California ISO
Shaping a Renewed Future

Review of the ISO 2014 LTPP System Flexibility Study

The ISO LTPP Webinar
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Agenda

- Summary of the study
- Modeling methodologies
- Modeling assumptions
- Deterministic simulation results
- Next steps

Summary of the Study

California ISO
Shaping a Renewed Future

The ISO conducted the 2014 Long-Term Procurement Plan (LTPP) study together with all involved parties.

- Followed the Planning Assumptions and Scenarios as determined in the CPUC May 14, 2014 Assigned Commissioner's Ruling (13-12-010)
- Implemented inputs from the CPUC and CEC staff
- Discussed modeling assumptions at the CPUC workshops, Advisory Team conference calls and regular conference calls with the CPUC and CEC staff
- Made the Plexos model, input data and simulation results available to all parties

The ISO studied four scenarios and one sensitivity.

- Trajectory scenario
  - 33% renewable
  - Conservative, little change in existing policies
- High Load scenario
  - Trajectory with higher load (energy use) forecast
- Expanded Preferred Resources scenario
  - Trajectory with 40% renewable and addition energy efficiency, customer PV and CHP
  - Reflection of the State's preferred resources policies

The ISO studied four scenarios and one sensitivity. (cont.)

- 40% RPS in 2024 scenario
  - Trajectory with 40% renewable
- Trajectory without Diablo Canyon sensitivity
  - Trajectory with early retirement of Diablo Canyon

The ISO proposed and implemented two important assumptions.

- 25% minimum local generation requirement
  - Meets at least 25% of load with local generation
  - Applied to the ISO, IID, LADWP, SCE, SDG&E, SMUD and TIDC
  - Removed the SCE 40/60 and SDG&E 25/75 under-frequency import limits
- No ISO net export allowed, based on
  - Must-take import from dedicated resources and 70% out of state RPS renewable generation
  - Lack of a broader range jointly-clearing market

The study found capacity shortfalls and renewable generation curtailments.

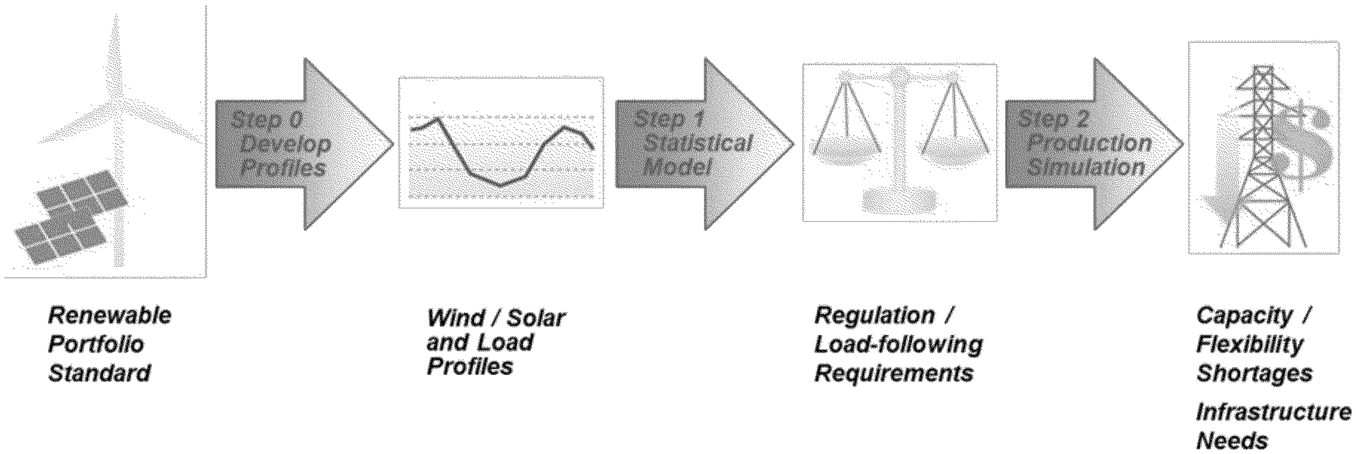
- Capacity shortfalls were identified in all but one scenario
- Renewable generation curtailment occurred in all scenarios, significant in some scenarios
- Curtailment may be masking the need for flexible capacity
- CO_2 emission reduction was not in proportion to the increase in renewable portfolios due to curtailment

Datasheet inadvertently excluded incremental supply-side CHP in Expanded Preferred Resources scenario.

- Identified after the testimony was filed
- The missed incremental supply-side CHP resource
  - 1,855 MW capacity
  - 1,298 MW peak-impact
  - 80% annually capacity factor
- Not relevant to other scenarios
- Ready to re-run, pending on the ALJ's direction
- Expect increase in renewable curtailment and CO_2 emission

Modeling Methodologies

The CAISO LTPP study process



- A three steps process
  - Step 0: creating profiles
  - Step 1: calculating regulation and load-following requirements
  - Step 2: conducting production simulations

Step 0 – creating profiles

- Outputs – hourly and 1-minute load, solar and wind generation profiles
- Inputs
  - CEC Load forecast and 2005 actual hourly load shapes
  - CPUC/CEC RPS solar and wind project information
  - 2005-weather based solar and wind hourly generation shapes from TEPPC 2024 Common Case
- Methodology reference document
  - http://www.caiso.com/282d/282d85c9391b0.pdf

Step 1 – calculating regulation and load-following requirements

- Outputs – hourly regulation and load-following requirements as input for Step 2 production simulation
- Inputs
  - 1-minute load, solar and wind generation profiles from Step 0
  - Forecast errors (*t*-30 and *t*-5 minutes)
- Tool – a statistical analysis tool developed by Pacific Northwest National Laboratories
- Methodology reference document
  - http://www.caiso.com/282d/282d85c9391b0.pdf

Step 2 – conducting production simulations

- Key outputs
  - Sufficiency of system capacity and flexibility
  - Renewable generation curtailment
  - Production cost, CO_2 emission, etc.
- Model
  - WECC-wide zonal, 25 zones, 8 in California
  - Transmission paths connecting the zones
  - Load, ancillary service and load-following requirement

Step 2 – conducting production simulations (cont.)

