Tehachapi Wind Energy Storage Project

U.S. DOE/OE Energy Storage Program Peer Review

EESAT 2015 Technical Conference

September 21–24 2015

Grant Davis

Advanced Energy Storage

Southern California Edison

Overview

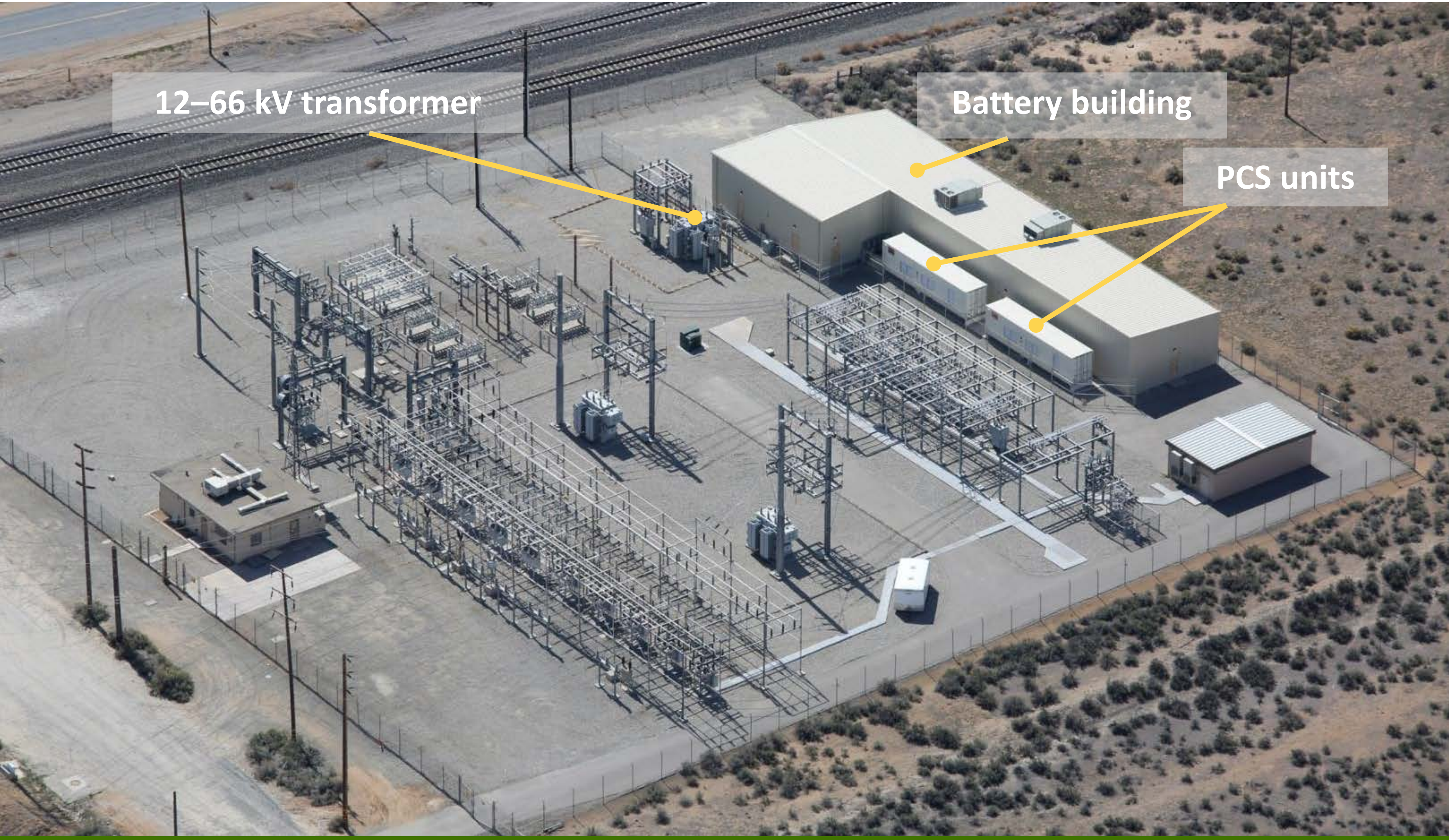
- Battery
  - Li-ion
  - 32 MWh usable
  - Manufactured by LG Chem

