DTE Energy Large Field Deployment of Community Energy Storage (DE-OE0000229)

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Manager Power Systems Technologies

Acknowledgements

I would like to thank Dr. Imre Gyuk, Program Manager Electrical Energy Storage Program, DOE's Office of Electricity for his support of the Energy Storage Projects.

Project Overview

- First large utility scale community energy storage (CES) project
- Aggregation of CES using a Distributed Resources System Operation Center (DR-SOC)
- Using utility industry protocol (DNP3)
- Determining value stream of storage on test circuit in MISO market
- Deploy secondary use EV batteries
- Integration of energy storage and PV

Project Team and Roles
(weekly project calls)

Project Team Members & Roles	
Team Member	**Role**
DTE Energy	• Project lead • Utility participant for DES 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 ask us what's next	• Investigation of regulatory issues surrounding energy storage and renewable energy • DOD applications
nationalgrid	• Utility technical advisor

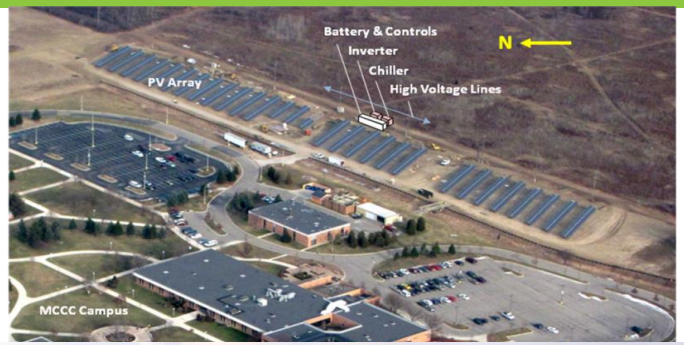
CES System Overview

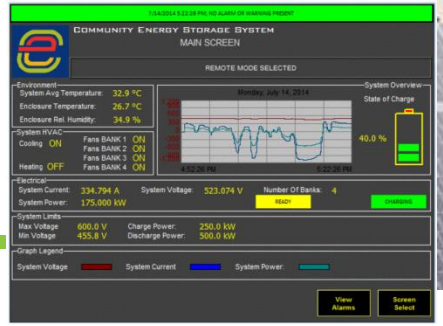
- Eighteen new units installed
  - One was installed in training yard
  - Developed engineering documents, installation and operation procedures
  - 17 on one distribution circuit
- Two repurposed EV batteries are demonstrating secondary-use application

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

Storage and PV Integration

- Large storage system
  - 500kW PV
  - 500kW Li-ion Storage– (250kWh)
- Status
  - PV operational
  - Energy storage installed
  - Final commissioning end of September 2014
- FAT July 2014