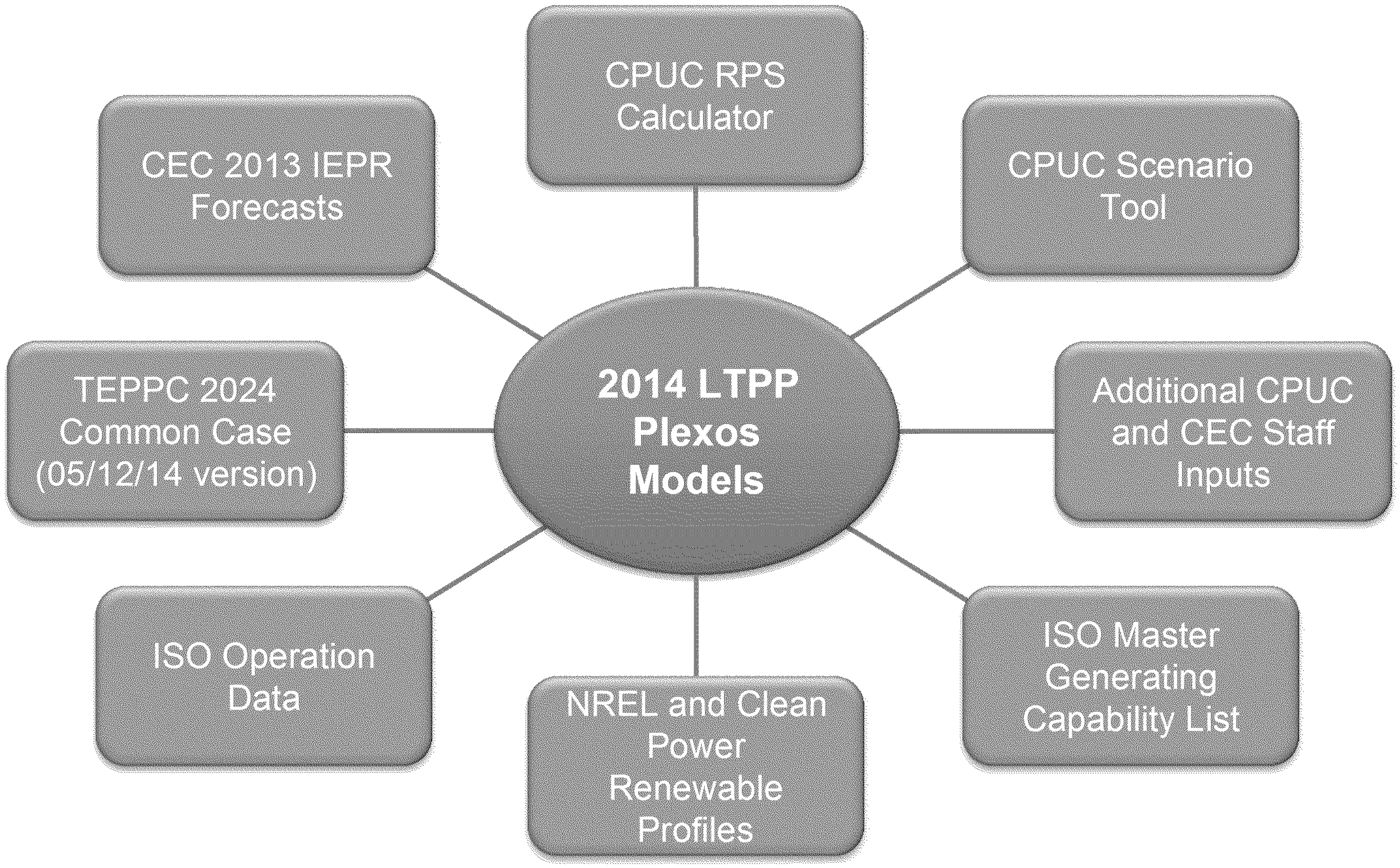
- Model
  - Generation resources
    - Thermal
    - Renewable (solar, wind, biogas, geothermal, small hydro)
    - Hydro
    - Pumped storage and battery storage
    - Demand response
- Tool – Plexos production simulation package from Energy Exemplar

Step 2 – conducting production simulations (cont.)

- Methodology - mimicking that implemented in the ISO markets
  - Mixed-Integer Linear Programing (MIP) optimization for unit commitment and dispatch
  - Chronological co-optimization for energy, ancillary services and load-followings
  - Least-cost solution to meet load, ancillary service and load-following requirements simultaneously
  - Shortfall in load-following, ancillary services and energy when supply or flexibility is insufficient

Modeling Assumptions

The Plexos production cost simulation models use data from multiple sources.



ISO aggregated demand and supply

CPUC Scenario Tool

CAISO-2024	Trajectory	High Load	Expanded Preferred Resources	40% RPS in 2024
Demand (MW) *				
IEPR Net Load	56,044	59,006	56,044	56,044
AA-EE	5,042	5,042	8,286	5,042
Managed Demand Net Load	51,003	53,964	47,758	51,003
BTM resources modeled as Supply (MW)				
1: Inc. Small PV	0	0	1,647	0
2: Inc. Demand-side CHP	0	0	1,832	0
Supply (MW)				
3: Existing Resources	51,878	51,878	51,878	51,878
4: Resource Additions	7,468	8,440	9,202	11,754
Non-RPS (Conventional Expected)	329	329	329	329
RPS	5,939	6,911	7,673	10,225
Authorized Procurement	1,200	1,200	1,200	1,200
5: Imports	13,396	13,396	13,396	13,396
6: Inc. Supply-side CHP	0	0	0	0
7: Dispatchable DR	2,176	2,176	2,176	2,176
8: Energy Storage Target	913	913	913	913
9: Energy Storage Other	0	0	0	0
10: Resource Retirements	13,708	13,708	13,708	13,708
OTC Non Nuclear	11,685	11,685	11,685	11,685
OTC Nuclear	0	0	0	0
Solar + Wind	0	0	0	0
Geothermal + Biomass	0	0	0	0
Hydro + Pump	0	0	0	0
Other (non-OTC thermal/cogen/other)	2,023	2,023	2,023	2,023
Net Supply = sum[1:9] - 10	62,122	63,094	67,335	66,408
Planning Reserve Margin	22%	17%	41%	30%

Missed CHP resource

Note: the load is coincident peak

SB_GT&S_0351401

Load forecast and adjustments - Trajectory scenario

CEC 2013 IEPR Forecasts

Trajectory	Load Forecast*	AAEE**	Embedded Small PV**	Pumping Load**	Total Load
Load Forecast (MW)					
IID	1,241	0	0	0	1,241
LDWP	7,208	0	0	0	7,208
PG&E_BAY	9,614	-998	499	0	9,115
PG&E_VLY	15,569	-1,292	646	-614	14,308
SCE	26,882	-2,308	732	-421	24,885
SDGE	5,357	-567	251	0	5,041
SMUD	5,240	0	0	-143	5,097
TIDC	721	0	0	0	721
CAISO	**57,422**	**-5,165**	**2,127**	**-1,035**	**53,349**
CA	**71,833**	**-5,165**	**2,127**	**-1,178**	**67,617**
Load Forecast (GWh)					
IID	4,777	0	0	0	4,777
LDWP	32,618	0	0	0	32,618
PG&E_BAY	51,511	-4,134	1,696	0	49,073
PG&E_VLY	68,832	-5,767	2,366	-4,556	60,875
SCE	119,137	-10,239	2,696	-5,700	105,894
SDGE	24,271	-2,425	958	0	22,805
SMUD	20,117	0	0	-1,455	18,662
TIDC	2,978	0	0	0	2,978
CAISO	**263,751**	**-22,565**	**7,716**	**-10,256**	**238,646**
CA	**324,241**	**-22,565**	**7,716**	**-11,711**	**297,681**

Note: this is non-coincident peak

* CEC 2013 IPER Form 1.5a and 1.5b. All scenarios have Mid (1-in-2) except High Load scenario, which has High (1-in-2) forecast
** CEC 2013 IPER

Load forecast and adjustments - High Load scenario

CEC 2013 IEPR Forecasts

High Load	Load Forecast*	AAEE**	Embedded Small PV**	Pumping Load**	Total Load
Load Forecast (MW)					
IID	1,299	0	0	0	1,299
LDWP	7,610	0	0	0	7,610
PG&E_BAY	10,378	-998	437	0	9,818
PG&E_VLY	15,971	-1,292	567	-614	14,631
SCE	28,383	-2,308	638	-421	26,292
SDGE	5,724	-567	218	0	5,375
SMUD	5,546	0	0	-143	5,404
TIDC	762	0	0	0	762
CAISO	**60,457**	**-5,165**	**1,859**	**-1,035**	**56,116**
CA	**75,674**	**-5,165**	**1,859**	**-1,178**	**71,190**
Load Forecast (GWh)					
IID	5,048	0	0	0	5,048
LDWP	34,417	0	0	0	34,417
PG&E_BAY	55,072	-4,193	1,484	0	52,362
PG&E_VLY	71,762	-5,708	2,020	-4,556	63,519
SCE	126,306	-10,239	2,313	-5,700	112,680
SDGE	25,959	-2,425	823	0	24,357
SMUD	21,251	0	0	-1,455	19,796
TIDC	3,157	0	0	0	3,157
CAISO	**279,099**	**-22,565**	**6,640**	**-10,256**	**252,918**
CA	**342,972**	**-22,565**	**6,640**	**-11,711**	**315,336**

