Flexibility Metrics and Standards Project

– a California Energy Systems for the 21st Century (CES-21) Project

CPUC Workshop

January 6, 2016

Purpose & Agenda

1. Background
2. Project Objectives and Scope
3. Analysis and Preliminary Findings
   3.1 Analytical Framework and Study Cases
   3.2 Reliability
   3.3 Cost and Policy
   3.4 Metrics & Standards
4. Next Steps

Project Background

1. CES-21 Program
2. Flexibility Metrics & Standards Project
3. Project Team
   – Astrape Consulting, EPRI, LLNL, PG&E and SDG&E
4. Advisory Group
   – CAISO, CEC, CPUC, ORA, SCE, and TURN

Project Objectives

PROJECT OBJECTIVE

Study and recommend, if appropriate, planning metrics and standards that explicitly consider operational flexibility

RESOLUTION E-4677 REQUIREMENTS

Leverage results from collaborative review of planning model work

Form a collaborative advisory group

- *Meet every six months*
- *Connect project progress with LTPP/RA flexibility modeling efforts*

Produce results for use in the 2016 LTPP

- *Present preliminary results / recommendations in a public workshop using 2014 LTPP assumptions*
- *Demonstrate recommended metrics / standards in the 2016 LTPP using updated assumptions*

Project Scope – Key Questions

Q1 Reliability
How much capacity and operating flexibility is needed for the CAISO system to meet the 1 day in 10 years Loss of Load Expectation (LOLE) reliability standard in 2024?

Q2 Cost and Policy
Is there additional flexible capacity needed to achieve state policy goals or to lower cost? If so, what type of operating flexibility?

Q3 Metrics / Standards
How to translate capacity and flexibility requirements into planning standards (for procurement purposes)?

<u>In Scope</u>	<u>Out of Scope</u>
Examine whether planning standards need to be updated to explicitly include operating flexibility	Develop optimal solution to meet reliability, operating flexibility (and cost) goals for a generic electric system

Preliminary Findings and Indications – Summary

F1 The projected CAISO system[1] has sufficient flexibility and capacity to meet the 1 day in 10 years standard in 2024, provided that:

- a CAISO can curtail renewables to address hourly ramping needs
- b CAISO can vary net import to meet hourly ramping needs
- c CAISO sets aside sufficient load following reserves to meet intra-hour ramping needs

F2 A less flexible system yields higher costs and emissions

- a The Commission can review flexibility choices in the IRP process[2]

I3 The existing PRM[3] planning metric may continue to work

- a If the reliability contribution of each resource type is accurately accounted for

Next Steps

- a Confirm preliminary findings with a 50% RPS scenario and with improved modeling of WECC (and utilizing a high performance computing platform)

1. 2014 LTPP Trajectory and 40% RPS Scenarios; 2. As required in SB 350; 3. Planning Reserve Margin

Analytical Framework & Modeling Tool

Inputs	Model	Results
Load and Resource Assumptions (e.g., CAISO system with 33% RPS in 2024)	**Strategic Energy Risk Valuation Model (SERVM)** (A hybrid resource adequacy and production cost model)	**System Performance** Reliability (capacity / flexibility) Cost Environmental Impact
Uncertainties considered: • 33 **weather years** (correlated profiles for load / wind / solar) • 5 **economic load growth uncertainty** levels • 25 (or more) resource **outage draws** • **Forecast errors** for load / wind / solar (intra-day and intra-hour)	Modeling parameters: • **# of simulations for each case:** 33 * 5 * 25 = 4,125 full years (8,760 hours each at 5 minute intervals) of system operation • **Loss of Load (LOL)** defined as operating reserves (including regulations) drop below 4.5% of load • **Load Following Reserves** set to address intra-hour ramping needs	Results included: • LOLE due to lack of capacity • LOLE due to lack of flexibility (new metrics) • Unserved Energy • Production costs • CO2 emissions • RPS curtailment

Ultimate Goal: Enable Commission and parties to understand the holistic impact of their proposals or actions

List of 22 Sensitivity Cases Studied

Sensitivity Case # (33% RPS)	Sensitivity Case # (40% RPS)	Case Name	Flexibility - Pmin	Installed Capacity	Flexibility - LFR[1]	Load Shed Threshold
Sa-01	*Sb-01*	Base Case[2]	Base Case	Base Case	2% and *3%*[3]	4.5% of Load[4]
Sa-02	*Sb-02*	High Flexibility (-4k Pmin)	Base - 4k MW			
Sa-03	*Sb-03*	High Flexibility (-2k Pmin)	Base - 2k MW			
Sa-04	*Sb-04*	Low Flexibility (+2k Pmin)	Base + 2k MW			
Sa-05	*Sb-05*	Low Flexibility (+4k Pmin)	Base + 4k MW			
Sa-06	*Sb-06*	Low Flexibility (+6k Pmin)	Base + 6k MW			
Sa-07	*Sb-07*	Low Reserve Margin		Base - 1k MW		
Sa-08	*Sb-08*	Low Load Following			1% and *1.5%*[3]	
Sa-09	*Sb-09*	LOL[5] Sensitivity (3% Reserves)				3.0% of Load
Sa-10	*Sb-10*	LOL Sensitivity (1.5% Reserves)				1.5% of Load
Sa-11	*Sb-11*	LOL Sensitivity (0% Reserves)				0% of Load

