DTE Energy Implementation of Community Energy Storage System for Grid Support

Haukur (Hawk) Asgeirsson, PE
Manager - Power Systems Technologies
September 23, 2015
Disclaimer

DOE OE supported under award DE-OE0000229

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Project Overview

• First large utility scale community energy storage (CES) project on one circuit (1 MW of storage)
• Aggregation of CES using a Distributed Resources System Operation Center (DERMS)
• Using utility industry protocol (DNP3)
• Determining economic value of storage on a distribution circuit in MISO market
• Built and deployed secondary use EV batteries
• Integration of energy storage and PV
## Project Team Members & Roles

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role</th>
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</thead>
</table>
| **DTE Energy** | • Project lead  
• Utility participant for CES field demo  
• Project reporting |
| **S&C** | • CES Unit suppliers  
• Factory acceptance testing  
• Technical Support |
| **DNV-GL** | • CES functional testing  
• Economic analysis and reporting  
• Technical Support |
| **edd** | • Circuit model development for baseline  
• Reliability & economic dispatch algorithm |
| **Chrysler** | • Durability & conditioning testing of EV battery  
• Secondary use EV battery supplier  
• Provide baseline data for EV battery |
| **NEXTENERGY** | • Investigation of regulatory issues surrounding energy storage and renewable energy  
• DOD applications |
| **National Grid** | • Utility technical advisor |
CES System Overview

• Eighteen new units installed
  – One was installed in training yard
  – Developed engineering documents, installation and operating procedures
  – 17 on one distribution circuit
  – IEEE 1547 certification
• Two repurposed EV battery systems demonstrating secondary-use application
• 500 kW of storage co-located with 500 kW PV

<table>
<thead>
<tr>
<th>CES Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>25 kW</td>
</tr>
<tr>
<td>Energy</td>
<td>50 kWh</td>
</tr>
<tr>
<td>Voltage</td>
<td>240/120V AC</td>
</tr>
<tr>
<td>Cells</td>
<td>Li-Ion</td>
</tr>
</tbody>
</table>
CES Field Installation

• 18 new units installed in 2013
  – One in Training Yard
  – 17 on one circuit
• Winter reliability problems
• Desire to test as an aggregated fleet
• Uses case testing started in June 2014
Large Storage and PV Integration

- Large storage system with PV
  - 500 kW PV
  - 500 kW Li-ion Storage-(250kWh)
- Located at MCCC
- Common 480 volt bus with 2-250 kW PV inverters
- 500 kVA Trf at 13.2 kV - Export limited
Test Distribution Circuit

Substation

MCCC Solar & Large Storage

8 CES units installed

500 kW PV
500 kW/250 kWh
Li-ion storage
480 Volt/13.2 kV

9 CES units installed

CES Parameters – S&C Electric
Li-ion Kokam cells
Power = 25 kW
Energy = 50 kWh
Voltage = 120/240 Vac

Circuit 13.2k
Peak Load = 10.8MVA 2011
Customers = 2522
Residential = 2413
Commercial = 105
Industrial = 4
All storage systems individually addressable or in a fleet hub command mode using DNP3
CES Communication

• DNP3 Master in DR-SOC
• Cell APN communication
• CES Display includes
  • Utility load and voltage
  • Customers load and voltage
  • Inverter data
  • Battery data
  • System Status and Alarms
• Graph can display any variable
### CES Test Plan - Modes of operation

**Demonstrated capabilities**
- Voltage support
- VAR support
- Islanding during outages
- Frequency regulation (AGC)
- Renewable energy time shift
- Circuit peak shaving
- Discharge during high LMP price
- Circuit model commands (DEW Services)