Note: this is non-coincident peak

* CEC 2013 IPER Form 1.5a and 1.5b. All scenarios have Mid (1-in-2) except High Load scenario, which has High (1-in-2) forecast
** CEC 2013 IPER

Load forecast and adjustments - Expanded Preferred Resources scenario

CEC 2013 IEPR Forecasts

Expanded Preferred Resources	Load Forecast*	AAEE**	Embedded Small PV**	Pumping Load**	Total Load
Load Forecast (MW)					
IID	1,241	0	0	0	1,241
LDWP	7,208	0	0	0	7,208
PG&E_BAY	9,614	-1,726	516	0	8,404
PG&E_VLY	15,569	-2,099	628	-614	13,484
SCE	26,882	-3,766	732	-421	23,427
SDGE	5,357	-898	251	0	4,710
SMUD	5,240	0	0	-143	5,097
TIDC	721	0	0	0	721
CAISO	**57,422**	**-8,490**	**2,127**	**-1,035**	**50,025**
CA	**71,833**	**-8,490**	**2,127**	**-1,178**	**64,292**
Load Forecast (GWh)					
IID	4,777	0	0	0	4,777
LDWP	32,618	0	0	0	32,618
PG&E_BAY	51,511	-6,667	1,696	0	46,540
PG&E_VLY	68,832	-9,302	2,366	-4,556	57,340
SCE	119,137	-16,339	2,696	-5,700	99,794
SDGE	24,271	-3,761	958	0	21,469
SMUD	20,117	0	0	-1,455	18,662
TIDC	2,978	0	0	0	2,978
CAISO	**263,751**	**-36,068**	**7,716**	**-10,256**	**225,143**
CA	**324,241**	**-36,068**	**7,716**	**-11,711**	**284,178**

Note: this is non-coincident peak

* CEC 2013 IPER Form 1.5a and 1.5b. All scenarios have Mid (1-in-2) except High Load scenario, which has High (1-in-2) forecast
** CEC 2013 IPER

Load forecast and adjustments - 40% RPS in 2024 scenario

CEC 2013 IEPR Forecasts

40% RPS in 2024	Load Forecast*	AAEE**	Embedded Small PV**	Pumping Load**	Total Load
Load Forecast (MW)					
IID	1,241	0	0	0	1,241
LDWP	7,208	0	0	0	7,208
PG&E_BAY	9,614	-998	499	0	9,115
PG&E_VLY	15,569	-1,292	646	-614	14,308
SCE	26,882	-2,308	732	-421	24,885
SDGE	5,357	-567	251	0	5,041
SMUD	5,240	0	0	-143	5,097
TIDC	721	0	0	0	721
CAISO	**57,422**	**-5,165**	**2,127**	**-1,035**	**53,349**
CA	**71,833**	**-5,165**	**2,127**	**-1,178**	**67,617**
Load Forecast (GWh)					
IID	4,777	0	0	0	4,777
LDWP	32,618	0	0	0	32,618
PG&E_BAY	51,511	-4,134	1,696	0	49,073
PG&E_VLY	68,832	-5,767	2,366	-4,556	60,875
SCE	119,137	-10,239	2,696	-5,700	105,894
SDGE	24,271	-2,425	958	0	22,805
SMUD	20,117	0	0	-1,455	18,662
TIDC	2,978	0	0	0	2,978
CAISO	**263,751**	**-22,565**	**7,716**	**-10,256**	**238,646**
CA	**324,241**	**-22,565**	**7,716**	**-11,711**	**297,681**

Note: this is non-coincident peak

* CEC 2013 IPER Form 1.5a and 1.5b. All scenarios have Mid (1-in-2) except High Load scenario, which has High (1-in-2) forecast
** CEC 2013 IPER

California RPS net short calculation

CPUC RPS Calculator

	All Values in GWh for Year 2024	Formula	Trajectory	High Load	Expanded Preferred Resources	40% RPS in 2024
1	Statewide Retail Sales - Dec 2013 IEPR		300,516	317,781	300,516	300,516
2	Non RPS Deliveries (CDWR, WAPA, MWD)		9,272	9,272	9,272	9,272
3	Retail Sales for RPS	3=1-2	291,244	308,509	291,244	291,244
4	Additional Energy Efficiency		24,410	24,410	36,713	24,410
5	Additional Rooftop PV		0	0	5,360	0
6	Additional Combined Heat and Power		0	0	16,016	0
7	Adjusted Statewide Retail Sales for RPS	7=3-4-5-6	266,834	284,099	233,156	266,834
8	**Total Renewable Energy Needed For RPS**	8=7*33% or 7*40%	**88,055**	**93,753**	**93,262**	**106,734**
	Existing and Expected Renewable Generation					
9	Total In-State Renewable Generation		42,909	42,909	42,909	42,909
10	Total Out-of-State Renewable Generation		10,639	10,639	10,639	10,639
11	Procured DG (not handled in Calculator)		2,204	2,204	2,204	2,204
12	SB 1122 (250 MW of Biogas)		1,753	1,753	1,753	1,753
13	**Total Existing Renewable Generation for CA RPS**	13=9+10+11+12	**57,504**	**57,504**	**57,504**	**57,504**
14	**Total RE Net Short to meet 33% or 40% RPS In 2024**	14=8-13	**30,551**	**36,249**	**35,758**	**49,230**