1. Load Following Reserves; 2. 2014 LTPP Trajectory or 40% RPS Scenario; 3. Target modeled as % of load + expected hourly net load ramp
4. Represents the minimum level of regulations and operating reserves that must be maintained; 5. Loss of Load

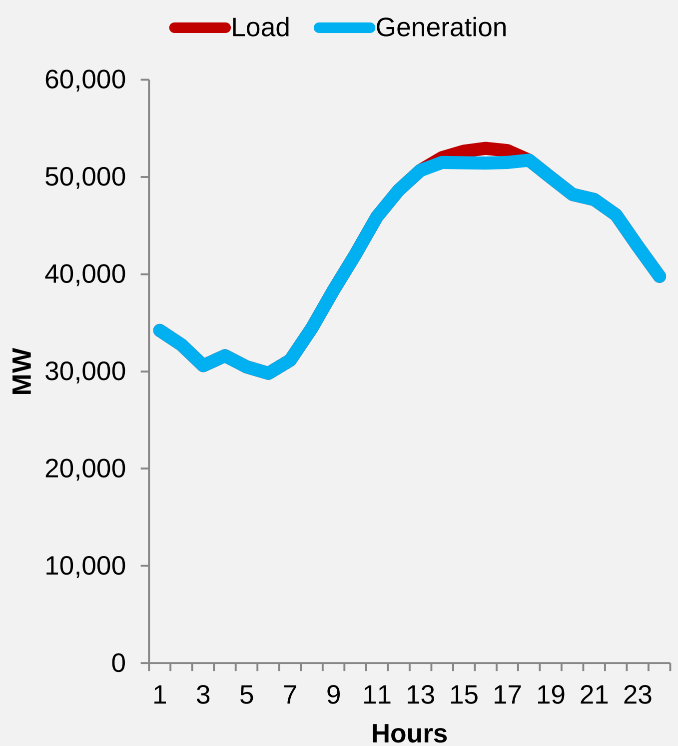
DRAFT // For Discussion Purposes Only

Definitions of Traditional and New Reliability Metrics

Traditional "Generic Capacity" Metrics

$LOLE_{GENERIC\text{-}CAPACITY}$

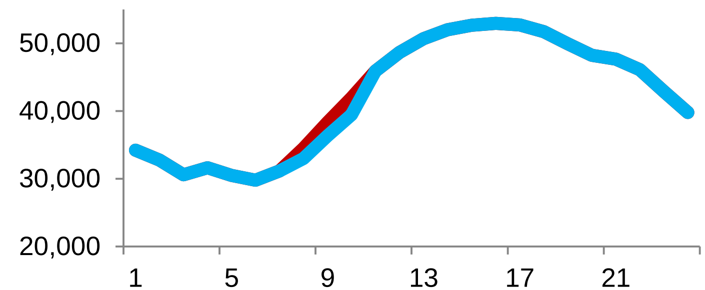
Traditional metric to capture events that occur due to capacity shortfalls in peak conditions



New "Flexible Capacity" Metrics

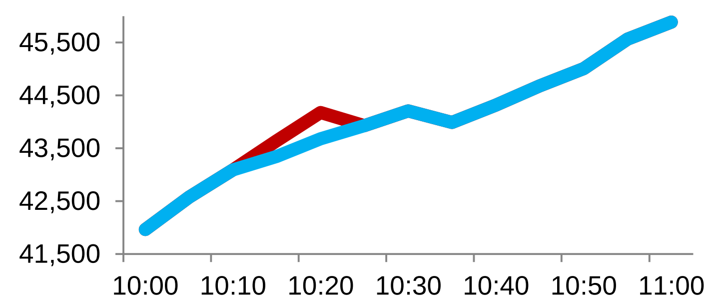
$LOLE_{MULTI\text{-}HOUR}$

New metric to capture events due to system ramping deficiencies of longer than one hour in duration

