



# **DTE Energy®**

## **DTE Energy Implementation of Community Energy Storage System for Grid Support**

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# Disclaimer











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- 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 and Roles

(weekly project calls)

Project Team Members & Roles	
Team Member	Role
	<ul style="list-style-type: none"> <li>Project lead</li> <li>Utility participant for CES field demo</li> <li>Project reporting</li> </ul>
	<ul style="list-style-type: none"> <li>CES Unit suppliers</li> <li>Factory acceptance testing</li> <li>Technical Support</li> </ul> 
	<ul style="list-style-type: none"> <li>CES functional testing</li> <li>Economic analysis and reporting</li> <li>Technical Support</li> </ul>
	<ul style="list-style-type: none"> <li>Circuit model development for baseline</li> <li>Reliability &amp; economic dispatch algorithm</li> </ul>
	<ul style="list-style-type: none"> <li>Durability &amp; conditioning testing of EV battery</li> <li>Secondary use EV battery supplier</li> <li>Provide baseline data for EV battery</li> </ul>
	<ul style="list-style-type: none"> <li>Investigation of regulatory issues surrounding energy storage and renewable energy</li> <li>DOD applications</li> </ul>
	<ul style="list-style-type: none"> <li>Utility technical advisor</li> </ul>

# 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

CES Parameters	Value
Power	25 kW
Energy	50 kWh
Voltage	240/120V AC
Cells	Li-Ion