Source: CPUC RPS Calculator

SB_GT&S_0351406

California RPS renewable portfolios*

Additional CPUC and CEC Staff Inputs

CPUC RPS Calculator

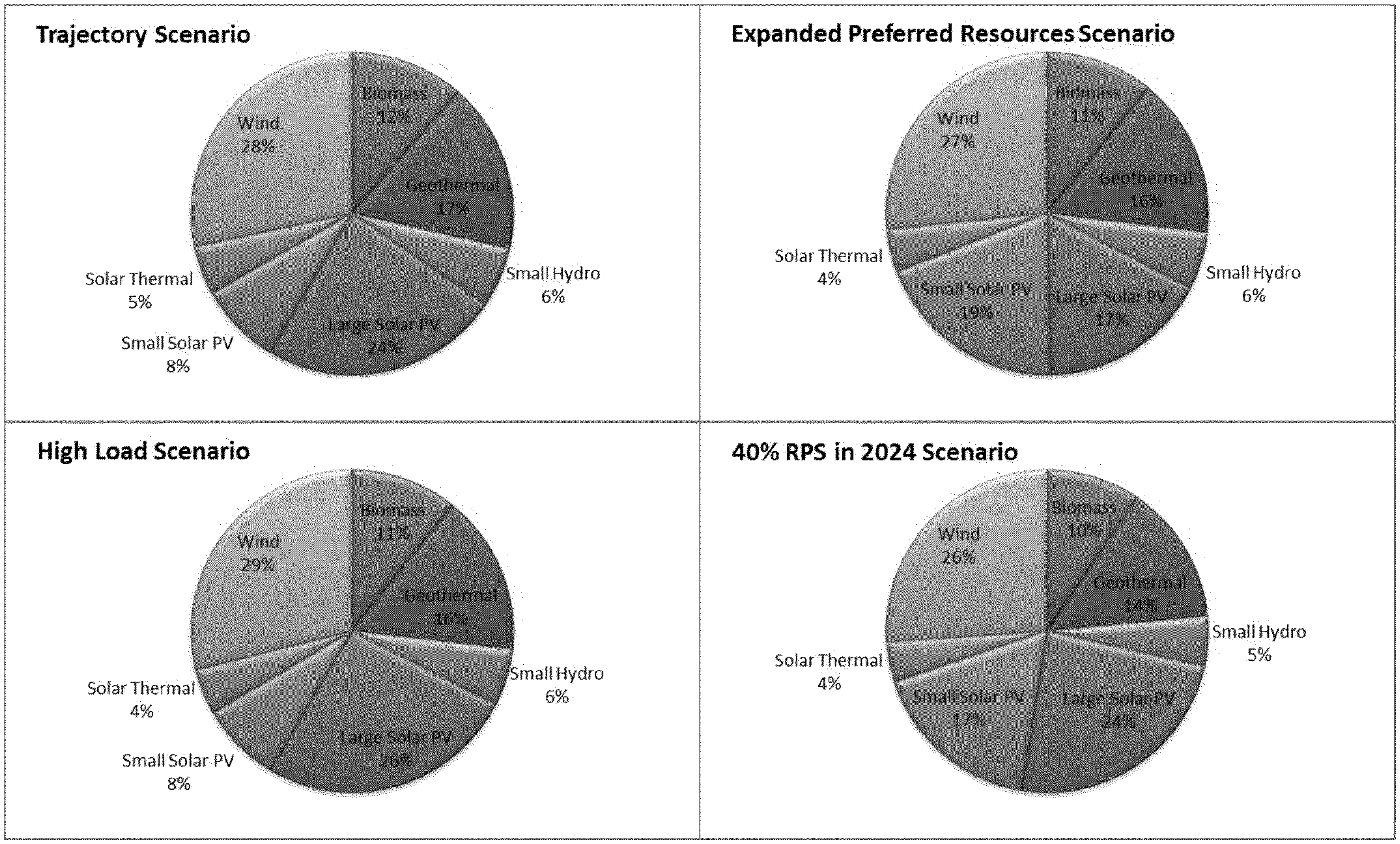
	Biomass	Geothermal	Small Hydro	Large Solar PV	Small Solar PV	Solar Thermal	Wind	Total
Trajectory Scenario								
Capacity (MW)	1,623	2,999	3,017	9,087	3,564	1,802	11,146	33,239
Energy (GWh)	10,096	15,003	5,334	21,091	7,312	4,322	24,899	88,056
In-State Energy	9,534	13,645	5,294	17,787	7,312	4,322	15,701	73,595
Out-State Energy	562	1,358	40	3,304	0	0	9,198	14,461
High Load Scenario								
Capacity (MW)	1,626	2,999	3,017	10,615	3,705	1,802	11,904	35,668
Energy (GWh)	10,117	15,003	5,334	24,326	7,611	4,322	27,040	93,753
In-State Energy	9,555	13,645	5,294	21,022	7,611	4,322	17,842	79,292
Out-State Energy	562	1,358	40	3,304	0	0	9,198	14,461
Expanded Preferred Resources Scenario								
Capacity (MW)	1,623	2,999	3,017	6,849	8,942	1,660	11,111	36,201
Energy (GWh)	10,096	15,003	5,334	15,895	18,145	3,990	24,800	93,263
In-State Energy	9,534	13,645	5,294	12,591	18,145	3,990	15,601	78,801
Out-State Energy	562	1,358	40	3,304	0	0	9,198	14,461
40% RPS in 2024 Scenario								
Capacity (MW)	1,626	2,999	3,017	11,195	9,115	1,802	12,189	41,943
Energy (GWh)	10,117	15,003	5,334	25,597	18,518	4,322	27,844	106,734
In-State Energy	9,555	13,645	5,294	22,293	18,518	4,322	18,646	92,273
Out-State Energy	562	1,358	40	3,304	0	0	9,198	14,461

* RPS portfolios do not include customer PV

California 2024 renewable portfolio comparison

Additional CPUC and CEC Staff Inputs

CPUC RPS Calculator



California solar resource technology mix – Trajectory scenario

CPUC RPS Calculator

New Large Solar PV

	Capacity (MW)	Energy (GWh)
Crystalline Tracking	1,437	3,432
Thin-Film	5,974	13,672
Total	**7,411**	**17,104**

New Solar Thermal

	Capacity (MW)	Energy (GWh)
Solar Thermal with Storage	150	473
Solar Thermal without Storage	1,200	2,804
Total	**1,350**	**3,277**

70% of out-state RPS renewable generation is modeled as must-take import into California.

ISO Proposed Assumptions

Out of State Renewable Import Scheduling Assumption

Dynamic Schedule	15-min Schedule	Hourly Schedule	Unbundled RECs
15%	35%	20%	30%

- Dynamic and 15-min Schedule reflects combination of FERC Order 764 and Energy Imbalance Market
- Dynamic and 15-min schedules may increase volatilities in renewable generation and result in higher Regulation and Load-Following requirements calculated in Step 1
- Hourly Schedules and Unbundled RECs were not included in Step 1 calculation

Southern California local capacity resources assumptions*

CPUC Scenario Tool

- CPUC Track 1 authorized resources
  - SDG&E
    - 3x100 MW GT (Pio Pico) plus 10 MW GT repower
  - SCE
    - 1x900 MW CCGT and 3x100 MW GT
    - 50 MW storage (included in the 1,325 MW total)
    - 400 MW preferred resource not included
- Up to 2,315 MW Track 1 and Track 4 capacity not modeled

* May 14, 2014 CPUC Assigned Commisioner's Ruling (13-12-010)

Demand response resources triggering prices and availabilities

Additional CPUC and CEC Staff Inputs

Event-Based Demand Response Resources

Utility	Price ($/MWh)	Max Capacity (MW)	Availability	Monthly Energy Limit (GWh)
PG&E	600	424	All Hours	8.5
PG&E	1,000	70	H12-19	
PG&E	1,000	6	H13-20	
PG&E		274	All Hours	
PG&E Total		**773**		**8.5**
SCE	600	1,169	All Hours	23.4
SCE	1,000	9	H12-19	
SCE	1,000	10	H13-20	
SCE		173	All Hours	
SCE Total		**1,361**		**23.4**
SDG&E	600	22	All Hours	0.4
SDG&E	1,000	17	H12-19	
SDG&E	1,000	3	H13-20	
SDG&E Total		**42**		**0.4**
Total		**2,176**		**32.3**

The CPUC energy storage target assumptions

CPUC Scenario Tool

Additional CPUC and CEC Staff Inputs

- 700 MW transmission plus 213 MW distribution-connected can contribute to ancillary services and load-following
- Lake Hodge's 40 MW pumped storage is counted to meet the SDG&E storage target (≤ 50 MW)
- Round-trip efficiency is 83.33%

	PG&E			SCE			SDG&E			Total
(MW)	2 hours	4 hours	6 hours	2 hours	4 hours	6 hours	2 hours	4 hours	6 hours	
Transmission	124	124	62	124	124	62	32	8	0	660
Distribution	74	74	37	74	74	37	22	22	11	425
Customer	43	43	0	43	43	0	15	15	0	200
Total	241	241	99	241	241	99	69	45	11	1,285

Note: storage volume is measured as number of hours of discharge at full capacity.

The ISO calculated ramp rates and outage rates are applied to California resources

ISO Operation Data

- Ramp rate by capacity size group based on the ISO Master File data
- Planned outage and forced outage rates based on 2006-2010 operation data

Unit Type	Capacity Group 1 Ramp Rate (MW/min)	Capacity Group 2 Ramp Rate (MW/min)	Capacity Group 3 Ramp Rate (MW/min)	Capacity Group 4 Ramp Rate (MW/min)	Planed Outage Rate (%)	Forced Outage Rate (%)
COMBINED CYCLE	CAP_0-200	CAP_200-400	CAP_400-600	CAP_600 ABOVE	6.76	5.23
	6.58	8.44	15.61	15.54		
DIESEL / OIL CT	CAP_50-100				2.85	2.79
	5.00					
GAS STEAM TURBINE	CAP_0-200	CAP_200-400	CAP_400-600	CAP_600 ABOVE	9.11	4.01
	2.79	7.62	4.80	26.66		
GAS TURBINE	CAP_0-50	CAP_50-100	CAP_100-150	CAP_150 ABOVE	4.53	5.82
	9.26	12.32	17.14	19.41		
NUCLEAR	CAP_600 ABOVE				8.16	3.39
	6.98					
PUMPED STORAGE	CAP_0-200	CAP_200-400	CAP_400-600	CAP_600 ABOVE	8.65	6.10
	34.35	46.61	80.80	56.26		

Reserve and load following requirements assumptions

TEPPC 2024 Common Case (05/12/14 version)

- Operating reserve requirements for all regions
  - Spinning = 3% of load
  - Non-spinning = 3% of load
- Regulation and load following requirements
  - CA regions based on Step 1 calculation
  - Regions outside CA based on TEPPC 2024 Common Case

Monthly maximum CAISO regulation and load-following requirements.