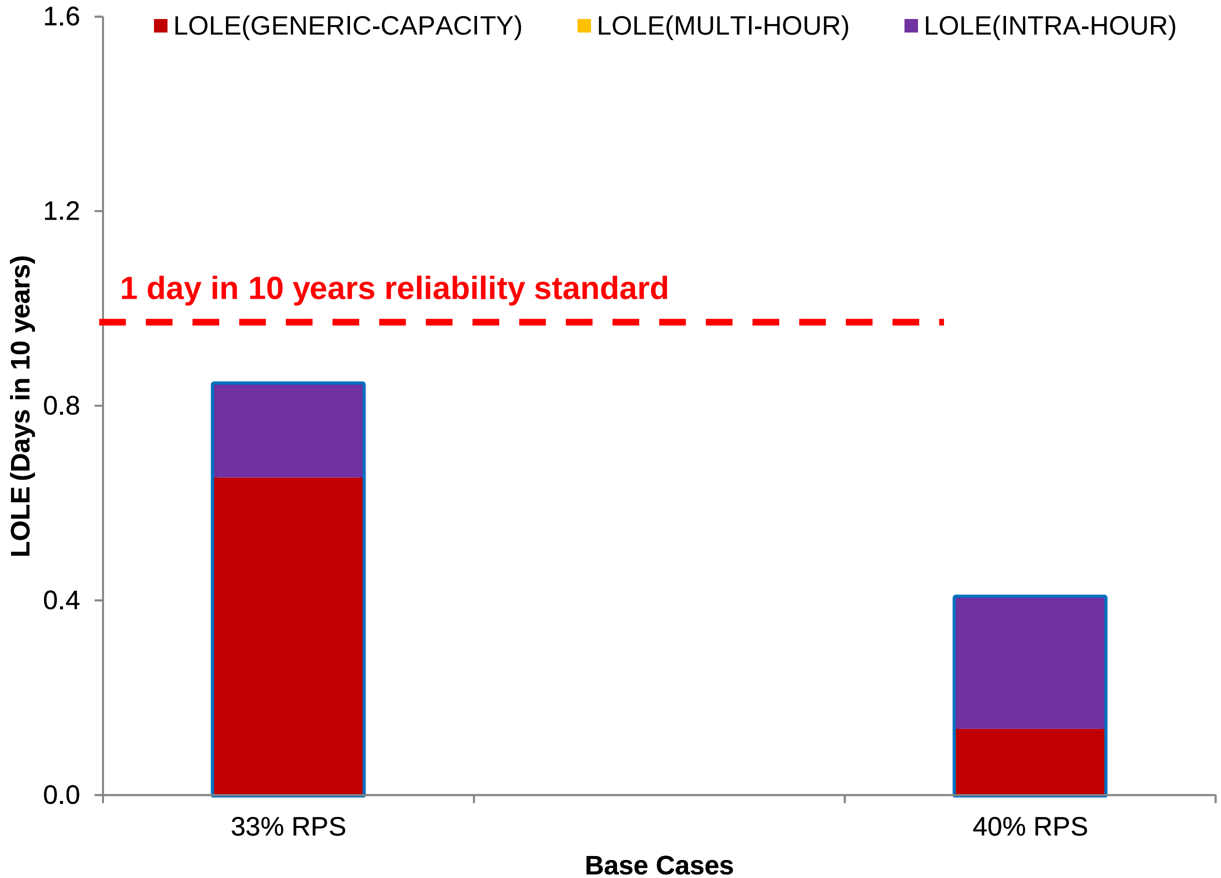


$LOLE_{INTRA\text{-}HOUR}$

New metric to capture events due to system ramping deficiencies inside a single hour



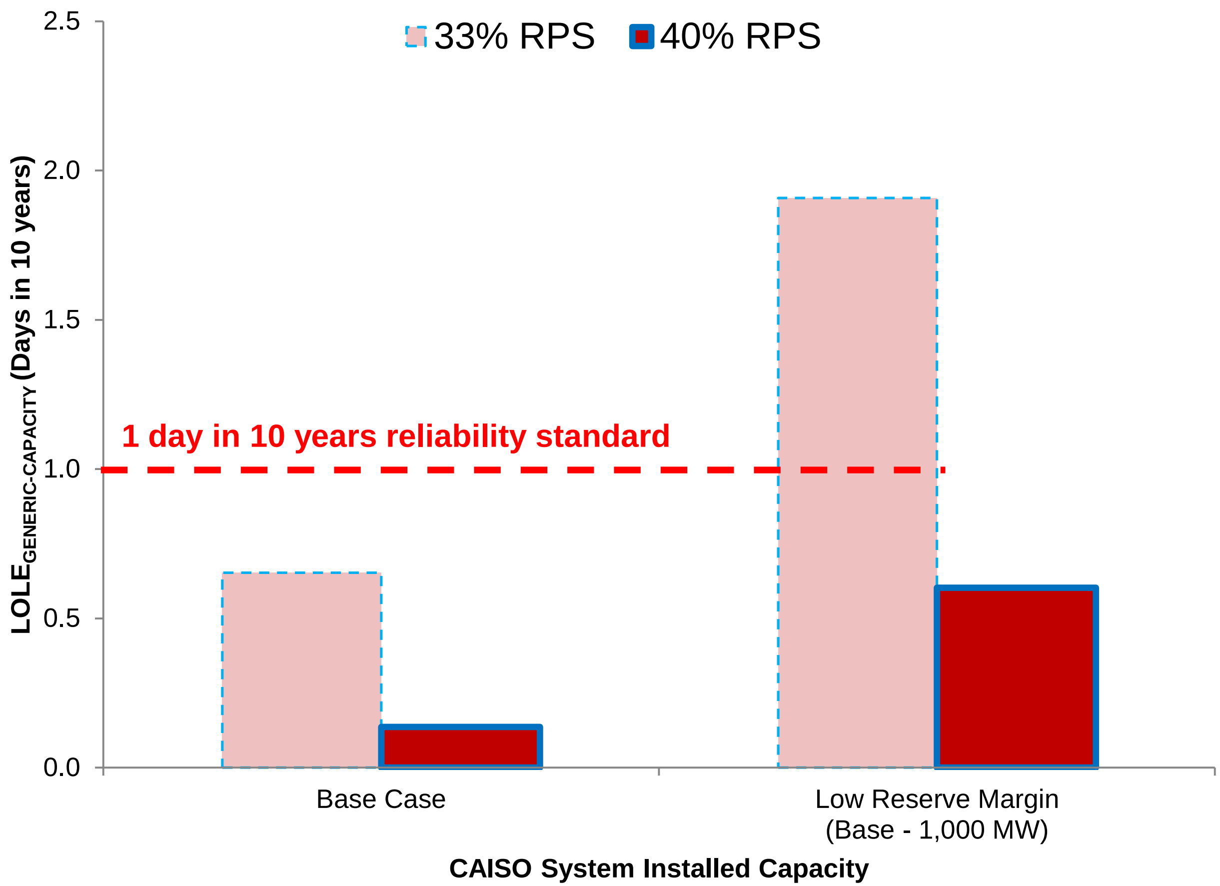
Overall Reliability Results For Projected Base Cases