- Power conversion
  - 9 MVA
  - 12 kV connected
  - Manufactured by ABB

Facility

- Located near Tehachapi, in California's largest wind resource area
- 4,500 MW of wind development potential, driving grid infrastructure
- Installed at SCE's Monolith Substation
- Connected at sub-transmission level through a 12–66 kV transformer

Layout



Timeline

02/09/2010 – Project started

10/13/2010 – DOE contract signed

02/28/2011 – Original vendor contract signed

10/16/2012 – Original vendor filed for bankruptcy

03/27/2013 – New vendor contract signed

07/18/2014 – System commissioning & acceptance completed; start of M&V

12/31/2014 – First technical performance report delivered

04/21/2015 – PCS MV transformers replaced

M&V

Objectives

- Test a large-scale BESS as a system reliability and market-driven device
  - **Dual control interfaces**
  - **13 operational uses**
- Integrate battery storage technology into SCE's grid
  - Test and demonstrate smart inverter technology
  - Assess performance and life cycle of grid-connected lithium-ion BESS
  - Expand expertise in energy storage technologies and operations

8 core tests

Under grid operator control (EMS)

1. Voltage regulation
2. Voltage regulation + any other mode
3. Charge under high line load, discharge under low line load
4. Charge off peak, discharge on peak
5. Smooth renewables

Under market control (GMS)

6. Frequency regulation
7. Energy & spin/non-spin reserves
8. Follow energy price signal

M&V schedule

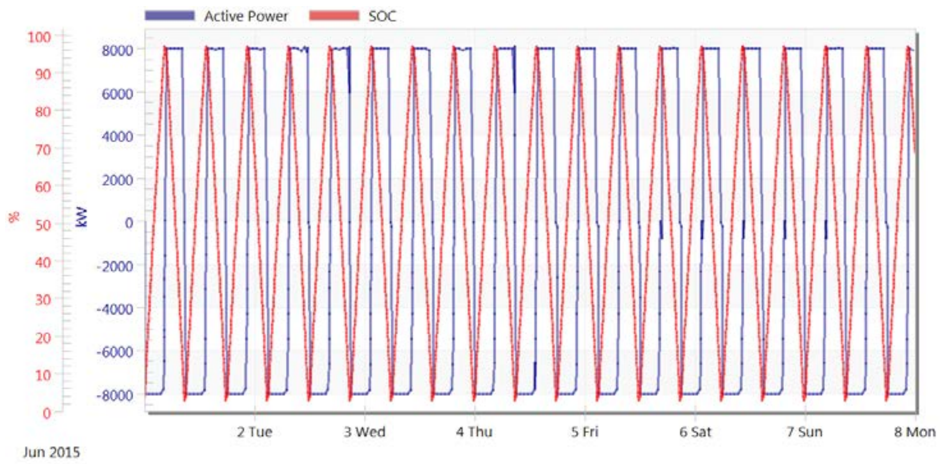
- Late 2014, May 2015: Characterization testing
  - Constant cycling performance, round trip efficiency
- June–July 2015: EMS short-term testing
  - Core tests 1, 2, 3, 4, 5
- September 2015: GMS short-term testing
  - Core tests 6, 7, 8
- October 2015–June 2016
  - (2) EMS long-term testing periods
  - (2) GMS long-term testing periods

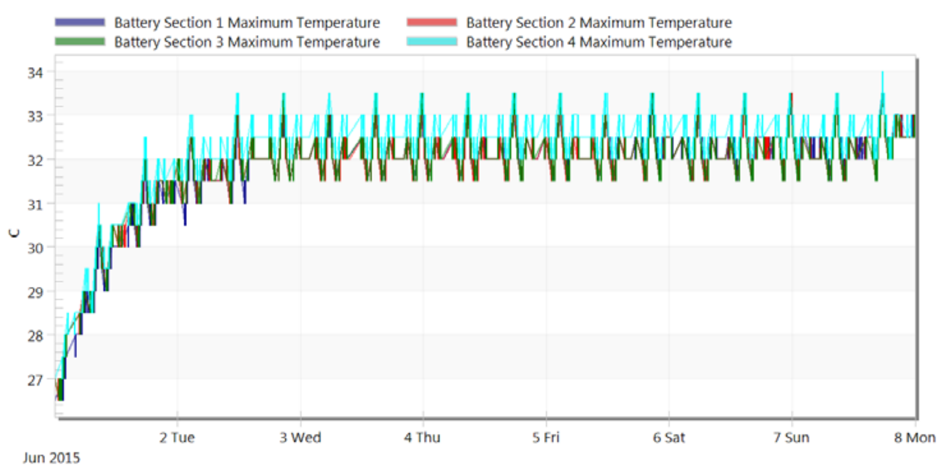
System characterization testing, May 2015

