, lack field history

• Performance considerations (Li-ion)
  o Efficiency → ~90%
  o Lifetime → ~ 10 years
Residential Storage

• Typically 3-10 kW, 5-20 kWh, 2 or 4 duration
• Lithium ion batteries
• Cost: $1025-1800/kWh installed
• Typical Applications
  o TOU management
  o PV self consumption
  o Backup
Commercial & Industrial Storage

- Typically 50-500 kW, 50-2000 kWh, 2-4 hour duration
- Lithium ion batteries
- Cost: $725-1375/kWh installed
- Typical Applications
  - TOU management
  - PV self consumption
  - Demand Charge Management
  - Power Quality/Backup
Utility Scale Storage

- Typically 5 MW, 20 MWh, 4 hour duration
- Lithium ion batteries
- Cost: $425-650/kWh installed
- Typical Applications
  - Grid/Ancillary Services
  - Load Matching
  - Energy Arbitrage
How Much Do They Cost?
Storage System Costs

- Battery cost main driver for all costs
- Capital Costs
  - Installation
  - Batteries
  - Balance of system (everything else)
- Operating Costs:
  - Maintenance
  - Energy capacity augmentation

---

(GTM Storage Summit 12/2018)

$1025-1800/kWh (Resi)
$725-1375/kWh (C&I)

$1400-1850/kWh (Utility)
$425-650/kWh (Utility)
Costs – Past, Present, and Future

- 80% price drop since 2010
- ~$70/kWh by 2030, ~$40/kWh by 2040

- Systems prices follow battery prices
PCE Goals and Energy Storage
PCE Policy, Goals & Objectives

Reduce Greenhouse Gases (GHG)
- Steady progress in reduction of PCE portfolio GHG
- 90% GHG free in 2019 with target of 100% GHG-free in 2021

PCE Supply Portfolio
- Evolve supply portfolio (energy) to ~100% renewable by/before 2025, subject to resource availability and market cost-effectiveness
- Manage supply portfolio to match ~100% renewable supply with customer demand on an hourly basis

*How can energy storage support these goals?*
Opportunities for Storage and PCE

• **Energy**
  - Shaping RE output to match load & meet ~100% RE objectives
  - Economically dispatch energy into CAISO day ahead or real time markets

• **Capacity (Resource Adequacy)**
  - System, Local, Flexible
  - Storage can provide RA but must participate in CAISO markets

• **Ancillary Services**
  - Regulation Energy Management
    - Frequency Regulation and Reserves

*New rules at CAISO are being developed and market for products/services is evolving*
Thank You!