<u>Finding 1</u>: The projected CAISO system has sufficient flexibility and capacity to meet the 1 day in 10 years standard in 2024*

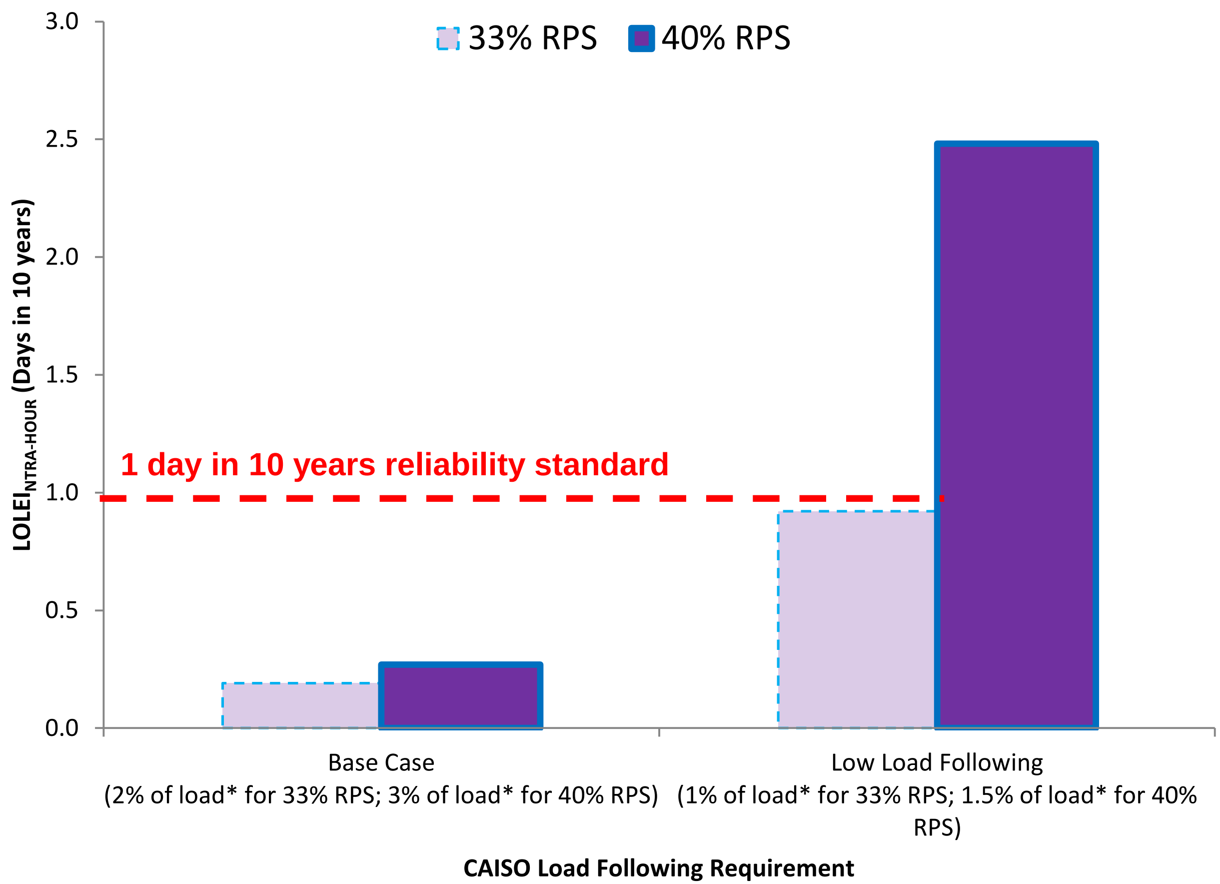
* *Assumes no incremental retirements for the 40% RPS case; A loss of load day is a day with one or more loss of load event*

Results by Individual Metric – $\text{LOLE}_{\text{GENERIC-CAPACITY}}$ vs. Installed Capacity