# 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



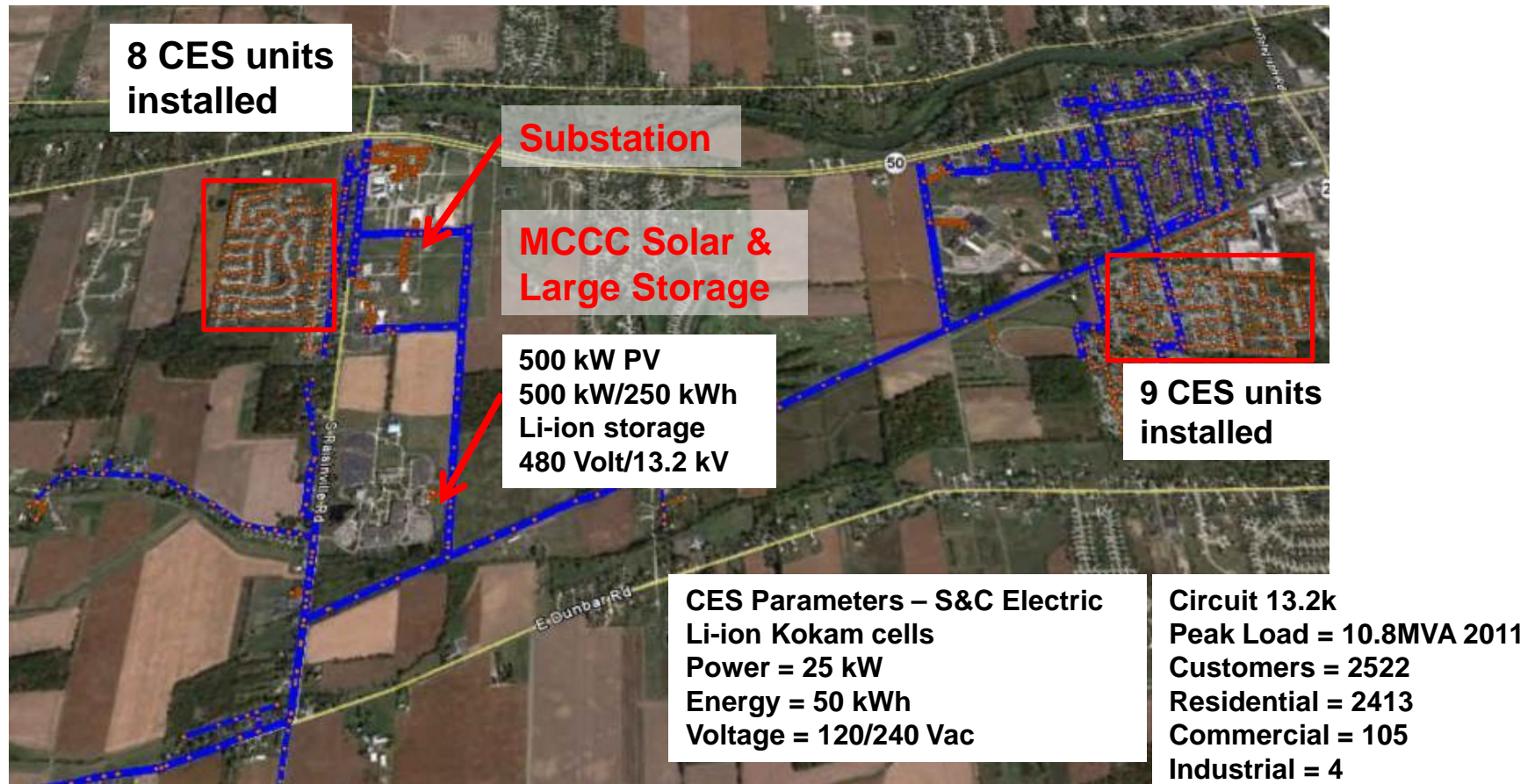
# Large Storage and PV Integration

- 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



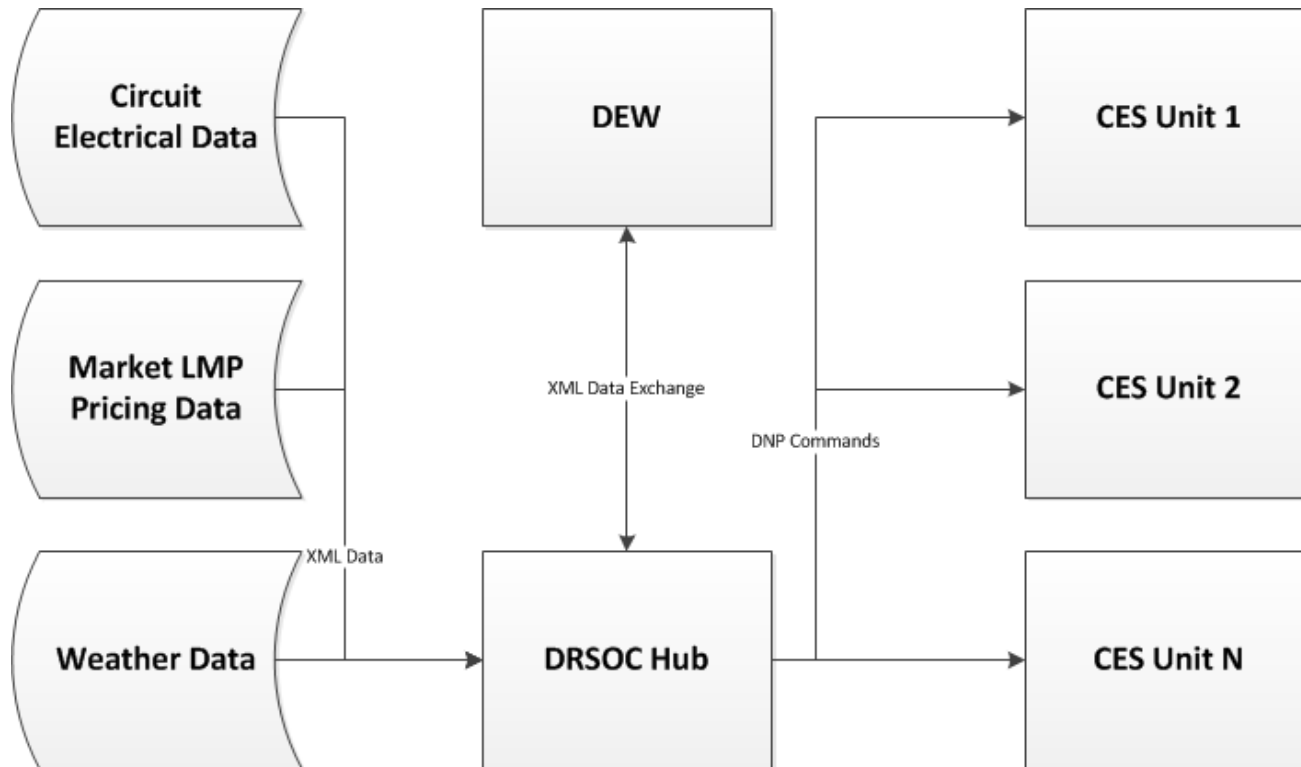


# Test Distribution Circuit



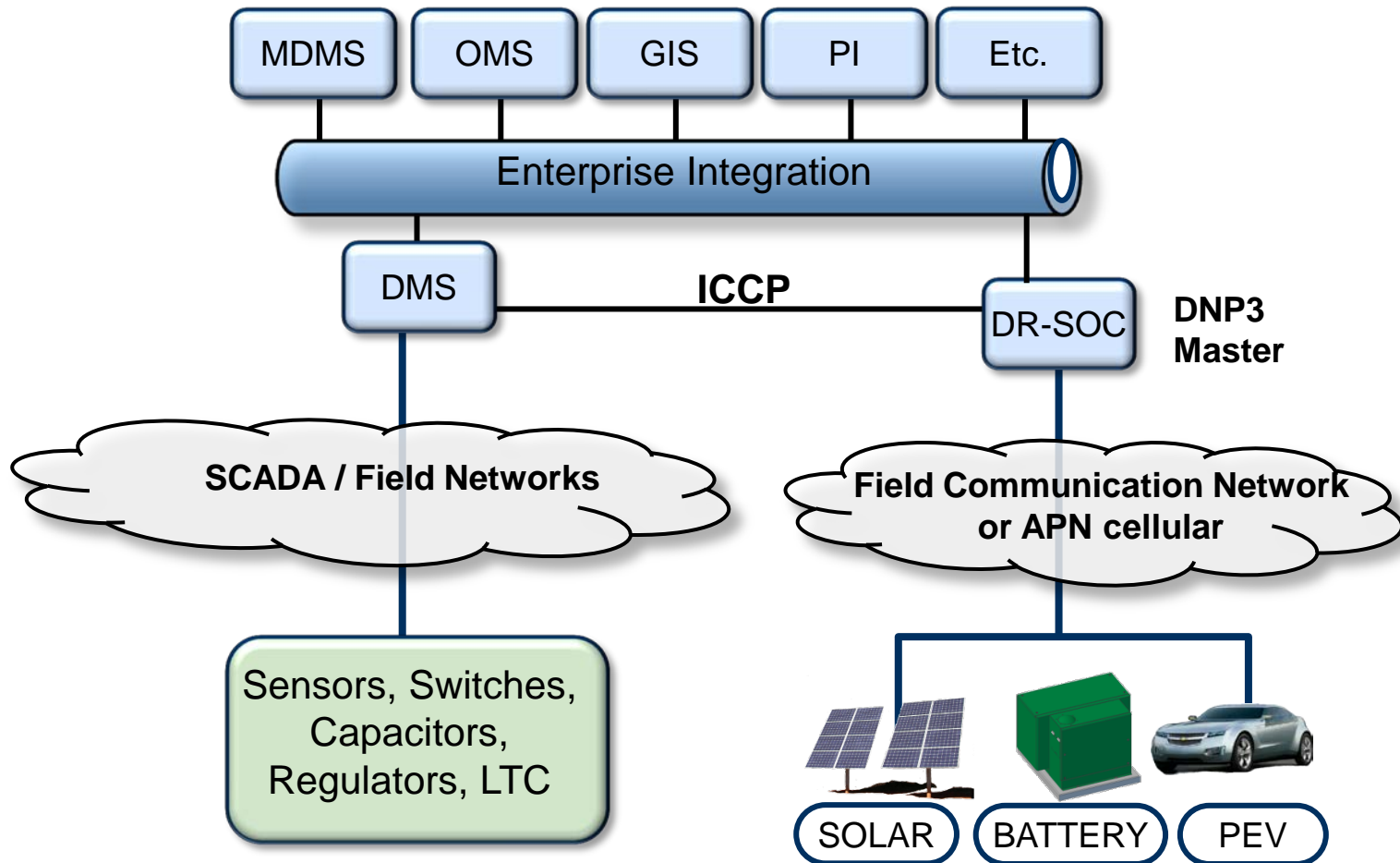


# CES - Communications Architecture



**All storage systems individually addressable or in a fleet hub command mode using DNP3**

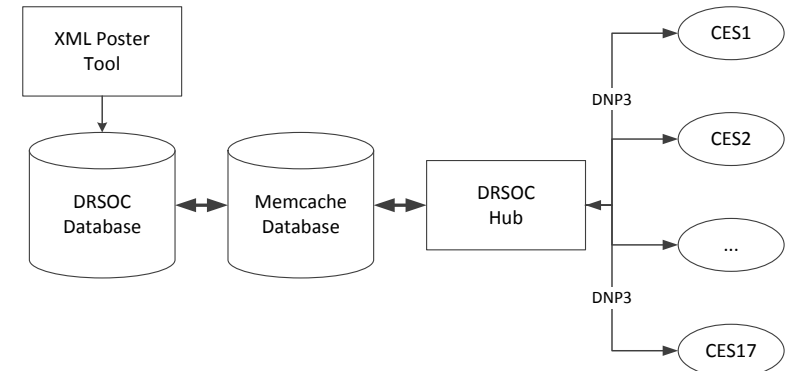
# DTE Energy DERMS



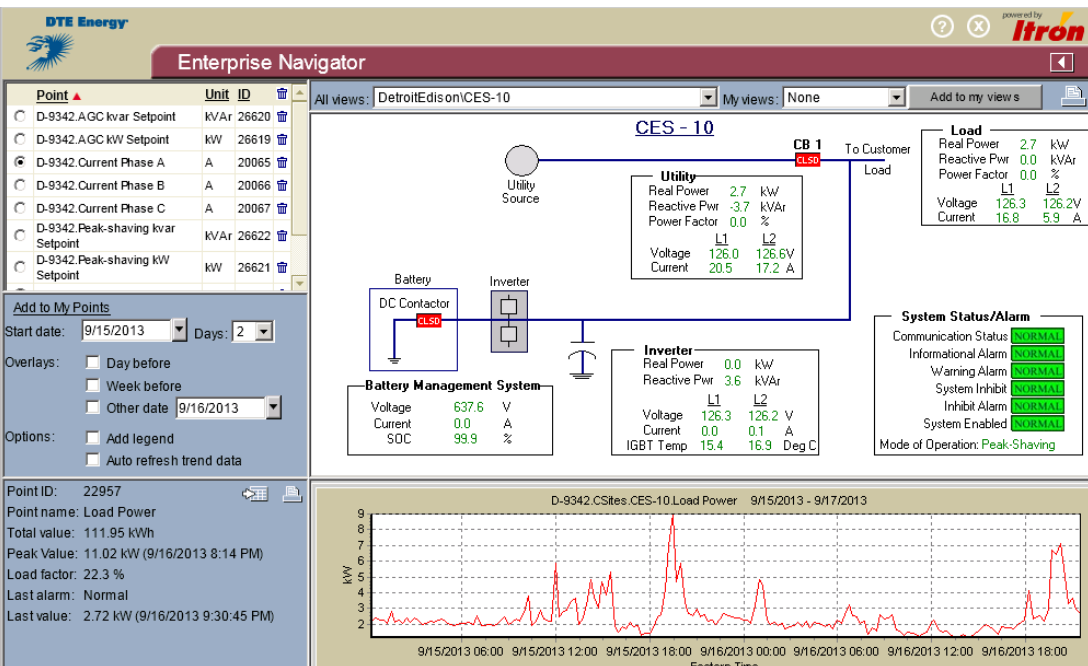
# CES Communication

**CES Site Summary**

Site	Battery SOC	Comm	PCS Power	PCS VARs	Load Power	Inhibit Alarm
CES-1	80.70 %	NORMAL	0.00 kW	3.46	0.06 kW	NORMAL
CES-2	92.80 %	NORMAL	-0.18 kW	14.99	3.68 kW	NORMAL