(MW)	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Trajectory													
Regulation Up	480	481	423	416	411	564	558	575	792	803	796	481	803
Load Following Up	2,336	2,246	2,422	2,190	2,056	1,922	1,967	2,053	2,517	2,552	2,573	2,320	2,573
Regulation Down	551	554	743	651	688	647	688	690	995	1,109	915	540	1,109
Load Following Down	2,535	2,451	2,127	2,119	2,087	1,959	1,948	1,962	2,643	2,646	2,669	2,521	2,669
High Load													
Regulation Up	505	508	431	430	433	600	595	624	878	886	836	485	886
Load Following Up	2,326	2,296	2,579	2,312	2,270	2,083	2,089	2,269	2,571	2,697	2,613	2,329	2,697
Regulation Down	568	579	806	729	805	657	714	717	1,030	1,162	958	568	1,162
Load Following Down	2,521	2,516	2,286	2,290	2,282	2,056	2,078	2,077	2,860	2,892	2,874	2,526	2,892
Expanded Preferred Resources													
Regulation Up	516	512	462	463	464	627	620	665	911	929	838	495	929
Load Following Up	2,428	2,448	3,066	2,679	2,631	2,197	2,516	2,517	3,155	3,225	3,206	2,445	3,225
Regulation Down	611	608	804	755	801	702	878	827	1,092	1,182	1,091	611	1,182
Load Following Down	2,800	2,764	2,599	2,566	2,597	2,327	2,458	2,461	3,087	3,133	3,127	2,766	3,133
40% RPS in 2024													
Regulation Up	578	583	502	503	503	639	640	712	1,026	1,026	907	557	1,026
Load Following Up	2,734	2,702	3,483	3,113	3,015	2,448	2,779	2,885	3,490	3,532	3,482	2,740	3,532
Regulation Down	694	691	1,042	900	1,038	745	893	865	1,234	1,413	1,136	693	1,413
Load Following Down	3,101	3,081	2,838	2,849	2,806	2,631	2,545	2,626	3,415	3,529	3,519	3,095	3,529

SCIT and California import limits were calculated using the ISO SCIT Tool.

ISO Proposed Assumptions

(MW)	Summer Peak	Summer Off-Peak	Non-Summer Peak	Non-Summer Off-Peak
Trajectory Scenario				
SCIT Limit	13,942	10,654	10,467	7,874
CA Import Limit	14,142	10,854	10,667	8,074
High Load Scenario				
SCIT Limit	13,393	10,187	9,899	7,508
CA Import Limit	13,593	10,387	10,099	7,708
Expanded Preferred Resources Scenario				
SCIT Limit	12,820	9,120	8,426	5,957
CA Import Limit	13,020	9,320	8,626	6,157
40% RPS in 2024 Scenario				
SCIT Limit	12,326	9,239	8,735	6,803
CA Import Limit	12,526	9,439	8,935	7,003

California CO_2 emission cost modeling

CEC 2013 IEPR Forecasts

ISO Proposed Assumptions

- In CA as a generation cost adder:

  CO_2 Cost Adder = $23.27/Mton (in 2014 dollars)

- In WECC, except CA and BPA, as a CA import hurdle rate (an adder to wheeling charge):

  Hurdle Rate = 0.435 MTons/MWh * 23.27 $/MTon = $10.12 /MWh

- BPA to CA hurdle rate:

  Hurdle Rate = 20% x $10.12 = $2.02/MWh

  Refer to ARB rules

  http://www.arb.ca.gov/regact/2010/ghg2010/ghgisoratta.pdf

California dedicated import is modeled as must-take import.

ISO Proposed Assumptions

- Dedicated import includes
  - 100% of CA ownership shares of generation by conventional resources (Hoover, Palo Verde, etc.)
  - 70% of out-of-state RPS renewable generation
- Dedicated import is not subject to the CO_2 emission cost hurdle rate
- Dedicated import energy as well as upward ancillary services and load following provided by resources outside CA are all subject to the CA import limit

Renewable generation curtailment modeling assumptions

Additional CPUC and CEC Staff Inputs

ISO Proposed Assumptions

- Set renewable generation curtailment price to -$300/MWh
- There is no curtailment quantity limit
- Curtailment occurs when there is over-generation and energy price drops to -$300/MWh
- It may cause the total production cost of the simulation to be negative*

* See discussion on slide 56

List of the renewable generation resources curtailable at the -$300/MWh price

ISO Proposed Assumptions

- All California transmission-connected solar and wind resources except the solar thermal with storage resource

Existing Solar_IID	Existing Wind_SCE	Small_SolarPV_PG&E_VLY
Existing Solar_LDWP	Existing Wind_SDGE	Small_SolarPV_SCE
Existing Solar_OOS	Existing Wind_SMUD	Small_SolarPV_SDGE
Existing Solar_PGE_BAY	Large_SolarPV_IID	Solar_Thermal_SCE
Existing Solar_PGE_VLY	Large_SolarPV_PG&E_VLY	Wind_AESO
Existing Solar_SCE	Large_SolarPV_SCE	Wind_CFE
Existing Solar_SDGE	Large_SolarPV_SDGE	Wind_LDWP
Existing Solar_SMUD	Large_SolarPV_SPP	Wind_SCE
Existing Wind_OOS	Large_SolarPV_SRP	Wind_SDGE
Existing Wind_PGE_BAY	Small_SolarPV_IID	
Existing Wind_PGE_VLY	Small_SolarPV_PG&E_BAY	

Deterministic Simulation Results

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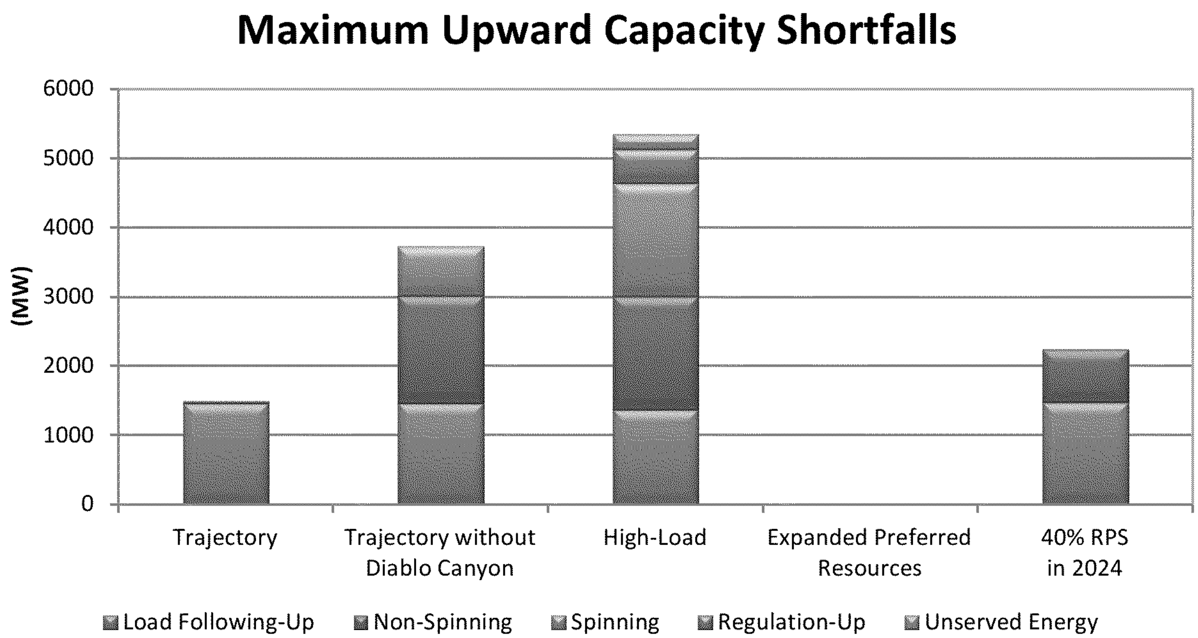
Capacity shortfall summary