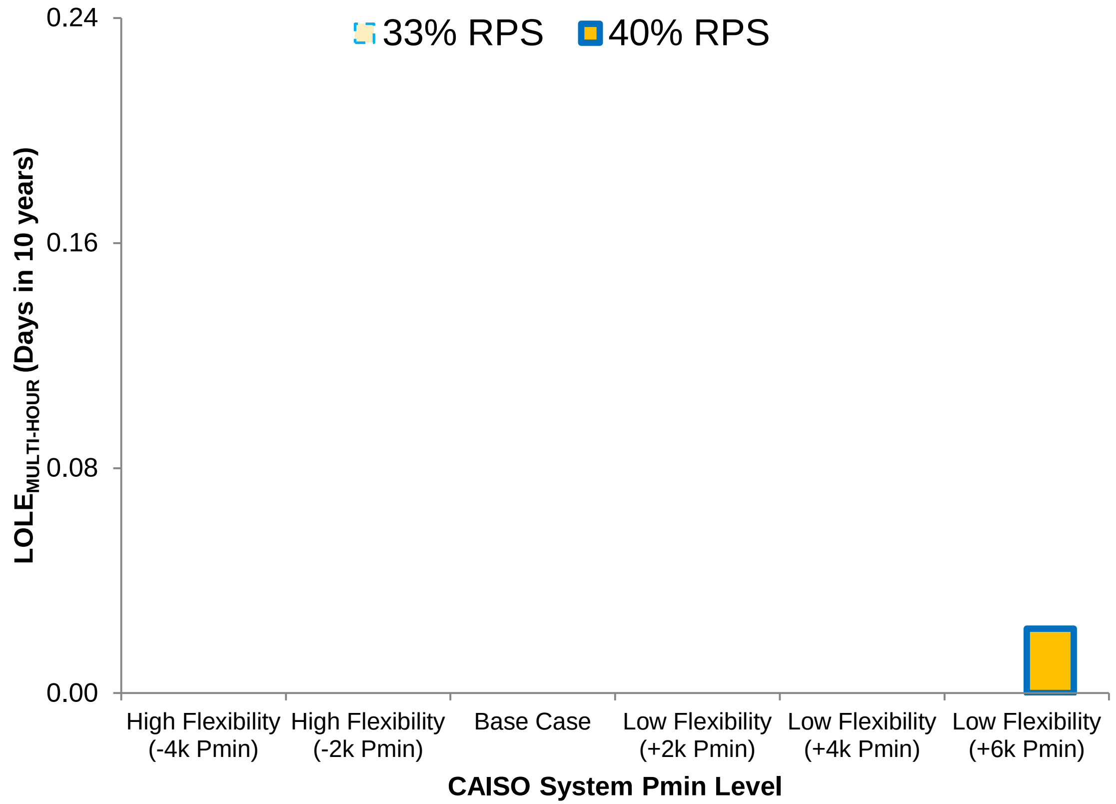
Based on the $\text{LOLE}_{\text{GENERIC-CAPACITY}}$ metric alone, the 33% RPS system can afford to lose little capacity (less than 1,000 MW) in order to meet the reliability standard

Results by Individual Metric – $\text{LOLE}_{\text{INTRA-HOUR}}$ vs. Load Following Reserves



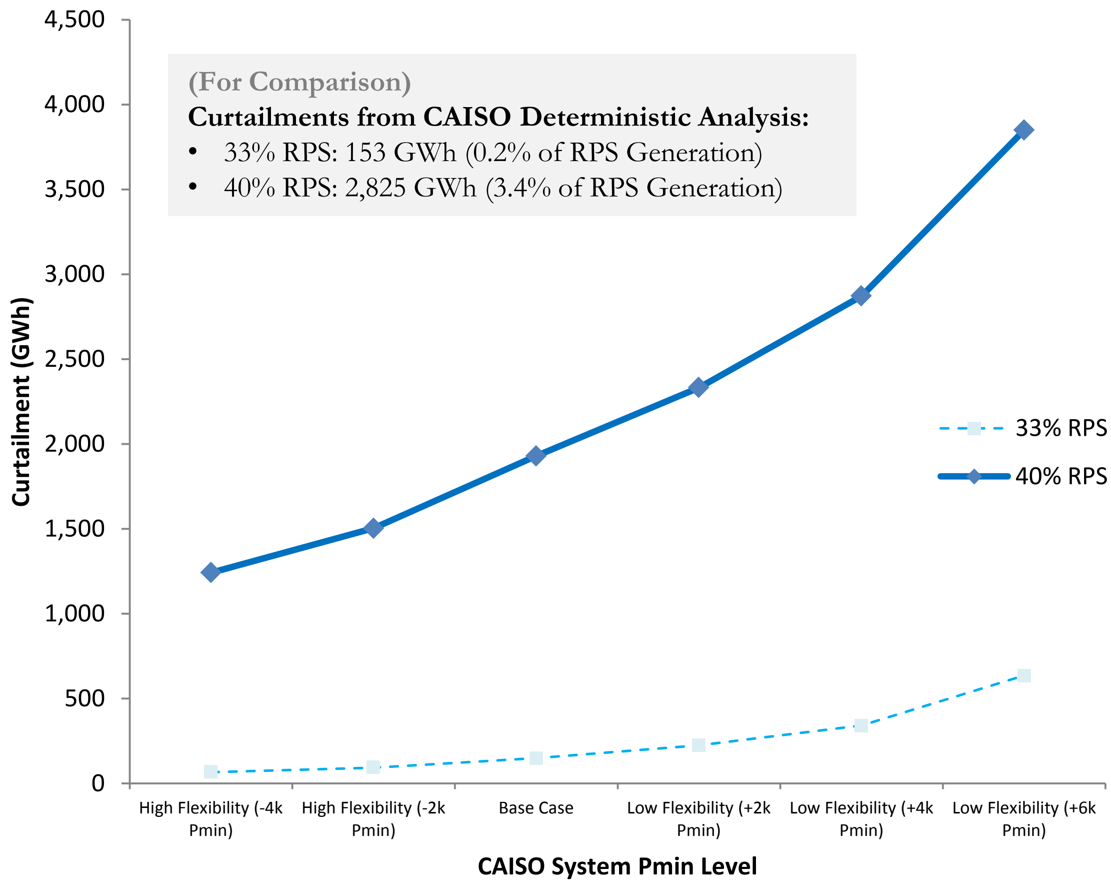
In addition to installed capacity, sufficient load following reserves must be set aside to maintain a reliable system (this is mainly an operational, not planning, requirement)