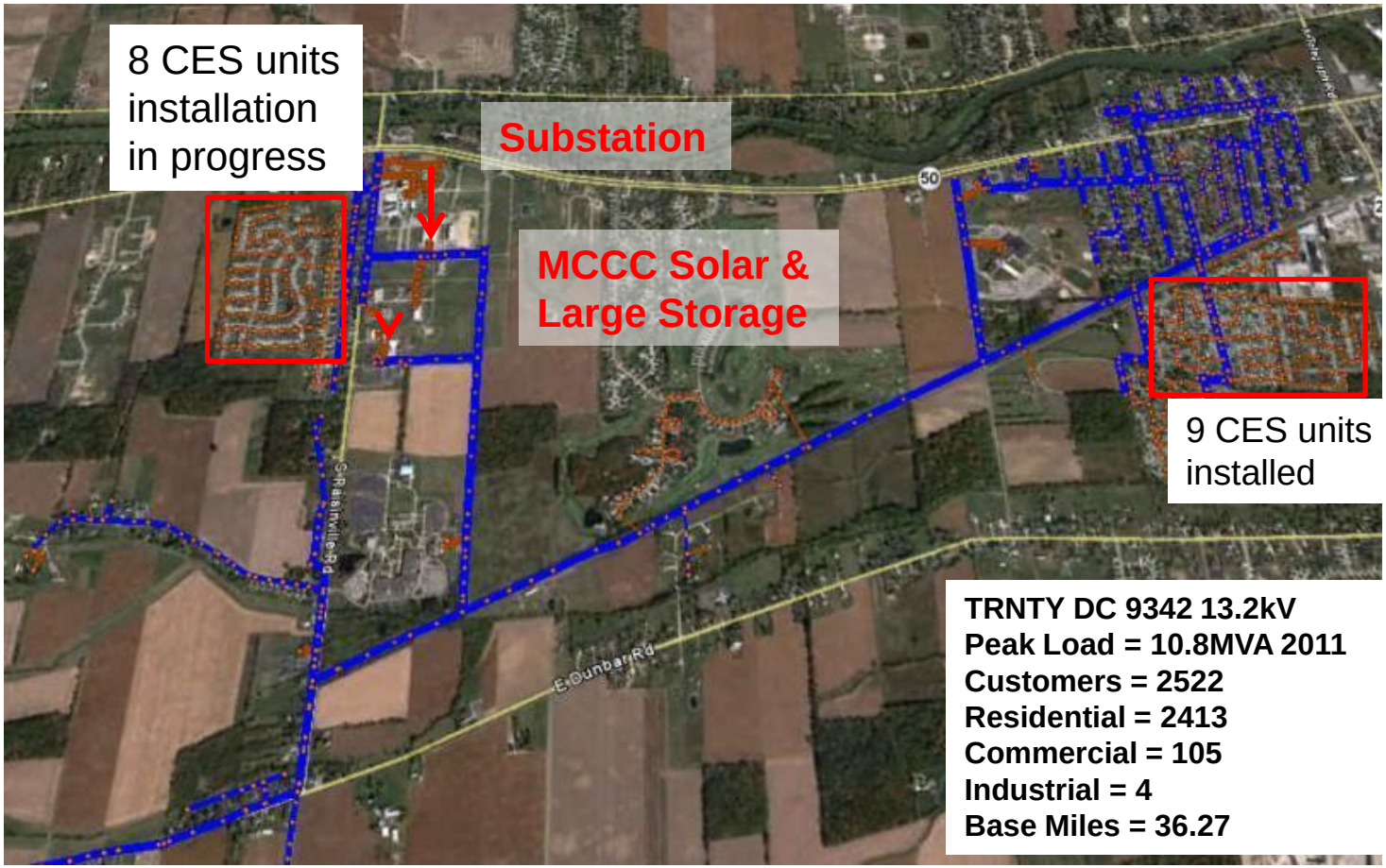




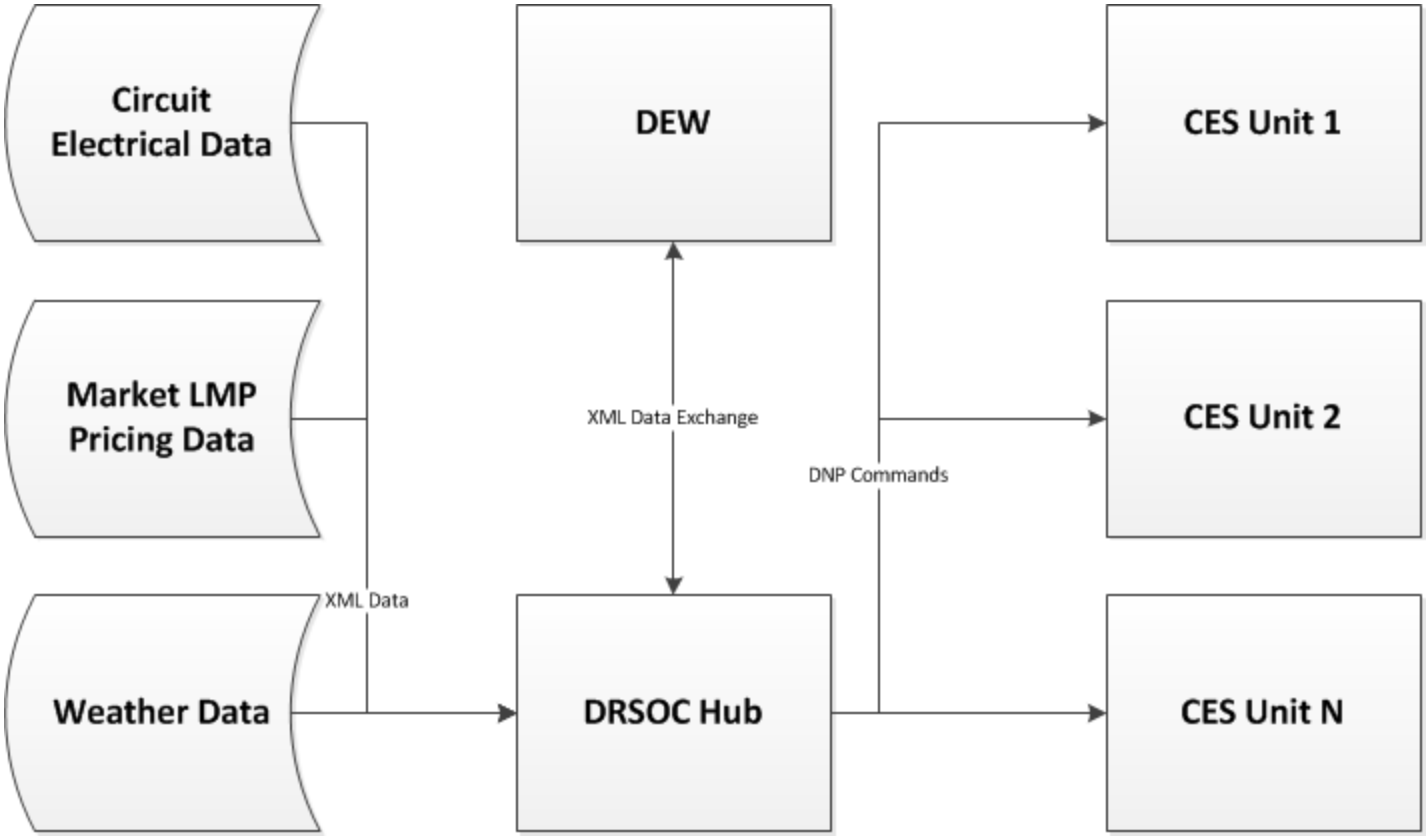
CES Field Installation Status

- 18 new units installed in 2013
  - One in Training Yard
  - 17 on one circuit
- Winter reliability problems
- Uses case testing started in June 2014

Test Circuit