CES-3	88.00 %	NORMAL	-0.02 kW	15.01	1.94 kW	NORMAL
CES-4	96.80 %	NORMAL	0.00 kW	15.00	1.81 kW	NORMAL
CES-5	95.70 %	NORMAL	-0.29 kW	14.99	1.86 kW	NORMAL
CES-6	0.00 %	NORMAL	0.00 kW	3.49	0.53 kW	ALARM
CES-7	59.40 %	NORMAL	-0.01 kW	0.01	-0.02 kW	ALARM
CES-8	79.50 %	NORMAL	-0.32 kW	15.02	3.36 kW	NORMAL
CES-9	91.90 %	ALARM	0.00 kW	3.41	1.40 kW	ALARM
CES-10	97.90 %	NORMAL	-0.38 kW	-15.02	2.35 kW	NORMAL
CES-11	97.40 %	NORMAL	-0.83 kW	-14.99	1.15 kW	NORMAL
CES-12	96.10 %	NORMAL	-0.86 kW	-15.00	2.47 kW	NORMAL
CES-13	98.00 %	NORMAL	-0.68 kW	-15.02	2.63 kW	NORMAL
CES-14	96.10 %	NORMAL	-0.22 kW	-15.01	7.76 kW	NORMAL
CES-15	88.60 %	NORMAL	0.00 kW	3.45	0.89 kW	NORMAL
CES-16	0.00 %	NORMAL	0.00 kW	3.43	1.28 kW	ALARM
CES-17	97.40 %	NORMAL	-0.85 kW	-14.98	1.07 kW	NORMAL