Results by Individual Metric – $LOLE_{MULTI\text{-}HOUR}$ vs. System Flexibility



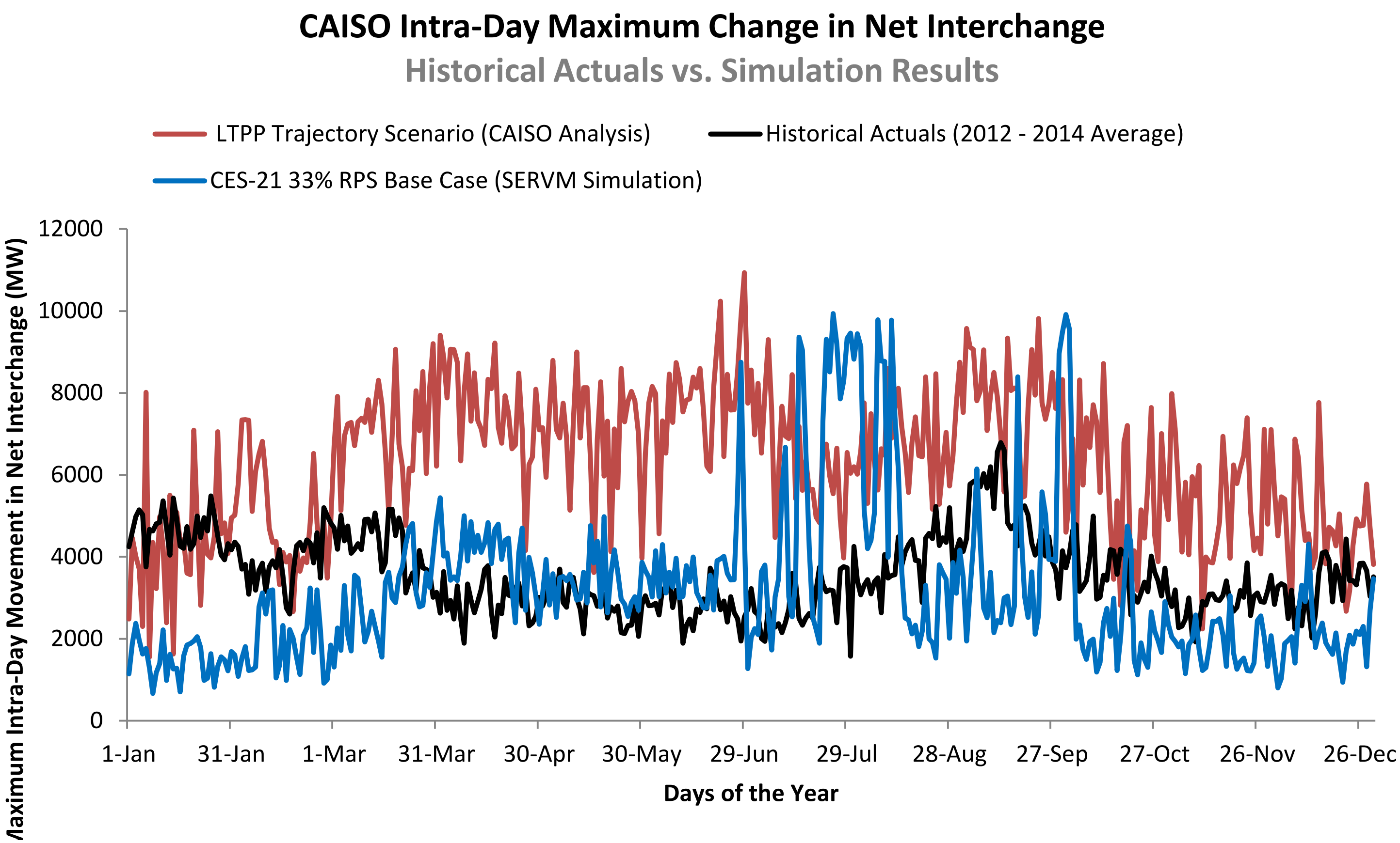
The projected CAISO system experienced few loss of load events due to multi-hour deficiencies ($LOLE_{MULTI\text{-}HOUR}$), ASSUMMING…

Key Assumption #1: Curtailments



Unrestricted curtailments provide additional flexibility to mitigate $\text{LOLE}_{\text{MULTI-HOUR}}$