- 4 MW cycle test
  - 1 cycle per day with a rest at 30 % SOC
- 8 MW cycle test
  - 2 cycles per day with a rest at 30 % SOC
- 8 MW cycle test w/o rest
  - Back-to-back cycling at full power

Auxiliary Loads	Average RTE
Not included	88.6 %
Included	87.4 %

For 8 MW cycle test w/o rest, as measured at 66 kV. All results are preliminary. Final results will be presented in the TPR.

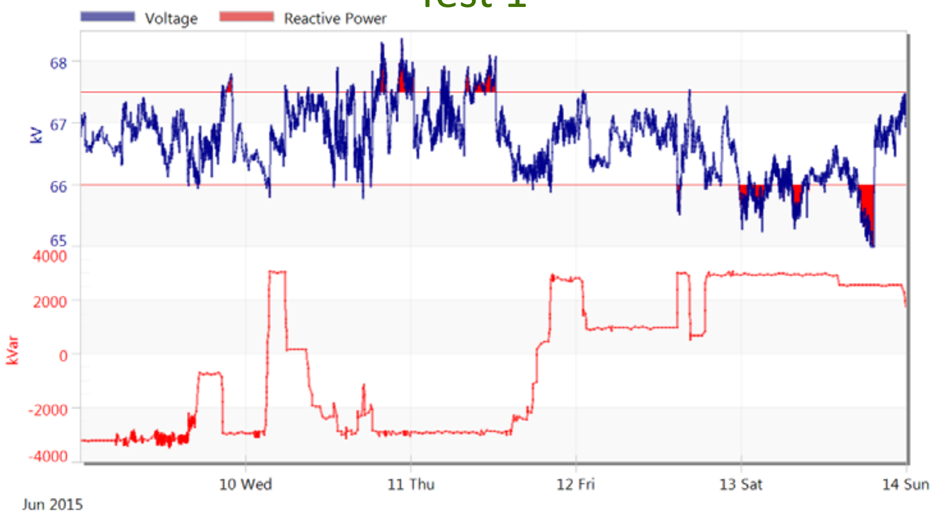




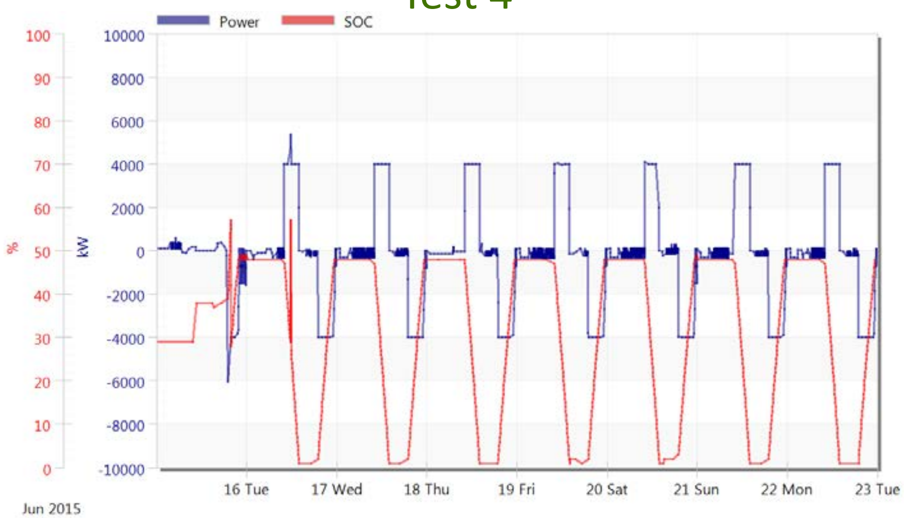
EMS short term testing, June–July 2015

- Test 1: Voltage regulation
  - System dispatched correctly
  - Limited effect due to size of system relative to bus conditions
- Test 4: Charge off peak, discharge on peak
  - Schedule-based dispatch
  - System operated correctly with one PCS off line