- 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 document



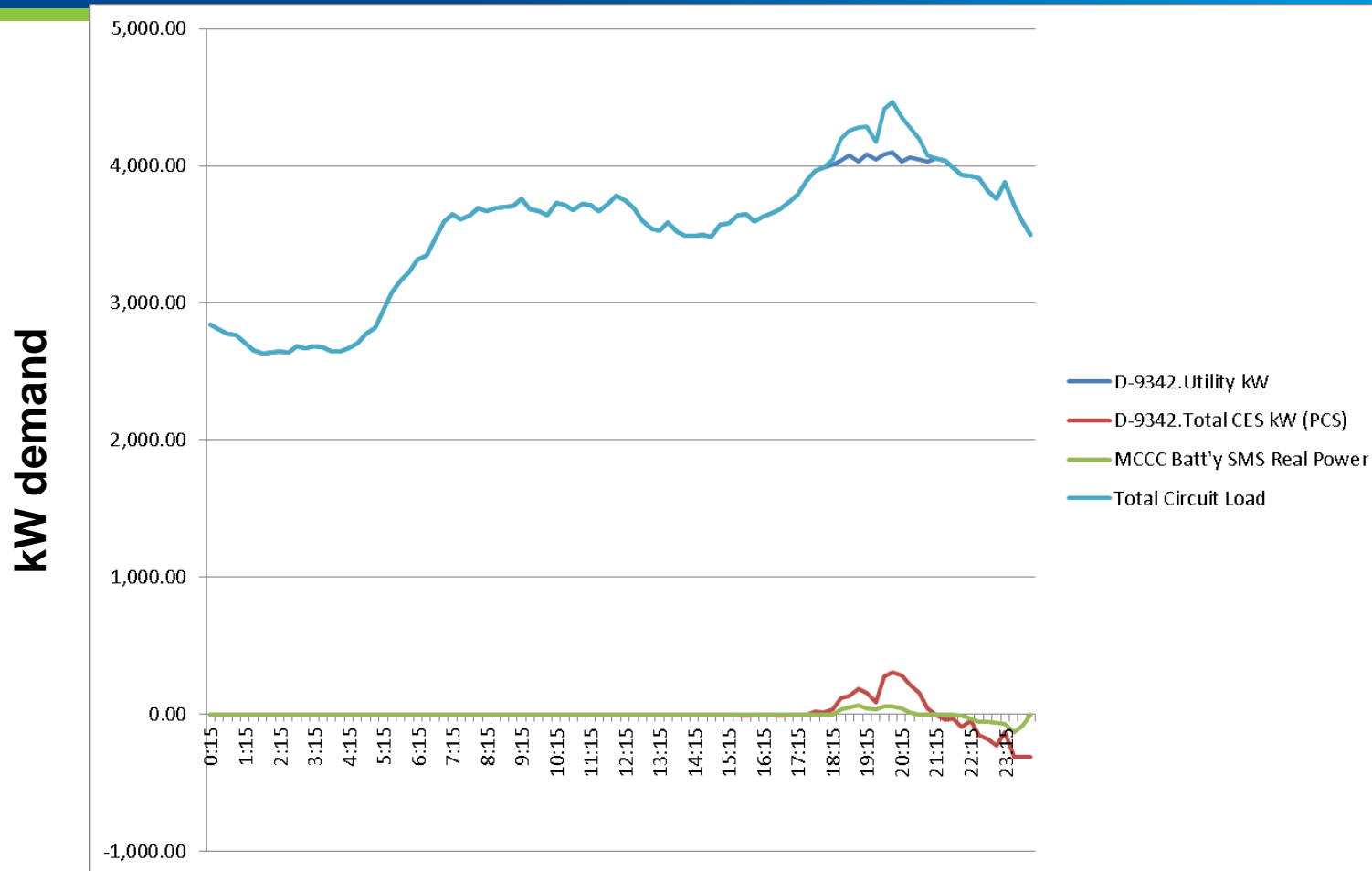
REQUIREMENT#	TEST PERFORMED	COMPONENT TESTED	Mode of Operation
DRSOC-CES-001	Data usage test	Cellular communications	Stand-by / Hub Command
DRSOC-CES-002	CES maintains Minimum Reserve Margin	CES controller logic	Hub Command
DRSOC-CES-003	CES unit will operate safely when unit is at 100% SOC and is given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