Key Assumption #2: Net Imports

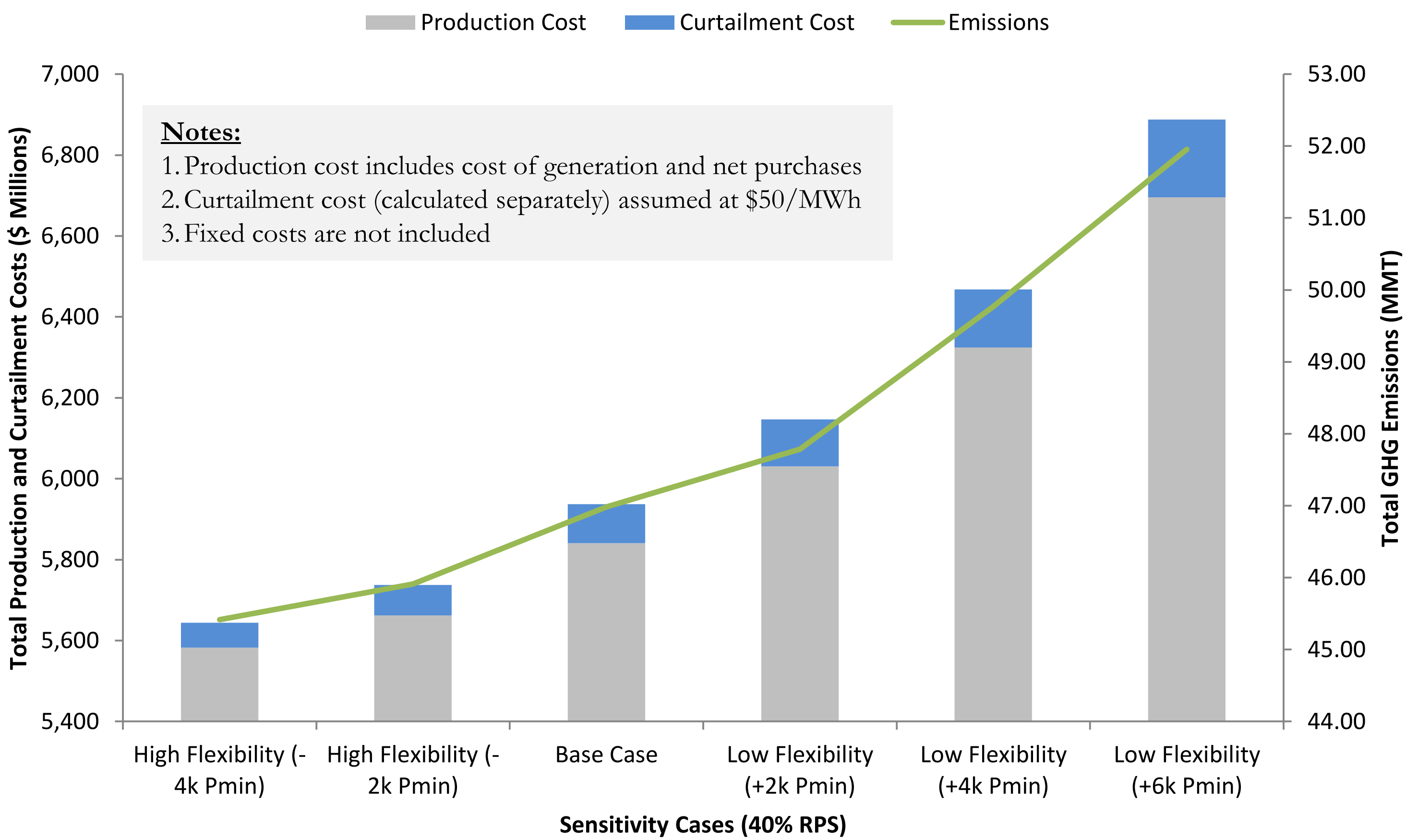


Net imports provide additional flexibility to mitigate $\text{LOLE}_{\text{MULTI-HOUR}}$

However, flexibility from modeled net imports exceeds historical actuals

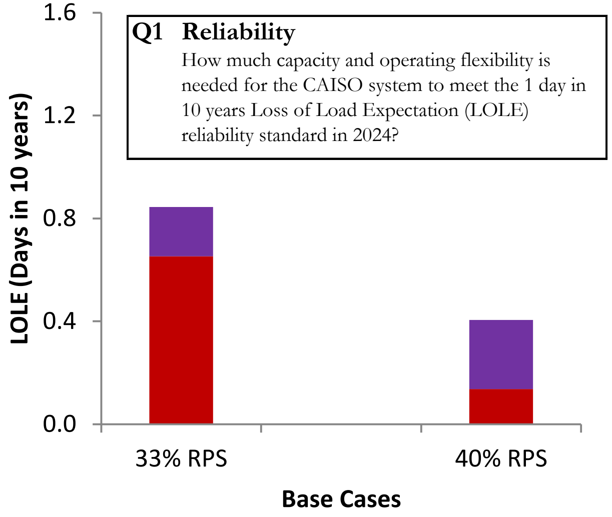
More granular WECC modeling (in next phase) to further test assumption #2