Scenario	Upward/ Downward	Number of Hours	Maximum Shortfall (MW)	Types with Shortfall
Trajectory Scenario	Up	5	1,489	LF, Nspin
Trajectory without Diablo Canyon	Up	19	3,730	LF, Nspin, Spin
High Load Scenario	Up	34	5,353	LF, Nspin, Spin, Reg, energy
Expanded Preferred Resources Scenario		0	0	
40% RPS in 2024 Scenario	Up	9	2,242	LF, Nspin



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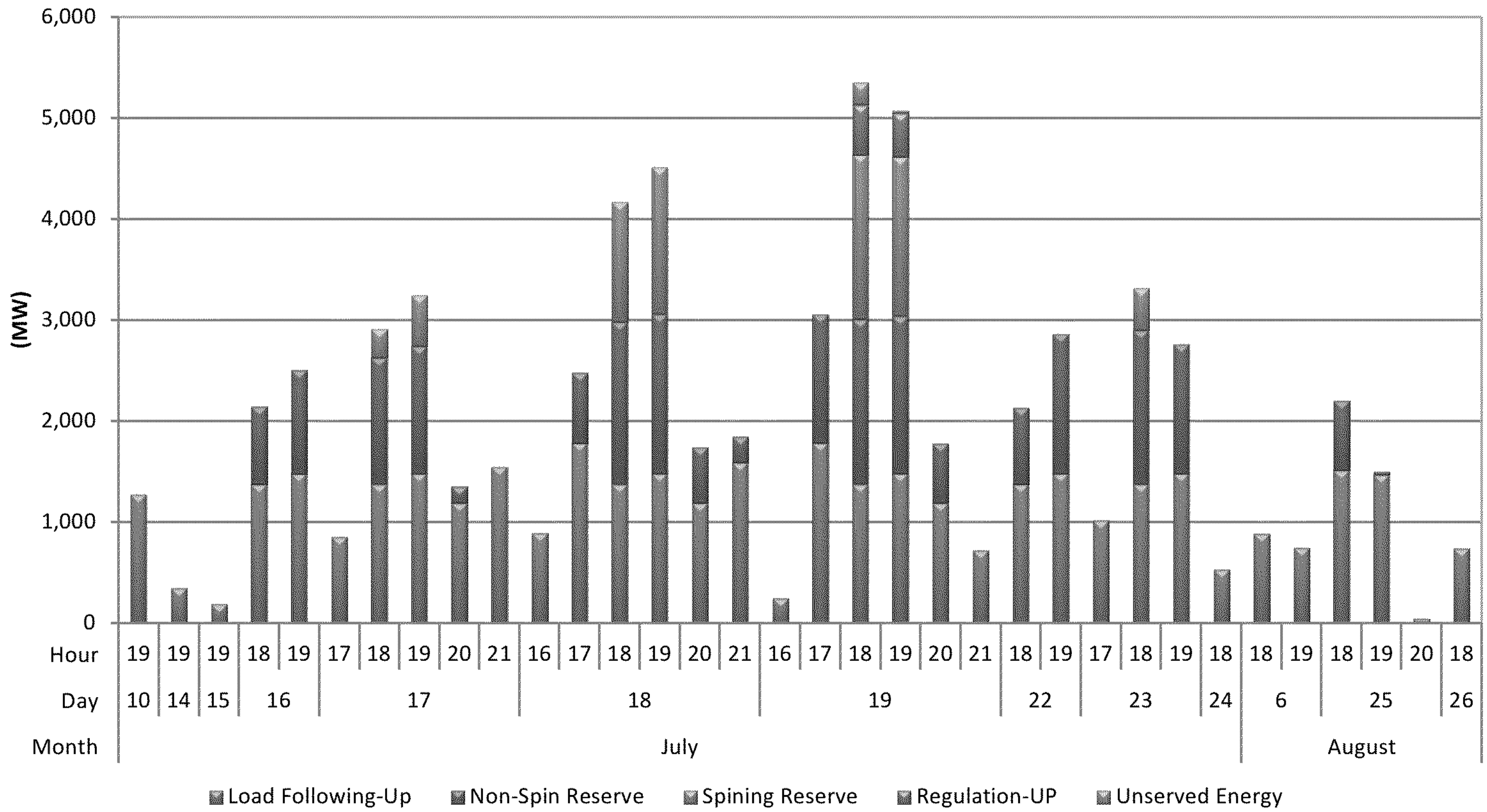
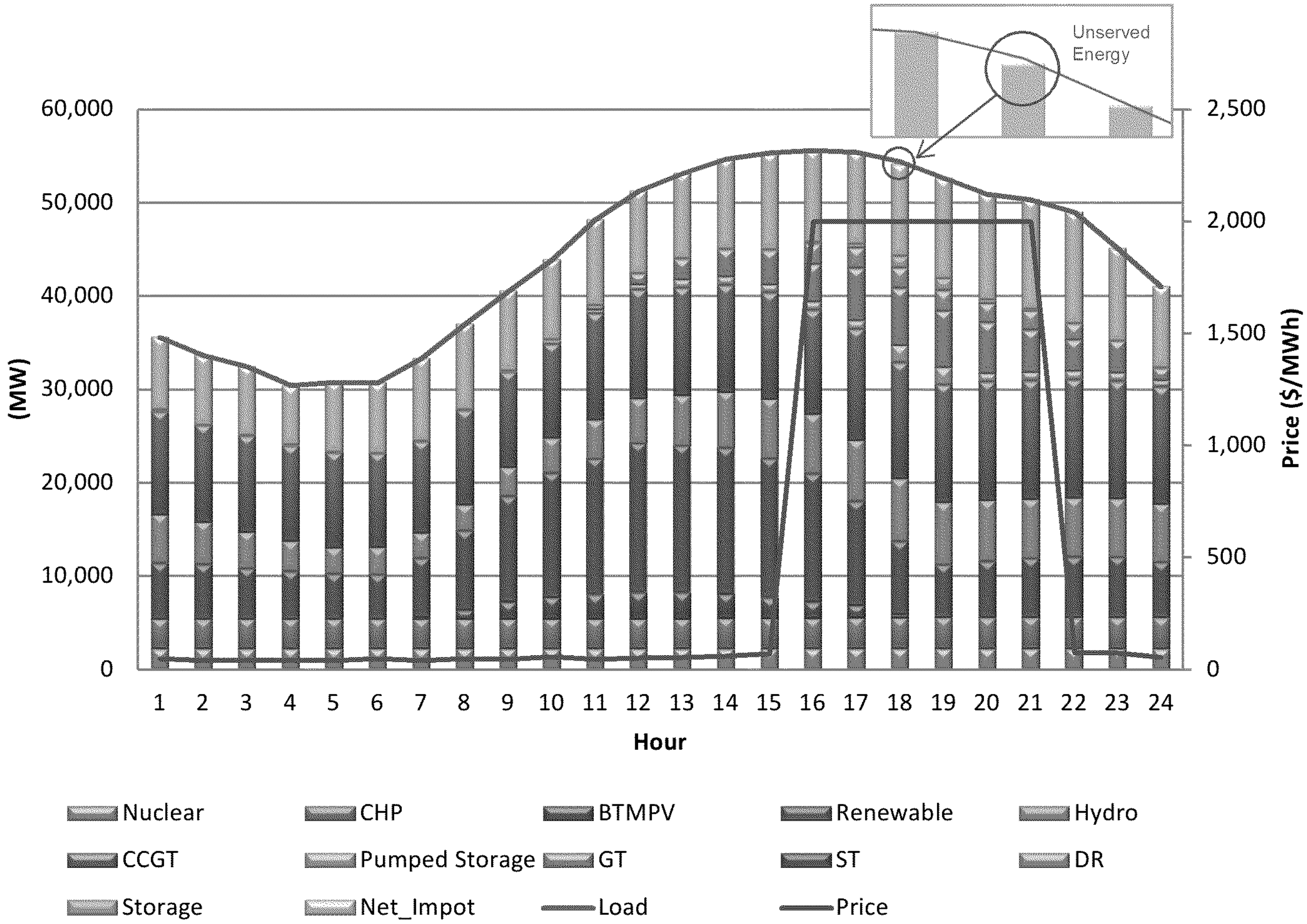
Capacity shortfalls in High Load scenario indicate Stage Emergencies in the ISO operation.*