## 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)



# Use case: Circuit Peak Shaving



**24 hour profile. Light blue=Total circuit load. Dark blue=Load from system. Red=CES fleet. Green=MCCC battery.**

# Use case: DEW Economics Mode



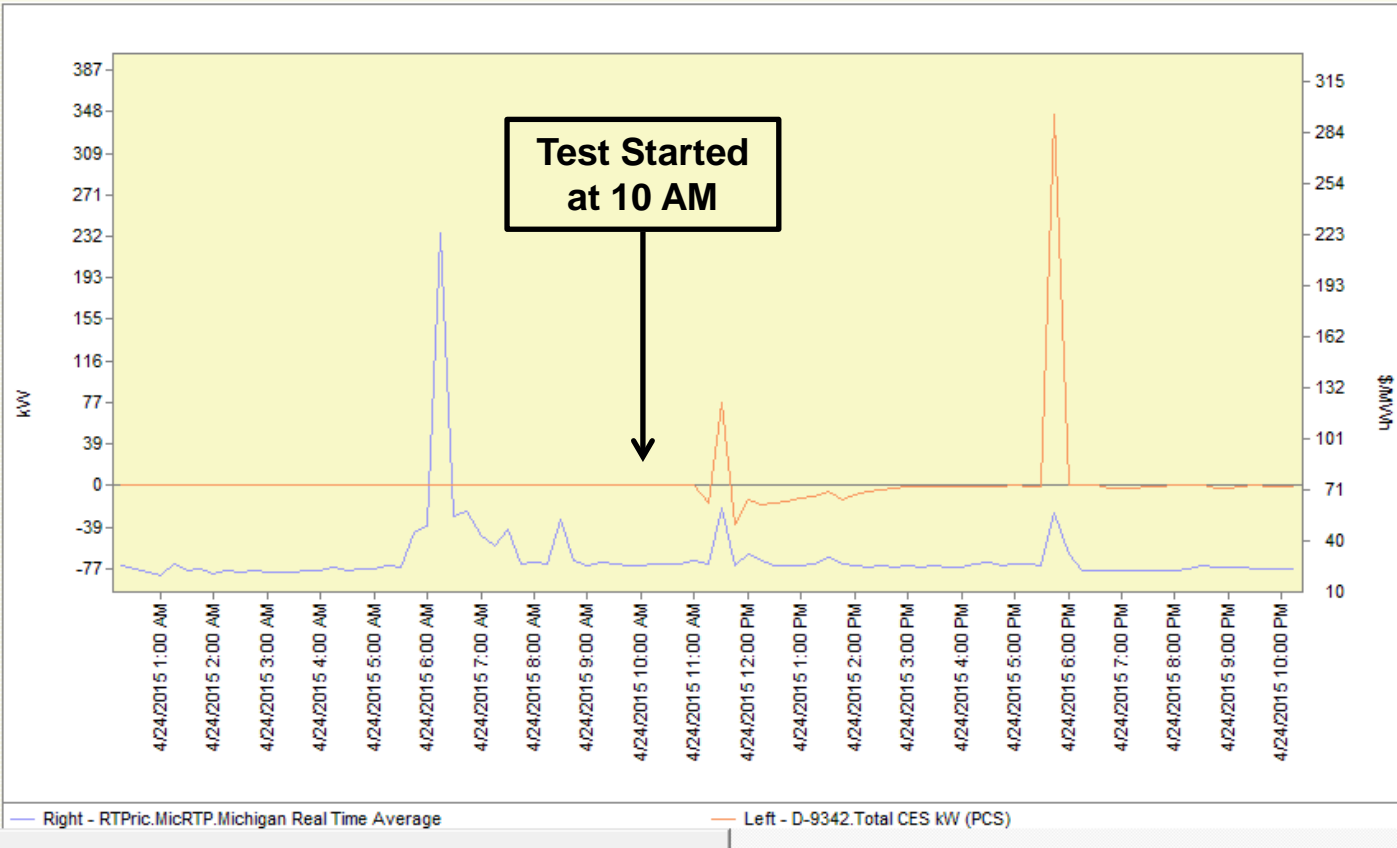
## Multi-Point Trend report

Report date: 4/24/2015 10:25:36 PM

