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Sr. Director, Business Development

ELECTRIC ENERGY STORAGE
January 12-13, 2011
Phoenix, AZ
The Simpsons Go “Off Grid”

The Simpsons Season 21 Episode 19
The Squirt and the Whale
The Simpsons Go “Off Grid”

The Simpsons Season 21 Episode 19
The Squirt and the Whale
Without Battery Storage.
With Battery Storage Solution.
Assessing Battery Storage Solutions for the Utility Distributed Energy Market

I. Distributed Energy Storage System (DESS)

II. Value Chain for DESS

III. Comparing Battery Chemistries for DESS

IV. Current DESS Applications

V. Future Applications for DESS
In 1917
Genzo Shimadzu
Founded Japan Storage Battery Co., Ltd. Shimadzu-san succeeded in developing the first lead acid battery in Japan. He is a holder of 178 patents in over 12 countries.

In 1918
Shichizaemon Yuasa
Founded Yuasa Battery Manufacturing. During World War I, Yuasa-san expanded the company to provide batteries worldwide. He developed the first EV batteries in Japan and introduced them to Ford, GM.
**Major Products**

**Automotive Batteries**
- Automotive
- Motorcycle

**Advanced Batteries**
- Satellite
- Aircraft
- EV/HEV

**Industrial Batteries and Power Supply System**
- Motor Power
- Water purification plant
- Backup Power
- Telecommunications
- Photovoltaic power generation systems
New Products

Large-sized Lithium-ion Battery

Ni-MH batteries

Advanced Lead Acid batteries

HEV
Distributed Energy Storage System (DESS) - uses renewables to decentralize power generation and storage. DESS includes:

- **CES** – Community Energy Storage - small distributed energy storage unit connected to the secondary of transformers serving a few homes or commercial sites.
- **RES** – Residential Energy Storage – integrates small distributed energy storage unit into one residential site building.
What is Smart Grid?

The integration of two infrastructures ... securely ...

Distributed Energy Storage System (DESS)

Electrical infrastructure

- Embracing renewables
- Increasing productivity

Information infrastructure

- Empowering consumers
- Reducing CO₂ emissions
- Increasing efficiency

Sources: (1) UtilityPoint, by Ethan Cohen 7/18/0 (2) EPRI@Intelligent
Distributed Energy Storage System (DESS)

The Evolution of the Electric Utility System

Before Smart Grid:
One-way power flow, simple interactions

After Smart Grid:
Two-way power flow, multi-stakeholder interactions

Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 29, 2008
Distributed Energy Storage System (DESS)

The Evolution of the Electric Utility System

Energy Storage is a central component...

...in the success of the Smart Grid!

Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008
Distributed Energy Storage System (DESS)

CES Benefits

Local Benefits:
1. Backup power
2. Voltage correction

Grid Benefits:
3. Load Leveling at substation level
4. Power Factor Correction
5. Ancillary services

Source: AEP
Distributed Energy Storage System (DESS)

**RES Benefits**

**Local Benefits:**
1. Backup power
2. Renewable shifting
3. Demand response
4. Voltage correction

**Grid Benefits:**
5. Power factor correction
6. Some ancillary services

Source: Silent Power Inc.
Value Chain for DESS

Wind/PV Variability and Intermittency

**Variability:**
- Caused by day/night cycles
- Predictable
- Slow

**Intermittency:**
- Caused by cloud cover
- Somewhat unpredictable
- Fast

Source: GE
Solar power and load peaks are shifted by ~5 hours.
The greatest value to the utility may be aggregation of many residential systems.

Source: Silent Power Inc.
### Value Chain for DESS

#### Benefits/Applications of Storage

<table>
<thead>
<tr>
<th>Category</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Supply</td>
<td>1. Electric Energy Time-Shift 2. Electric Supply Capacity</td>
</tr>
<tr>
<td></td>
<td>6. Voltage Support</td>
</tr>
<tr>
<td></td>
<td>10. Substation Onsite Power</td>
</tr>
<tr>
<td></td>
<td>14. Electric Service Power Quality</td>
</tr>
<tr>
<td>Renewables Integration</td>
<td>15. Renewables Energy Time-Shift 16. Renewables Generation Capacity Firming</td>
</tr>
<tr>
<td></td>
<td>17. Wind Generation Grid Integration</td>
</tr>
</tbody>
</table>

Value Chain for DESS

Distributed Storage Value Curve

Value Associated with Storage Locations on the Grid

765 kV  345 kV  138 kV  69 kV  4 to 34 kV  480 V  120/240 V

Storage Value

Central Generation

Devaluators:
- Limited Value to Customer
- High Security Risk
- Does not remove Grid Constraints

Devaluators:
- Aesthetics
- O&M?

