Detroit Edison’s Advanced Implementation of Community Energy Storage Systems for Grid Support (DE-OE0000229)

Nicholas Carlson
Senior Engineer

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Agenda

• CES Overview
• Project Team & Roles
• Project Phases and Schedule
• CES Operating Zones
• Communication & Control Architecture
• CES Modes of Operation
• CES Baseline & Location Selection Criteria
• CES Test Plan
• Secondary Use of Electric Vehicle Batteries
• Future Work
Community Energy Storage

• The project is a proof of concept of an aggregated Community Energy Storage (CES) system in a utility territory; demonstrating the following capabilities:
  – Voltage/VAR Support
  – Integration renewable generation
  – Islanding during outages
  – Frequency Regulation

• Demonstrate the application of secondary-use EV batteries as CES devices. Identifying alternative applications for EV type batteries may accelerate the reduction of cost for electric vehicle batteries.

• Identify gaps, areas of improvement, and provide suggestions on how CES devices and control algorithms can be standardized to be used across the U.S.

• Provide a functional and economic analysis for using the CES system in electric utility applications.
## Project Team Members & Roles

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role</th>
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</table>
| **DTE Energy** | • Project lead  
• Utility participant for CES filed demo  
• Project reporting |
| **S&C A123 SYSTEMS** | • CES Unit suppliers  
• Factory acceptance testing  
• Technical Support |
| **KEMA** | • 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 |
| **NEXT ENERGY** | • Investigation of regulatory issues surrounding energy storage and renewables |
| **national grid** | • Technical Support |
## Project Phases

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
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<tbody>
<tr>
<td>Project Definition and NEPA Compliance</td>
<td>Final Design and Construction</td>
<td>Commissioning and Operations</td>
<td>Utilization of Secondary Use Batteries</td>
<td>Write Up of Demonstration Assessment</td>
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<tr>
<td>• Update Project Management Plan</td>
<td>• Finalize Design of CES System</td>
<td>• Commissioning of Operational Functionalities</td>
<td>• Integration of Secondary Use Batteries</td>
<td>• Write final report</td>
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<tr>
<td>• NEPA Compliance</td>
<td>• CES System Design for Project</td>
<td>• Field Testing of Designed CES Capabilities</td>
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<tr>
<td>• Baseline for Evaluating Project Performance</td>
<td>• Planning, Measuring, Architecture and Algorithms</td>
<td>• Data Monitoring and Collection of Performance Data</td>
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<tr>
<td>• Preliminary Design &amp; Planning</td>
<td>• Creation of Dispatch Algorithms</td>
<td>• Reporting of Data and Operation</td>
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<tr>
<td></td>
<td>• Communications and Control</td>
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<td></td>
<td>• Procurement of CES Systems for Installation</td>
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CES – Operating Zones

Zone 1
- Islanding
- PQ (Voltage Support)
- Peak Shaving
- Frequency Regulation

Zone 2
- Peak Shaving
- Volt/VAR Support
- Frequency Regulation
- Islanding

Zone 3
- Frequency Regulation
- Voltage/VAR Support
- Peak Shaving
- Islanding

Zone 4
- Voltage/VAR Support
- Energy shifting
Modes of Operation

• Standby Operation Mode
  – Locally-initiated operation due to power loss or site-specific power quality issue.
  – This mode of operation pre-empts all other modes unless specifically overridden.

• Scheduled Operation Mode
  – Control is initiated by the DRSOC Hub on a pre-defined unit-specific schedule.

• Automatic Generation Control (AGC) Mode
  – Aggregate kW output is requested by the Independent System Operator (ISO). Individual units are dispatched by the DRSOC Hub at the appropriate outputs to meet the AGC set-point.

• Hub Command Mode
  – Control is initiated by an operator and dispatched on a unit-specific basis by the DRSOC Hub.

• Peak-shaving Mode
  – Units are dispatched by the DRSOC Hub to ensure that circuit ratings are not exceeded.
• **DEW Economic & Reliability Dispatch Modes**
  – Control is initiated by algorithms implemented in the DEW software package.
  – Algorithms are intended to maximize the economic potential of the unit.
  – May include running of the CES units in grid-parallel mode under normal circuit conditions.
  – Dispatching is done by the DRSOC Hub to each CES unit.