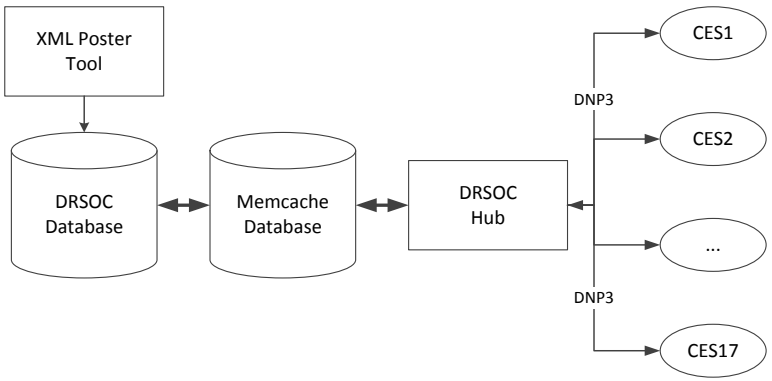
CES - Communications Architecture

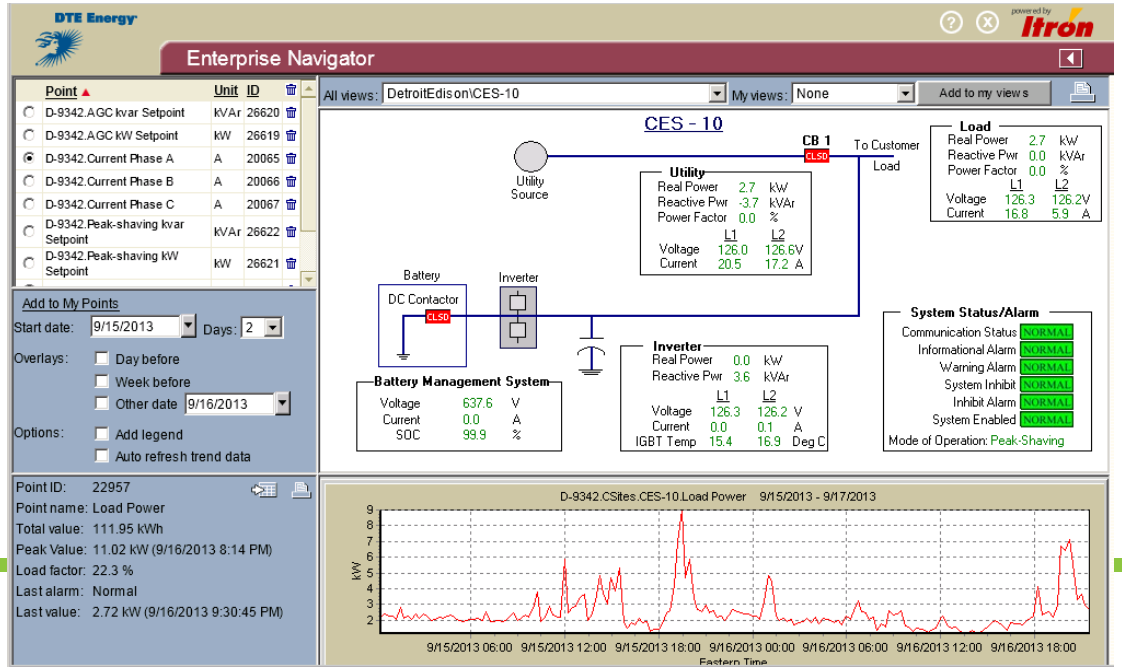


CES Communication

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





- 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 Communication Hub Command