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Peak Shaving, upgrade deferral, Improved service reliability

Distribution circuits appear to offer most value for hosting storage

CES/RES
## Value Chain for DESS

### Comparison RES vs CES

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>CES</th>
<th>RES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Engineering</td>
<td>100% Paid by Utility</td>
<td>Part of Solar PV install</td>
</tr>
<tr>
<td>Installation Costs</td>
<td>100% Paid by Utility</td>
<td>Part of Solar PV install</td>
</tr>
<tr>
<td>Customer Acceptance</td>
<td>NIMBY, low</td>
<td>Opt in</td>
</tr>
<tr>
<td>Communication Costs</td>
<td>100% Paid by Utility</td>
<td>End customer broadband</td>
</tr>
<tr>
<td>Balance of system and inverter reuse</td>
<td>None</td>
<td>Reuses solar inverter and components</td>
</tr>
<tr>
<td>30% Federal Investment Tax Credit</td>
<td>None</td>
<td>100%</td>
</tr>
<tr>
<td>Applicability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume to drive down cost</td>
<td>1,000(s)</td>
<td>10,000(s)</td>
</tr>
</tbody>
</table>

Source: Silent Power Inc.
Value Chain for DESS

Utility Energy Storage – Legislation

Federal Legislation

- The Storage Technology of Renewable and Green Energy Act of 2009
- Explicit support for RES and storage on commercial buildings
- Removes requirement for renewable resource to receive the investment tax credit
- Great opportunity for commercial and residential customers to reduce/eliminate demand charges
Value Chain for DESS
Policy initiatives to integrate energy storage in grid

- US Congress has proposed “Storage Technology of Renewable and Green Energy Act” of 2009 to provide investment tax credits for storage projects.

Map:
- MISO has created a Stored Energy Resource (SER) category for storage participation in regulation markets from 2010.
- NYISO has created a Limited Energy Storage Resource (LESR) category for allowing storage participation in regulation market.
- CAISO has initiated a stakeholder process to integrate non-generation resources. FERC approved transmission incentives for storage in CA.
- In 2009, ERCOT added requirements for wind farms to provide regulation and voltage support.
- FERC issued Order 890 in 2007 to open regulation market for non-gen resources.

Source: FERC
Comparing Battery Chemistries for DESS

- **Proven Reliable Technology**
  - Evaluate production batteries, not engineering samples only
  - Manufacturer’s history and financials
  - Reliable test data to UL/IEEE Standards

- **Optimization of Storage for DESS Applications**
  - Operate in a controlled environment
  - Reliable and consistent charge controls
  - Energy density/Discharge rate
  - Roundtrip efficiency
  - Size and space

- **Economics of battery storage compared to other solutions**
  (flywheel, compressed air, etc.)
  - Cost per Wh
  - Cost per Cycle

- **Maintenance and Service Life**
  - Life in years and cycles
  - Replacement costs

- **Safety and Environmental Impact**
  - Recyclable
  - Non-hazardous materials
  - No risk of fire or explosion
### Comparing Battery Chemistries for DESS

<table>
<thead>
<tr>
<th></th>
<th>VRLA Mono-block</th>
<th>Advanced VRLA</th>
<th>Advanced VRLA Hybrid</th>
<th>Lithium-ion Manganese mixed metal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Capacity</strong></td>
<td>246Ah/20HR</td>
<td>1000Ah/10HR</td>
<td>80Ah/20HR</td>
<td>LIM50E 50Ah/1HR</td>
</tr>
<tr>
<td><strong>Nominal Voltage</strong></td>
<td>12V</td>
<td>2V</td>
<td>4V</td>
<td>3.7V / cell</td>
</tr>
<tr>
<td><strong>Cycle life</strong></td>
<td>----/Up to 1000</td>
<td>2000 / 3000</td>
<td>3000 / 4000</td>
<td>Over 3000</td>
</tr>
<tr>
<td>VRLA: DOD 70% / 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li-ion: DOD 100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design floating life at 25°C / 77°F</strong></td>
<td>10 years</td>
<td>8+ years</td>
<td>10 years</td>
<td>10+ years</td>
</tr>
<tr>
<td><strong>Maximum Discharge rate</strong></td>
<td>2C</td>
<td>1C</td>
<td>1C</td>
<td>6C (60 seconds) 4C (Continuous)</td>
</tr>
<tr>
<td><strong>Operation Temperature</strong></td>
<td>0 to 40°C 32°C to 104°F</td>
<td>-10°C to 45°C 14°C to 113°F</td>
<td>-10°C to 45°C 14°C to 113°F</td>
<td>-10°C to 45°C 14°C to 113°F</td>
</tr>
<tr>
<td><strong>Round trip efficiency</strong></td>
<td>Up to 80%</td>
<td>Up to 80%</td>
<td>Up to 85%</td>
<td>95%+</td>
</tr>
<tr>
<td><strong>Cost per Wh</strong></td>
<td>$0.14</td>
<td>$0.29</td>
<td>$0.92</td>
<td>$1.5 to $2.5</td>
</tr>
<tr>
<td><strong>kWh Cost per Cycle</strong></td>
<td>$0.14</td>
<td>$0.10</td>
<td>$0.23</td>
<td>Less than $0.50</td>
</tr>
<tr>
<td><strong>Specific energy (Wh/kg)</strong></td>
<td>41.8</td>
<td>31.3</td>
<td>29.1</td>
<td>109</td>
</tr>
</tbody>
</table>
## Current DESS Applications