• **DEW Model-Based Real Time Control**
  – CES Operation Modes:
    • Normal: Economic
    • Storm: Reliability (Load Serving)
  – Objective Function:
    • Minimize Operation Cost
    • Minimize Loss
    • Maximize Load Serving Time After Outage
DEW CES Control Module I/O

- Real time LMP
- Predicted LMP
- Frequency Regulation Price
- Battery Status
- Battery minimum charge limits
- Battery charge/discharge rate limits
- Feeder Volt and Amp
- CES Transformer Volt, Amp, Watt, Var
- Real time temperature
- Temperature forecast
- Real time solar Irradiation
- Solar Irradiation forecast

DEW CES Control and Forecast Module

- Dynamic reserve margins for each battery (i.e., min charge per hour)
- 24 Hr operational strategy for each battery (i.e., charge per hour)
- Circuit operational cost with/without battery
Criteria for List of 50 Transformers:

- Rated at 25 or 50 kVA
- 5-10 Customers
- Max Annual kVA between 25 and 50
- Heavily loaded
- Frequent outages
- Circuit phase imbalance
- Accessibility
Simulation Results, One CES Unit

![Graph showing CES Capacity and RT LMP for a weekday. The graph displays the hourly variation of LMP prices and CES capacity. The x-axis represents the hours of the day from 0 to 24, and the y-axis represents the LMP price in $/MWh and CES capacity in kWh. The graph highlights the peak demand hours and the corresponding LMP prices.]
Simulation Results, 20 CES Units

CES Units Output and RT LMP _Weekday

- CES1 Output [kW]
- CES2 Output [kW]
- CES3 Output [kW]
- CES4 Output [kW]
- CES5 Output [kW]
- CES6 Output [kW]
- CES7 Output [kW]
- CES8 Output [kW]
- CES9 Output [kW]
- CES10 Output [kW]
- CES11 Output [kW]
- CES12 Output [kW]
- CES13 Output [kW]
- CES14 Output [kW]
- CES15 Output [kW]
- CES16 Output [kW]
- CES17 Output [kW]
- CES18 Output [kW]
- CES19 Output [kW]

Hours

Real Time LMP Price [$/MWh]

CES Output [kW]
# CES Test Plan

<table>
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<tr>
<th>Testing</th>
<th>Test Description</th>
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<tr>
<td><strong>Equipment/ Factory Acceptance Test</strong></td>
<td>• S&amp;C will design perform a factory acceptance test for the CES equipment</td>
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<td>• KEMA will provide an independent evaluation of initial design CES equipment.</td>
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<td><strong>Functional Test</strong></td>
<td>• KEMA will develop a test plan and witness testing that will demonstrate the CES Unit capability to provide specific fundamental functions:</td>
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<tr>
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<td>i. Peak shaving, volt-VAR, demand response (</td>
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<td>ii. Remote communication and control of CES unit (DR SOC emulation)</td>
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<td>iii. Islanding</td>
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<td>iv. Respond to AGC simulated signal</td>
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<tr>
<td><strong>System Test (DTE Field)</strong></td>
<td>• The system test and evaluation will be performed in the field as the units are installed.</td>
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<td><strong>Testing of Automotive Batteries for Secondary Use Application</strong></td>
<td>• KEMA’s KERMIT model will be used for a portion of this analysis, establishing a model that projects remaining lifetime based on vehicle usage profile)</td>
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<tr>
<td><strong>Comparative Test</strong></td>
<td>• CES Unit original design test results will be compared to testing done on an identical CES Unit removed from service.</td>
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• **Project Activity**
  – Vehicle durability testing/battery conditioning started in June of 2011
  – Additional vehicles assigned to this program will begin durability testing later this month

• **Testing Locations for Mileage Accumulation & Battery Conditioning**
  – Chelsea Proving Grounds – Chelsea, MI
  – Arizona Proving Grounds – Yucca, AZ
  – Undisclosed Public Roads throughout North America
Secondary Use of EV Batteries

Battery Conditioning & Vehicle Durability Testing

Beginning of Vehicle Reliability Testing
- Capacity – Verification Test
- Power pulse capability

Quarterly
- Cumulative vehicle miles
- Number of charge cycles
- Energy per charge and charge time
- Summary of battery issues related to DOE program

End of Automotive Useable Life – or End Vehicle Reliability Test
- Capacity – Total Available Energy
- 10 sec power pulse capability
- Total Charge / Discharge cycles
- Cumulative vehicle miles
Future Work

• Finalize functional test plan
• Test DR-SOC communication and controls with CES unit with S&C CES control unit
• Test and validate DEW reliability and economic dispatch algorithm
• Finalize physical design of CES unit
• Begin internal CES equipment review and approval process
• Begin working with communities on site approval process