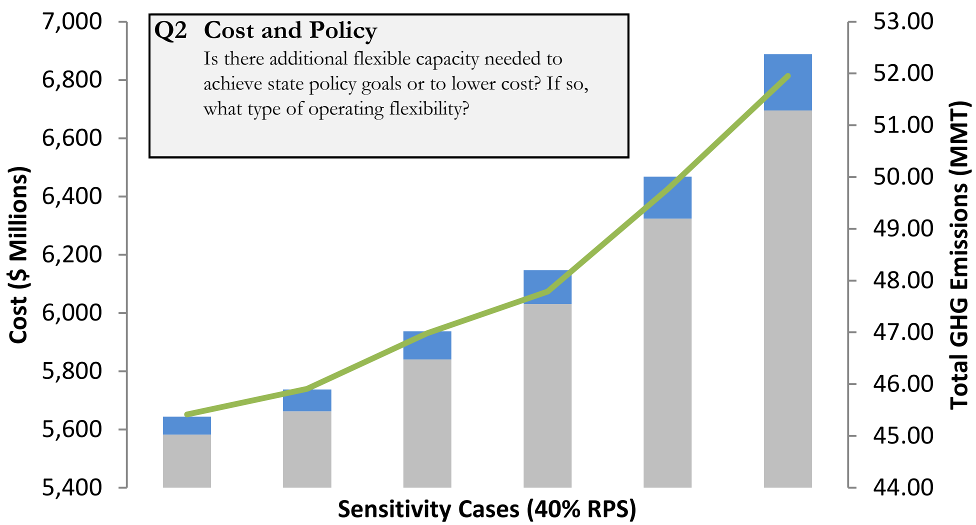
Results by Cost & Policy Metrics – Costs & Emissions vs. System Flexibility



<u>Finding 2</u>: A less flexible system yields higher costs and emissions (across the flexibility sensitivities studied)

Metrics and Standards – Slight Refinement May Work?





Under the 33% and 40% RPS scenarios studied, operating flexibility appears to be mostly an economics or policy issue (e.g., cost, curtailments, and emissions)

<u>Indication 3</u>: The existing PRM planning metric may continue to work provided that the reliability contribution of each resource type is accurately accounted

Next Steps and Final Deliverables

- Next Steps
  - Improved WECC representation (Load and Generation)
  - Incorporate 2016 LTPP Assumptions (expected in Q1)
  - Collaborate with LLNL to deploy SERVM on the High Performance Computing (HPC) platform
  - Refine and validate preliminary findings
- Final CES-21 Project Deliverables
  - File a demonstration in the 2016 LTPP
  - Make final report and dataset available to the public

1. Model Comparison (From the 2014 Collaborative Review of Planning Models)
2. 22 Sensitivity Cases – Summary of Results
3. Definitions by LOLE Type

APPENDIX

Model Comparison
(From the 2014 Collaborative Review of Planning Models)

Models/Approaches	Scenario(s) Considered	Simulating Operating Decisions
Deterministic (CAISO Deterministic)	A single "base case" or "stress" scenario at a time	Assumes perfect foresight, considers operating cost
Stochastic, statistical (SCE)	Many scenarios, enables calculation of probability metrics (e.g. LOLE)	Assumes perfect foresight, caps resource outage to 1,000 MW
Stochastic + uncertainty + recourse (REFLEX, SERVM)		Considers uncertainty, operating costs, and ability to adjust decisions (recourse)
Physics-based weather uncertainty + stochastic unit commitment (LLNL)		Considers physics-based weather uncertainty, operating costs, stochastic unit commitment

Modeling approaches vary:

- One vs. multiple scenarios at a time
- A range vs. a cap of resource outages
- Various degrees of forecast error and variability
- Recourse

22 Sensitivity Cases – Summary of Results

	Sensitivity Case #	Flexibility - Pmin	Installed Capacity	Flexibility - LFR	Load Shed Threshold	System Costs[1]	LOLE (Days / 10 Years)		Curtail	Total CO2 Emissions
						($ Millions)	Due to Capacity	Due to Flex[2]	(GWh)	(MMT)
33% RPS	Sa-01	Base				$6,250	0.65	0.19	148	53
33% RPS	Sa-02	- 4K				$6,107	0.61	0.33	67	52
33% RPS	Sa-03	- 2K				$6,158	0.61	0.26	93	53
33% RPS	Sa-04	+ 2K				$6,374	0.64	0.00	225	54
33% RPS	Sa-05	+ 4K				$6,615	0.62	0.01	341	55
33% RPS	Sa-06	+ 6K				$7,010	0.68	0.02	635	57
33% RPS	Sa-07		-1K			$6,256	1.91	0.36	165	53
33% RPS	Sa-08			Low		$6,190	0.90	0.92	147	53
33% RPS	Sa-09				3%	$6,235	0.00	0.11	152	53
33% RPS	Sa-10				1.5%	$6,219	0.00	0.25	159	53
33% RPS	Sa-11				0%	$6,178	0.00	0.25	161	53
40% RPS	Sb-01	Base				$5,937	0.14	0.27	1,930	47
40% RPS	Sb-02	- 4K				$5,644	0.15	1.09	1,241	45
40% RPS	Sb-03	- 2K				$5,737	0.13	0.59	1,503	46
40% RPS	Sb-04	+ 2K				$6,147	0.18	0.03	2,332	48
40% RPS	Sb-05	+ 4K				$6,468	0.17	0.12	2,871	50
40% RPS	Sb-06	+ 6K				$6,888	0.21	0.62	3,849	52
40% RPS	Sb-07		-1K			$5,954	0.60	0.53	2,010	47
40% RPS	Sb-08			Low		$5,820	0.16	2.48	1,900	47
40% RPS	Sb-09				3%	$5,909	0.00	0.23	1,964	47
40% RPS	Sb-10				1.5%	$5,885	0.00	0.22	2,011	47
40% RPS	Sb-11				0%	$5,680	0.00	0.19	1,971	45

1. Assuming a curtailment cost of $50/MWh; 2. Includes LOLE flex events due to both intra-hour and multi-hour ramping deficiencies

Definitions by LOLE Type