<table>
<thead>
<tr>
<th>Project</th>
<th>Customer</th>
<th>Product</th>
<th>Market</th>
<th>Benefit Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesa Del Sol</td>
<td>Forest City Enterprises</td>
<td>SLC70-4V (20.48kWh)</td>
<td>RES functions for commercial bldg.</td>
<td>PV Energy Time Shift</td>
</tr>
<tr>
<td>TVA SMART</td>
<td>EPRI/TVA</td>
<td>SLC70-4V (46.08kWh)</td>
<td>RES functions for EV charge stations</td>
<td>Energy Time Shift Site Voltage Support PV Firming</td>
</tr>
<tr>
<td>Suniva</td>
<td>Suniva</td>
<td>SLC70-4V (11.52kWh)</td>
<td>RES functions for commercial bldg.</td>
<td>Electric Service Reliability and Power Quality PV Energy Time Shift</td>
</tr>
<tr>
<td>GSB</td>
<td>GSB</td>
<td>SNS-3000 (144kWh)</td>
<td>RES functions for commercial bldg.</td>
<td>TOU Energy Cost Management Electric Service Reliability and Power Quality</td>
</tr>
</tbody>
</table>
Current DESS Applications

Mesa Del Sol

PV/Storage project – Albuquerque, NM

• 15kW PV system with battery storage

• (3) 5kW Power Conditioning Systems with PV and battery inputs

• (2) of the PCS units have (32) SLC70-4 batteries at their input for a total of 20.48kWh of storage
Current DESS Applications

TVA SMART

EV Charging Site – Knoxville, TN

• EV Charging site with 6 charge stations that are assisted by PV and battery storage.

• GSB’s scope included providing:
  - (3) 10kW battery charger/inverters (Silent Power OnDemand)
  - 3 sets of (48) SLC70-4 batteries for a total of 960Ah (46.08kWh) of storage
Suniva

PV/Battery System – Norcross, GA

• 5kW PV System with battery storage

• GSB’s scope includes providing:
  • (1) 5kW battery charger/inverter (Silent Power OnDemand)
  • (36) SLC70-4 batteries for a total of 240Ah (11.52kWh) of storage
Current DESS Applications

GS BATTERY (USA) Inc.

PV/Battery System – Roswell, GA

• 30kW PV system with battery storage
• (6) SMA 5kW PV Inverters
• (3) SMA Sunny Island Battery Charger/Inverters
• (24) SNS-3000 for a total of 3000Ah (144 kWh) of storage
Future Applications for DESS

CES

Proposed CES Project

• 30kW Community Energy Storage (CES) System.

• The proposed system consists of (3) parallel 10kW battery charge controllers/inverters each connected to a 48V battery rack of (24) SLE-1000 batteries for a total of 3000Ah (144kWh) of capacity.

• This system will have AMI (Advanced Metering Infrastructure) communication capability.

• All of this equipment will be enclosed in a weatherproof building with ventilation.

• Future Lithium design options are 30% smaller than VRLA
Future Applications for DESS

Anatolia SolarSmart℠ Homes Community
- High building efficiency measures
- 2kW PV systems
- Installing 15 RES and 3 CES units
- Firm renewables, reduce peak load and improve reliability
- Utility and customer portals will be used
- Price communicated to affect changes in customer usage
- Quantifying costs and benefits

Sources: SMUD, Silent Power Inc.
Future Applications for DESS

Virtual Power Plant Case Study III: Amagasaki PEV/PV pilot

- 4 MW PV array
- 500 kW Li-Ion battery system
- 150 smart meters
- PEV charge station

Source: Solar Power International
Future Applications for DESS

Global market will see first wave of EVs by end of 2010

“Overall, we believe by 2020, 17% of the global automobile market could be comprised of HEVs, PHEVs, and full EVs, up from 1% today” – Deutsche Bank, November 3, 2010
Future Applications for DESS

CEF Funded Energy Storage Demonstration Project

Utility-Scale Electricity Storage Demonstration Using New and Repurposed Lithium Ion Automotive Batteries
DESS Summary

- DESS will be necessary to support Renewable Generation due to variability, intermittency and existing generation capacity
- RES and CES storage solutions offer benefits to the utility and customer
- Guidelines need to be established when choosing a storage technology and Battery chemistry
- Storage Cost benefit analysis requires battery storage optimization to achieve lowest cost per Wh and cost per cycle
- Storage Reliability must include several criteria and not just battery design life
- EV respet batteries may not be a viable solution for DESS stationary storage for cost and reliability reasons
THANK YOU

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