

E3 Battery-like Services Study: Input Assumptions

July 2018

Overview of the Powerex study by E3

Powerex engaged E3 to investigate the value proposition of providing battery-like services to California

These modelled battery-like services include:

- Resource Adequacy (RA), Greenhouse Gas (GHG) and Renewable Integration Benefits

- 1000 MW of capacity with 8000MWh of storage

- No initial charging required to withdraw energy

- 80% round trip efficiency (to reflect transmission losses)

- Includes potential to settle some net daily differences contractually (i.e. under-draw or over-draw energy across a day)

E3 quantified the gross benefits of the battery-like services using three scenarios:

- “CPUC IRP” with same assumptions in the September 2017 CPUC Reference System Plan (42 MMT)

- “PWX” based on CPUC IRP case with Powerex updates to CPUC IRP to a few key input assumptions

 - More recent technology cost information and CEC peak load forecast

 - Reduced internal generating Firm Capacity assumptions

 - Reduced Import Capacity assumptions

- “CEC” baseline based on E3 analysis for California Energy Commission (80% GHG case) with the Powerex updates to input assumptions

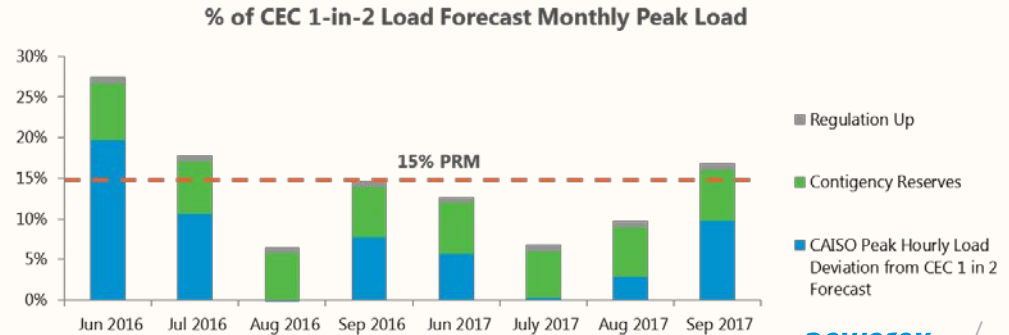
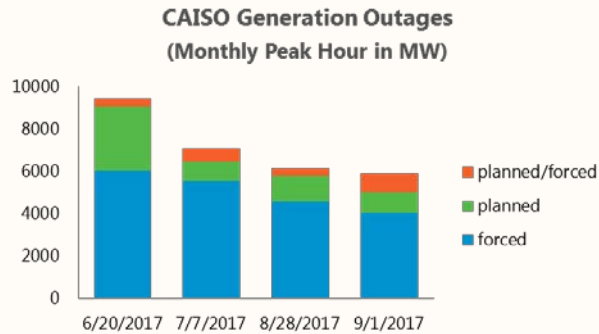
PWX Scenario defined in May 2018, study provided by E3 in July 2018

Powerex input assumptions for “PWX” from the E3 baseline model

Input Assumption	CPUC IRP Assumption	PWX Updated Assumption
Reduced solar installation costs	Black & Veatch RPS Calculator V6.3 Data Updates with E3 supplemental updates	2017 NREL Annual Technology Baseline (ATB) indicates lower solar installation costs
Reduced battery costs	Lazard v2.0 – Levelized Cost of Storage Analysis (December 2016)	Lazard v3.0 – Levelized Cost of Storage Analysis (November 2017)
Increased peak load forecast	2016 Integrated Energy Policy Report (IEPR)	2017 Integrated Energy Policy Report (IEPR) (~2,000 MW increase)
Reduced Firm Capacity of internal generation to reflect historic planned and forced generation outage rates	CAISO Net Qualifying Capacity (NQC) List (November 2016)	Same, but reduced by 10% (estimated based on CAISO 1515 Report)
Reduced imports to reflect <ul style="list-style-type: none"> • CAISO actual imports in 2017 monthly peak hours • Future expected NW coal retirements reduces NW surplus capacity • Reduced Powerex residual capability 	Assumes sufficient external capacity to fully utilize 11,310 MW Maximum Import Capacity - which includes the CAISO’s share of Hoover and Palo Verde (1,419 MW total share such that the remaining import capacity is 9,891 MW)	<ul style="list-style-type: none"> • Reduced to 4,000 MW to reflect CAISO actual imports in 2017 monthly peak hours; • Reduced further by 1,087 MW by 2026 as NW coal plants retire (50% not replaced); • Powerex residual capability 2,000 MW in 2018, declining to 800 MW in 2030