* Capacity shortfalls of all types are additive for each hour.
For the ISO Stage Emergency description, see http://www.caiso.com/Documents/EmergencyFactSheet.pdf

Extreme shortfall occurred after the system peak load hour on July 19, 2024 – High Load scenario.



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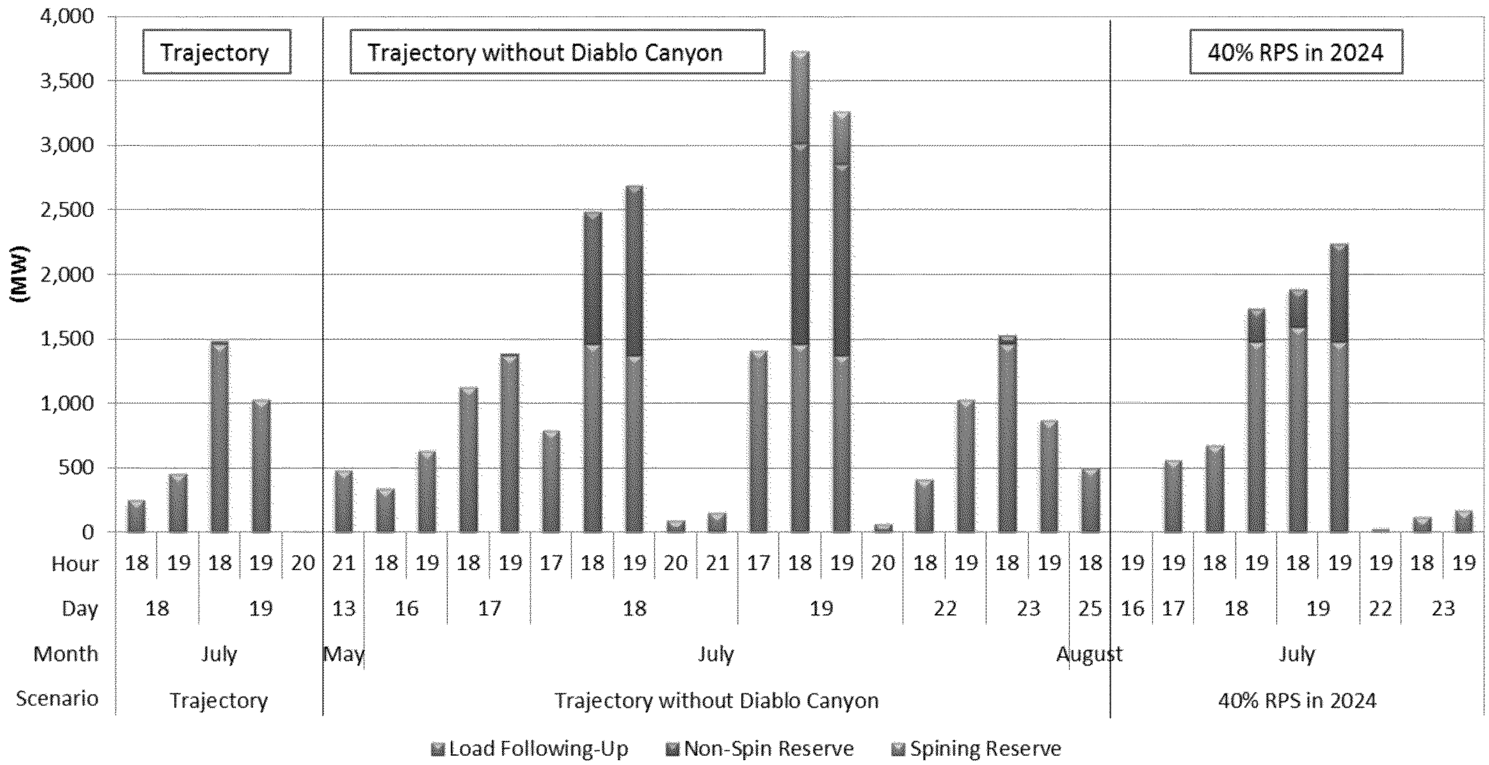
Capacity shortfalls and Stage Emergencies also occurred in other two scenarios and one sensitivity*

