Energy Storage at Substations

— Virtual Battery Application for Load Frequency Control —

Eri Isono
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Introduction to Yokohama Smart City Project

• YSCP
  – Japanese government funded smart grid demonstration
  – 6 demonstrations and research undertaken by 32 partners
  – Duration: 5 years (2010/4 to 2015/3)
  – Budget: 850million US dollar

• 6 Demonstrations
  – Home EMS
  – Building EMS
  – Factory EMS
  – Community EMS
  – Electric Vehicle
  – Battery aggregation
Battery SCADA demonstration

• **Background**
  – Storage batteries has become realistic option to counter against power quality disturbances, and lack of LFC reserve

• **Challenges**
  – Requires quantity
  – Unrealistic to control each storages
    • Differences among the types, rating, output of batteries,

• **Propose “Battery SCADA” system to control numerous and various storages as one “Virtual Battery” for grid operation**
Applications of Battery SCADA

• Load Frequency Control
  – New power plant for frequency control
  – Increase frequency control reserve
  – Easier controllability of numerous storage batteries

• Peak Shifting
  – Grid expansion deferral
  – Incentive from participation to electricity market

• Spinning Reserve
  – Provide spinning reserve capacity
  – UPS for critical applications

Utility benefit
Customer benefit
# Participants and schedule

**Sponsor:**
Ministry of Economy, Trade and Industry (JAPAN)

**7 Participants:**

<table>
<thead>
<tr>
<th>Role</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>Tokyo Electric Power Company</td>
</tr>
<tr>
<td></td>
<td>Kansai Electric Power Company</td>
</tr>
<tr>
<td>System Integrator, Demonstration managing</td>
<td>Toshiba</td>
</tr>
<tr>
<td>Stationary Battery Manufacturer</td>
<td>Toshiba, Hitachi, Meidensha &amp; NEC</td>
</tr>
<tr>
<td>Customer’s side battery Manufacturer</td>
<td>Sharp, Sony Energy Devices</td>
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<tr>
<td>Other</td>
<td>Mitsubishi Heavy Industry</td>
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</tbody>
</table>

**Project Schedule**

<table>
<thead>
<tr>
<th>Year</th>
<th>System development</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td></td>
<td>Development</td>
<td></td>
<td></td>
<td>Installation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Demonstration</td>
</tr>
</tbody>
</table>
Demonstration site photo

- Commissioned in October 2012

- Battery SCADA Demonstration Center
- Hitachi Stationary Battery 300kW-101kWh
- Meiden/NEC Stationary Battery 250kW-250kWh
- Toshiba Stationary Battery 300kW-100kWh
Demonstration system overview

- Upper EMS simulator
- Battery SCADA

Customer BESS simulator

- Toshiba Data aggregator
- Hitachi Data aggregator

Internet Protocol: HTTP

- Toshiba BESS: 300kW/100kWh
- Hitachi BESS: 100kW/100kWh, 250kW/51kWh
- Meidensha/NEC BESS: 250kW/250kWh

Low latency line, Protocol: IEEE1815, DNP3 (Distributed Network Protocol)

- Toshiba BESS: 300kW/100kWh
- Hitachi BESS: 100kW/100kWh, 250kW/51kWh
- Meidensha/NEC BESS: 250kW/250kWh

Toshiba BESS: 300kW/100kWh
Hitachi BESS: 100kW/100kWh, 250kW/51kWh
Meidensha/NEC BESS: 250kW/250kWh

- Sharp Customer BESS: 22kW/45kWh
- Sony ED Customer BESS: 3.5kVA/8.4kWh
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Requirements for battery aggregation system

• Three recommendations of applying storage batteries to LFC
  – Control value allocation
  – Inherent loss supplement
  – Rating update

• Demonstration condition

Two control signals used
- TEPCO LFC hydro
- PJM LFC signal

Grid EMS Simulator

Battery SCADA

Toshiba BESS
300kW/100kWh

Hitachi BESS
300kW/101kWh

Meiden/NEC BESS
250kW/250kWh

6.6kV power line
1. Control value allocation

- Maximize charge/discharge ability
  - Maintain SOC in same range

- Measurements
2. Inherent loss supplement

- LFC operation will eventually lead battery SOC to zero
- An algorithm to charge and maintain SOC required
- Measurements
3. Rating update

- Interface for Plug & Play functionality and reacquisition of information necessary

Initial data acquisition to acquire basic information of the connected battery

Functionality to reacquire same information as initial data acquisition

<table>
<thead>
<tr>
<th>Battery SCADA</th>
<th>Battery</th>
</tr>
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<tbody>
<tr>
<td>✅【Send Data item】</td>
<td>✅【Send Data item】</td>
</tr>
<tr>
<td>ID number</td>
<td>ID number</td>
</tr>
<tr>
<td>Rated chargeable power</td>
<td>Rated chargeable power</td>
</tr>
<tr>
<td>Rated dischargeable power</td>
<td>Rated dischargeable power</td>
</tr>
<tr>
<td>Short time chargeable power</td>
<td>Short time chargeable power</td>
</tr>
<tr>
<td>Short time dischargeable power</td>
<td>Short time dischargeable power</td>
</tr>
<tr>
<td>Chargeable capacity</td>
<td>Chargeable capacity</td>
</tr>
<tr>
<td>Dischargeable capacity</td>
<td>Dischargeable capacity</td>
</tr>
<tr>
<td>Control frequency</td>
<td>Control frequency</td>
</tr>
<tr>
<td>Charge and discharge efficiency</td>
<td>Charge and discharge efficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Battery SCADA</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>✅【Notification of information update】</td>
<td>✅【Set information update flag】</td>
</tr>
<tr>
<td>✅【Request to obtain Data item】</td>
<td>✅【Resend Data item】</td>
</tr>
<tr>
<td>✅【Periodic information transfer (1 second)】</td>
<td>✅【Periodic information transfer (1 second)】</td>
</tr>
</tbody>
</table>
Conclusion

• 2 years successful demonstration

• LFC operation strategies successful

• Requirements of battery aggregating system recognized
  – Control value allocation
  – Inherent loss supplement
  – Rating update

• Demonstration project will provide basis for future storage deployments with dedicated purposes