Report span: 4/24/2015 - 4/24/2015

Total days: 1

Battery Fleet kW

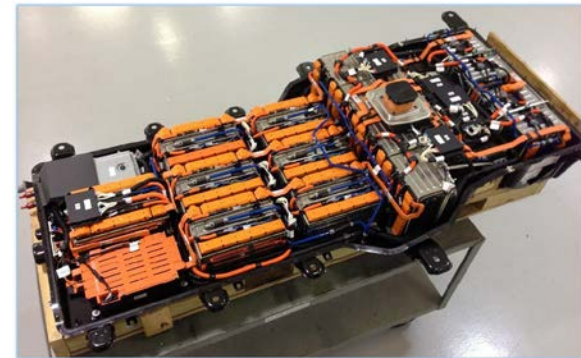
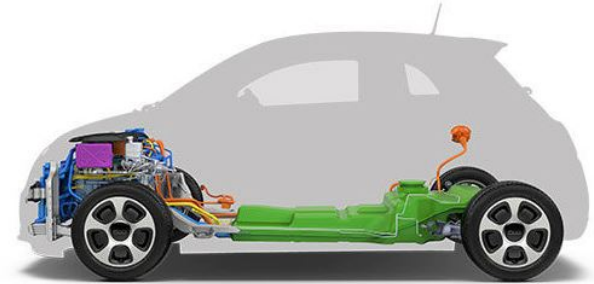


Real Time LMP \$/MWh

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

# 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

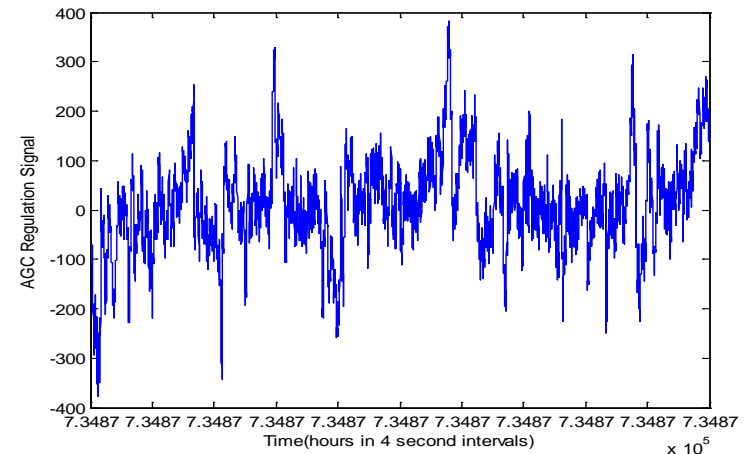
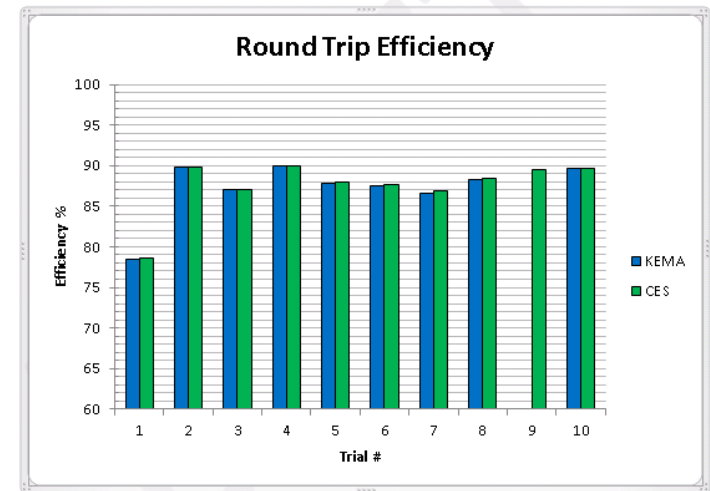