Test 1



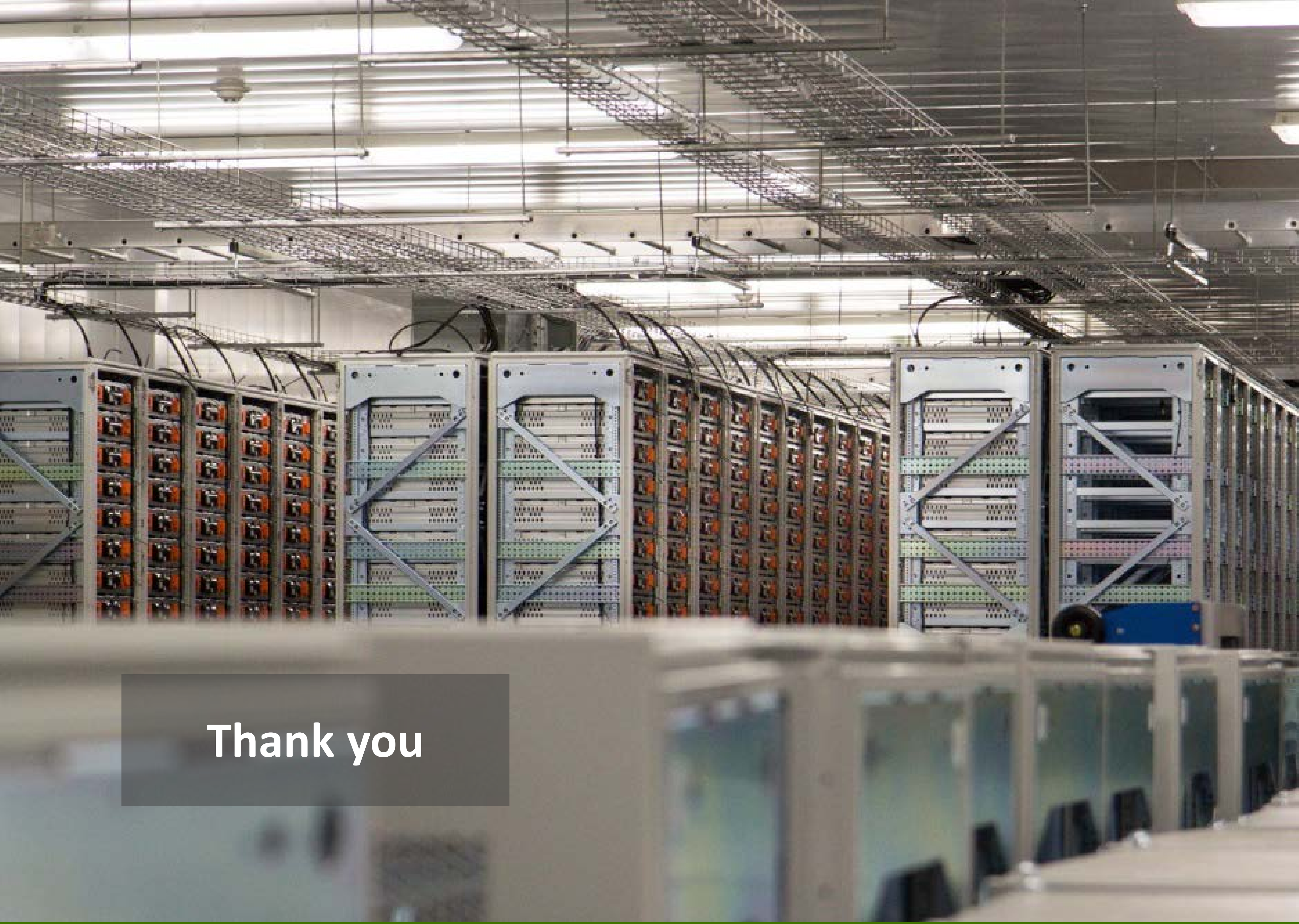
Test 4



- Test 3: Charge under high line load, discharge under low line load
  - System dispatched correctly
  - Limited effect due to size of system relative to line loading
- Test 5: Smooth renewables
  - Difficulty in selecting proper renewable plant output scaling and maximum allowable ramp rates for optimal operation

Operational issues & takeaways

Issues	Takeaways
PCS MV transformer failure & replacement	• Use off-the-shelf designs • Specify quick and easy modular component replacement
Substation availability	• Permanent interconnection required for long-term operation
PCS temperature trips	• Need for remote filter monitoring
Battery module failures & replacements	• Need for additional level of BMS power saving mode • Consider spare module storage and maintenance

Thank you