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Logout

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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CES Test Plan - Modes of operation document

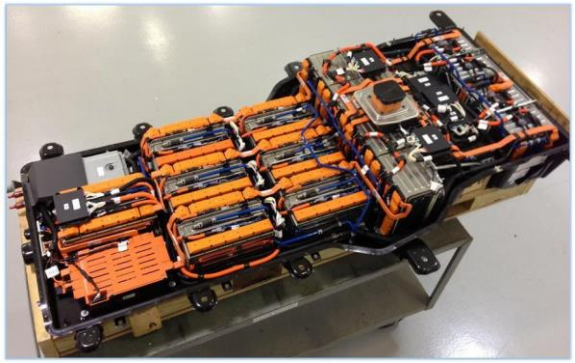
REQUIREMENT#	TEST PERFORMED	COMPONENT TESTED	Mode of Operation
DRSOC-CES-001	Data usage test	Cellular communications	Stand-by / Hub Command
DRSOC-CES-002	CES maintains Minimum Reserve Margin	CES controller logic	Hub Command
DRSOC-CES-003	CES unit will operate safely when unit is at 100% SOC and is given 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/VAR support
- Islanding during outages
- Frequency regulation (AGC)
- Renewable energy time shift
- Renewable generation smoothing
- Circuit peak shaving
- Discharge during high LMP price
- Circuit model commands (DEW Services)

Repurposed EV batteries

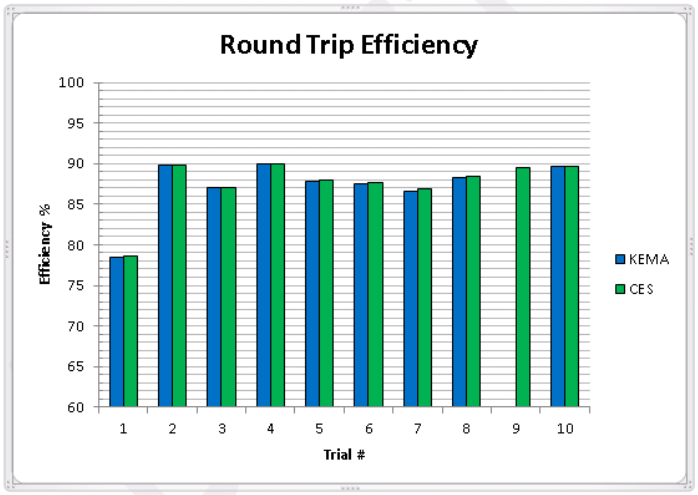
- Six end of life automotive battery packs – Fiat 500e
- Battery size - 25 kW/50 kWh
- Two energy storage configurations
  - Module level
  - Whole pack
- Containers with batteries built
- New control circuit boards being built
- One CES to DNV GL for testing (Oct 2014)
- One to DTE for installation (Nov 2014)

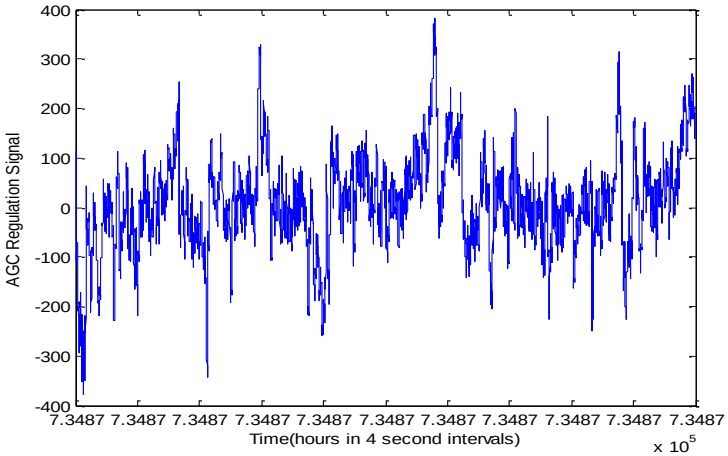


Sample reports

- 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

Table 1 AC Round Trip Efficiency





Future Tasks – 2015 FY

- Complete testing and installation of secondary used battery system (end of 2014)
- Energize 500 kW energy storage system (Sep 2014)
- Complete testing of use cases
- Complete final report
- Project ends FY 2015

Contact Information

Thank you to the DOE OE and especially Dr. Gyuk for his dedication and support to the Energy Storage industry.

Questions?

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