# Backup slides

# 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

Table 1 AC Round Trip Efficiency



# CES Communication Hub Command



Node Status

SOC Logs

Wiki

Reporting

Tools

Fleet Hub Command Setpoint

kW:  Current value: 250

kvar:  Current value: 25

Send Control

Unit status

CES # 1 Charge 99.7% HUB COMMAND CES.SNC1.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 2 Charge 99.6% HUB COMMAND CES.SNC2.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 3 Charge 99.9% HUB COMMAND CES.SNC3.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 4 Charge 100% HUB COMMAND CES.SNC4.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 5 Charge 0% HUB COMMAND CES.SNC5.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 6 OUT OF SCAN Charge 0% HUB COMMAND CES.SNC6.PCS_KW: 0 Hub Command 0 kvar -25 kW
CES # 7 Charge 99.6% HUB COMMAND CES.SNC7.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 8 Charge 99.7% HUB COMMAND CES.SNC8.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 9 Charge 99.5% HUB COMMAND CES.SNC9.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 10 Charge 79.3% HUB COMMAND CES.SNC10.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 11 Charge 100% HUB COMMAND CES.SNC11.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 12 Charge 100% HUB COMMAND CES.SNC12.PCS_KW: 0 Hub Command 0 kvar -25 kW
CES # 13 Charge 99.8% HUB COMMAND CES.SNC13.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 14 Charge 100% HUB COMMAND CES.SNC14.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 15 Charge 99.6% HUB COMMAND CES.SNC15.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 16 Charge 0% HUB COMMAND CES.SNC16.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 17 Charge 0% HUB COMMAND CES.SNC17.PCS_KW: 0 Hub Command 0 kvar -25 kW	CES # 18 Charge 0% STANDBY CES.SNC18.PCS_KW: 0 Hub Command 0 kvar 0 kW

Control

Change of Mode

Standby Mode

Schedule Mode

AGC Mode

Hub Command Mode

Hub Fleet Command Mode

Peakshave Mode

DEW Econ Mode

DEW Reliability Mode

Full kW / kvar operations

HUB 0 kW 0 kvar

HUB Full kW out (+)

HUB Full kW in (-)

HUB Full kvar out (+)

HUB Full kvar in (-)

Random

HUB Random kW out (+)

HUB Random kW in (-)

HUB Random kW (both + and -)

CES Site Summary

Site	Battery SOC	Comm	PCS Power	PCS VARs	Load	DC Contactor	Inhibit Alarm
CES-1	80.80 %	NORMAL	-3.57 kW	3.39	0.43 kW	CLSD	NORMAL
CES-2	55.90 %	NORMAL	-8.18 kW	6.35	0.76 kW	CLSD	NORMAL
CES-3	64.70 %	NORMAL	-6.55 kW	3.92	1.66 kW	CLSD	NORMAL
CES-4	85.40 %	NORMAL	-2.72 kW	3.48	1.98 kW	CLSD	NORMAL
CES-5	0.00 %	NORMAL	0.00 kW	3.40	1.86 kW	OPEN	NORMAL
CES-6	0.00 %	ALARM	0.00 kW	0.00	0.00 kW	OPEN	ALARM
CES-7	77.70 %	NORMAL	-4.14 kW	3.40	6.14 kW	CLSD	NORMAL
CES-8	73.40 %	NORMAL	-4.96 kW	3.66	7.90 kW	CLSD	NORMAL
CES-9	84.80 %	NORMAL	-2.83 kW	3.39	3.05 kW	CLSD	NORMAL
CES-10	79.30 %	NORMAL	0.00 kW	0.00	0.00 kW	OPEN	ALARM
CES-11	66.50 %	NORMAL	-6.22 kW	3.76	1.32 kW	CLSD	NORMAL
CES-12	63.20 %	NORMAL	-6.83 kW	3.78	0.68 kW	CLSD	NORMAL
CES-13	72.80 %	NORMAL	-5.01 kW	3.51	2.10 kW	CLSD	NORMAL
CES-14	72.40 %	NORMAL	-5.12 kW	3.45	2.57 kW	CLSD	NORMAL
CES-15	63.20 %	NORMAL	-6.83 kW	3.78	0.75 kW	CLSD	NORMAL
CES-16	0.00 %	NORMAL	0.00 kW	3.39	0.91 kW	OPEN	NORMAL
CES-17	0.00 %	NORMAL	0.00 kW	3.42	0.37 kW	OPEN	NORMAL

100 kW Charge

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# 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