Generation outages are not considered in CPUC IRP firm capacity assumption or covered by PRM

- **Firm capacity in CPUC IRP (and RA program) is based on Net Qualifying Capacity (NQC)**
 - NQC is generally based on deliverability of installed capacity, not reduced to reflect planned and forced outage rates (>10%)
- **Planning Reserve Margin (PRM) for Resource Adequacy (RA) is not sufficient to cover outages**
 - Set at 15% of 1-in-2 monthly peak load forecast
 - PRM only sufficient to cover monthly peak load deviations, contingency reserves and regulation up (CAISO OASIS data)
 - *“Currently, system resource adequacy requirements are set using a monthly 1-in-2 load forecast plus a 15% reserve margin. Recent experience shows that using this load forecast can result in resource adequacy requirements that are significantly less than observed peak loads in some months” CAISO in CPUC OIR R17-09-020, September 28, 2017*



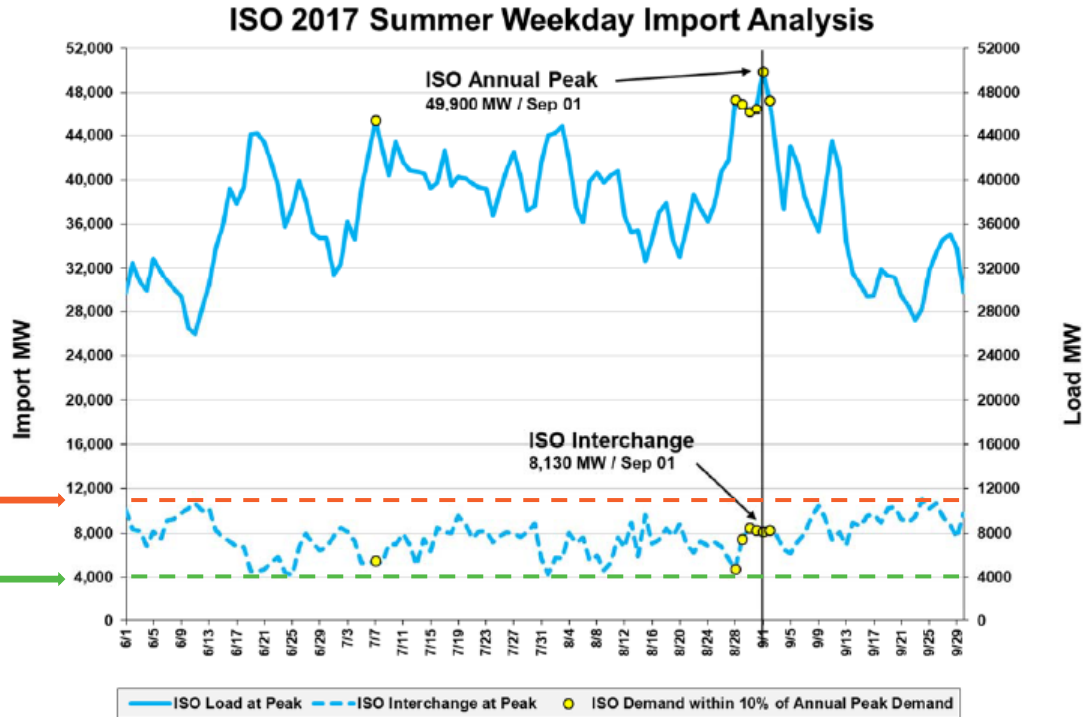
Source Data: 1515 Report outage data and CAISO OASIS

Import Capacity in E3 model (11,310 MW) overstates actual CAISO imports in monthly peak load hours

- 2017 data shows actual imports during peak load hours are far less than the Maximum Import Capability (11,310 MW)
- 2018 Import Capacity in E3 model should reflect the *minimum* level of imports experienced during monthly peak hours
 - Imports above this level may or may not occur, depending on external grid conditions

CPUC IRP scenario

Powerex scenario



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Thank You

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