<table>
<thead>
<tr>
<th>REQUIREMENT#</th>
<th>TEST PERFORMED</th>
<th>COMPONENT TESTED</th>
<th>Mode of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRSOC-CES-001</td>
<td>Data usage test</td>
<td>Cell. communications</td>
<td>Stand-by / Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-002</td>
<td>CES maintains Minimum Reserve Margin</td>
<td>CES controller logic</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-003</td>
<td>CES unit will operate safely when unit is at 100% SOC and is given a charge command.</td>
<td>CES controller logic</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-004</td>
<td>CES unit will operate safely when kW and kvar setpoints cause unit to exceed discharge KVA rating.</td>
<td>CES controller logic</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-005</td>
<td>CES unit will operate safely when kW and kvar setpoints cause unit to exceed discharge KVA rating.</td>
<td>CES controller logic</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-006</td>
<td>DRSOC Hub will dispatch a reasonable set-point when algorithms command a kW set-point that exceeds unit charge rating.</td>
<td>DRSOC Hub</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-007</td>
<td>DRSOC Hub will dispatch reasonable set-point when algorithms command a kW set-point that exceeds unit discharge rating.</td>
<td>DRSOC Hub</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-008</td>
<td>DRSOC Hub will distribute fleet kW charge or discharge across all units based on SOC of each unit.</td>
<td>DRSOC Hub</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-009</td>
<td>CES Efficiency</td>
<td>CES Efficiency</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-010</td>
<td>DRSOC Hub will issue commands per a set schedule to produce “Renewable Energy Time Shift”</td>
<td>DRSOC Hub</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-011</td>
<td>DRSOC Hub will issue commands per a set schedule to produce “Electric Energy Time Shift”</td>
<td>DRSOC Hub</td>
<td>Hub Command</td>
</tr>
<tr>
<td>DRSOC-CES-012</td>
<td>DRSOC Hub will send commands to CES units based on simulated AGC signal</td>
<td>DRSOC Hub</td>
<td>AGC</td>
</tr>
<tr>
<td>DRSOC-CES-013</td>
<td>DRSOC Hub will discharge CES fleet to maintain a maximum kW at the circuit feeder.</td>
<td>DRSOC Hub</td>
<td>Peak-Shifting</td>
</tr>
<tr>
<td>DRSOC-CES-014</td>
<td>Charge when needed for reserve capacity</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-015</td>
<td>Discharge when price is high and unit is not &quot;needed&quot;</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-016</td>
<td>Do not charge when would cause overload</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-017</td>
<td>Do not discharge when would violate reserve capacity</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-018</td>
<td>Resolve transformer overload by discharging</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-019</td>
<td>Resolve low voltage by supplying vars</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-020</td>
<td>Resolve high voltage by absorbing vars</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-021</td>
<td>Resolve low voltage by discharging</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-022</td>
<td>Resolve single-phase primary overload by discharging only batteries on that phase while charging others (low price)</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-023</td>
<td>Currently discharging w/ no overload, but do not stop discharging because discharging is preventing an overload.</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-024</td>
<td>Forecasted overload alert</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
<tr>
<td>DRSOC-CES-025</td>
<td>Minimum profit margin test</td>
<td>DEW Service</td>
<td>DEW</td>
</tr>
</tbody>
</table>
Use case: Circuit Peak Shaving

Use case: DEW Economics Mode

Orange curve battery fleet kW (left y-axis). Blue curve real time LMP $/MWh (right y-axis).

Test Started at 10 AM
Repurposed EV batteries

• Six end of life automotive battery packs – Fiat 500e
• Two battery system configurations installed
  ▪ 25 kW - 47 kWh and 94 kWh
• One CES tested at DNV GL
Remaining work & some lessons learned

• Remaining work
  – Using EPRI Energy Storage Valuation Tool to perform sensitivity analysis
  – Initial draft report in October
  – Final report to DOE early December

• Lesson learned
  – Change in energy storage supplier
  – Technology reliability maturity (TRL 6-7) – Automotive example
  – Reliability of hardware and software
  – Integration of communication systems
  – Physical location of CES
Backup slides
Sample test reports

• DNV KEMA Powertest
  – Round Trip Efficiency
  – Peak Shaving profile test
  – Frequency Regulation Profile Test
  – Islanding Test
  – Harmonic Analysis
• S&C Electric commissioned IEEE 1547 certification – Passed
  – Removed conditional Relay Engineering approval
• DNV KEMA cost effectiveness reports on circuit
  – Frequency Regulation
  – Peak Shaving
• DNV GL Battery degradation testing
CES Communication Hub Command

100 kW Charge
DERMS – Distributed Energy Resource Management System

- Distributed Resources System Operation Center (DR-SOC)
- Created a DNP3 master for distributed energy storage system
- Smart inverter functionality