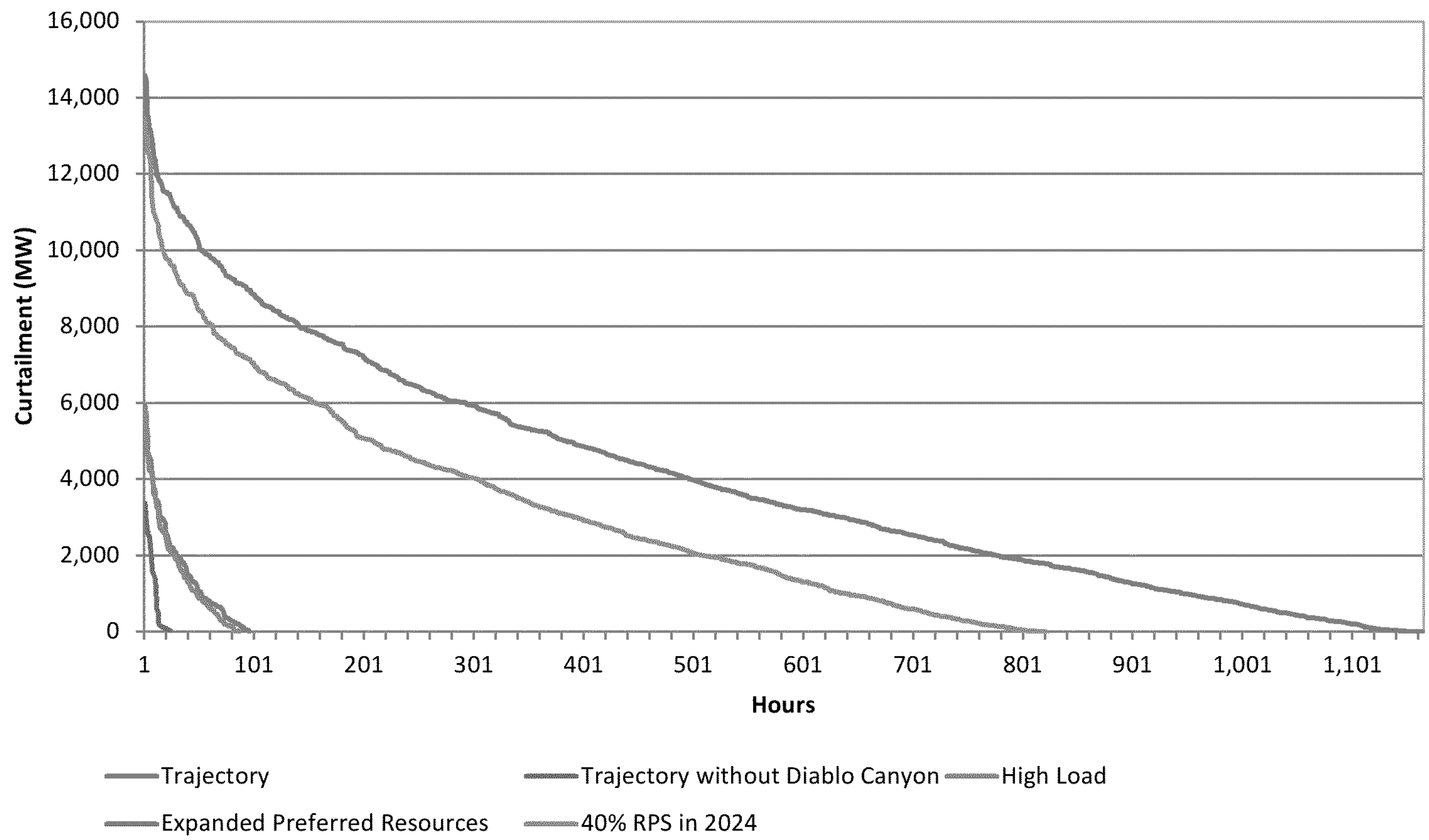


* Expanded Preferred Resources scenario does not have capacity shortfall.

The ISO renewable generation and curtailment – significant curtailment in high RPS scenarios

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Trajectory Scenario													
Number of Hours		2	26	47	16	5							96
Max Curtailment (MW)		243	5,927	5,410	2,984	2,025							5,927
Generation (GWh)	4,526	4,780	6,131	6,321	6,495	6,471	6,215	5,396	5,263	5,160	4,694	4,613	66,065
Curtailment (GWh)		0.5	48.4	76.7	21.7	6.2							153
Percent		0.0%	0.8%	1.2%	0.3%	0.1%							0.2%
Trajectory without Diablo Canyon													
Number of Hours			9	14	1								24
Max Curtailment (MW)			2,960	3,383	99								3,383
Generation (GWh)	4,526	4,781	6,166	6,385	6,517	6,477	6,215	5,396	5,263	5,160	4,694	4,613	66,193
Curtailment (GWh)			13.3	12.8	0.1								26
Percent			0.2%	0.2%	0.0%								0.0%
High Load Scenario													
Number of Hours			25	43	14	5							87
Max Curtailment (MW)			5,841	5,725	2,708	2,494							5,841
Generation (GWh)	4,840	5,142	6,626	6,825	7,011	6,967	6,691	5,778	5,641	5,524	5,021	4,933	70,999
Curtailment (GWh)			44.3	67.5	17.9	6.2							136
Percent	0.0%	0.0%	0.7%	1.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Expanded Preferred Resources Scenario													
Number of Hours	35	49	185	231	205	161	34	25	73	63	68	36	1,165
Max Curtailment (MW)	5,238	9,323	13,543	14,599	12,289	11,522	8,434	3,611	7,819	7,666	4,526	4,738	14,599
Generation (GWh)	4,721	4,891	5,708	5,545	6,071	6,534	6,805	6,018	5,611	5,412	4,858	4,713	66,886
Curtailment (GWh)	54	126	846	1,396	961	574	107	40	186	165	126	57	4,637
Percent	1.1%	2.5%	12.9%	20.1%	13.7%	8.1%	1.6%	0.7%	3.2%	3.0%	2.5%	1.2%	6.5%
40% RPS in 2024 Scenario													
Number of Hours	15	29	141	202	165	114	20	5	36	33	42	20	822
Max Curtailment (MW)	3,384	7,484	12,927	13,402	10,035	9,363	5,006	557	4,770	5,849	2,805	2,862	13,402
Generation (GWh)	5,537	5,825	7,156	7,165	7,717	8,046	8,058	7,084	6,751	6,482	5,802	5,575	81,198
Curtailment (GWh)	15	59	583	1,013	594	291	47	2	70	88	48	17	2,825
Percent	0.3%	1.0%	7.5%	12.4%	7.1%	3.5%	0.6%	0.0%	1.0%	1.3%	0.8%	0.3%	3.4%

Duration curves of the ISO renewable generation curtailment



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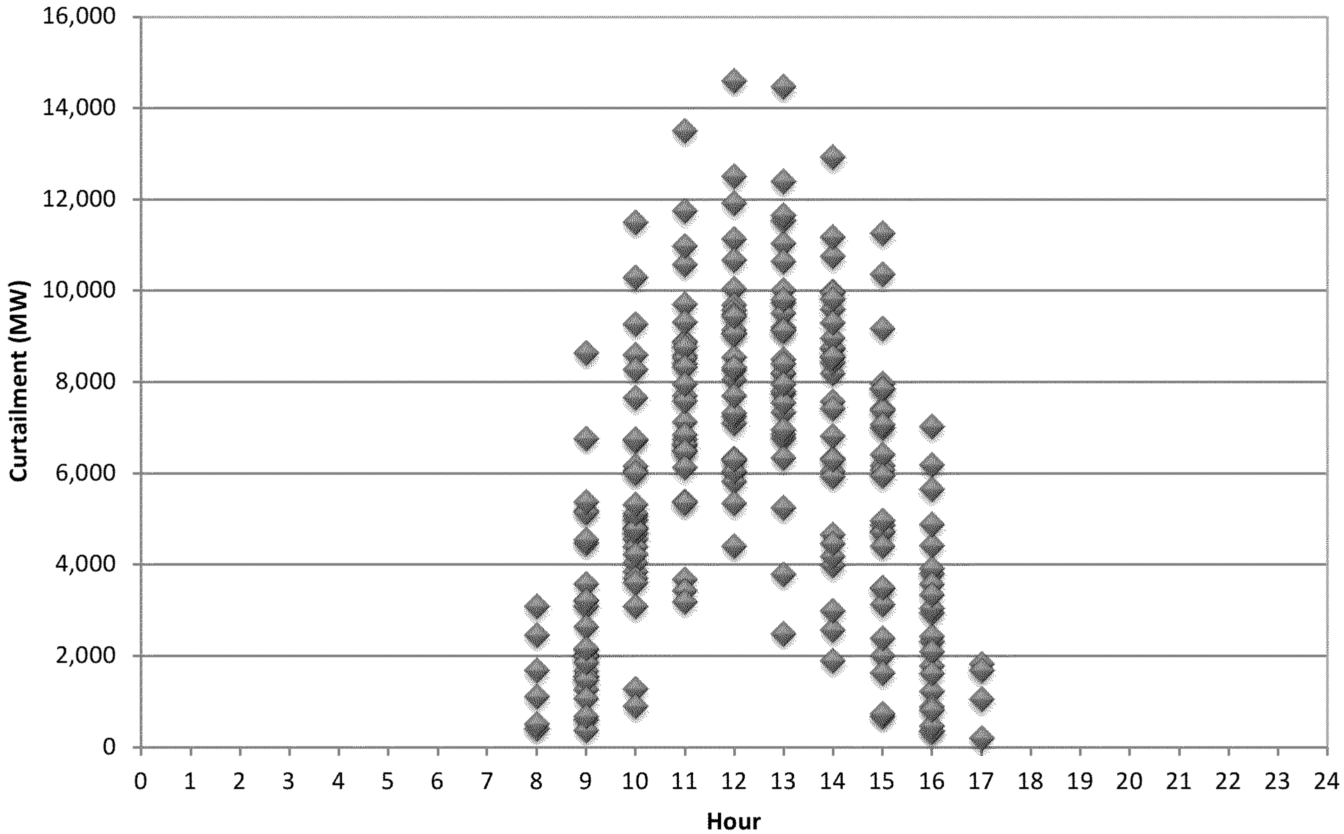
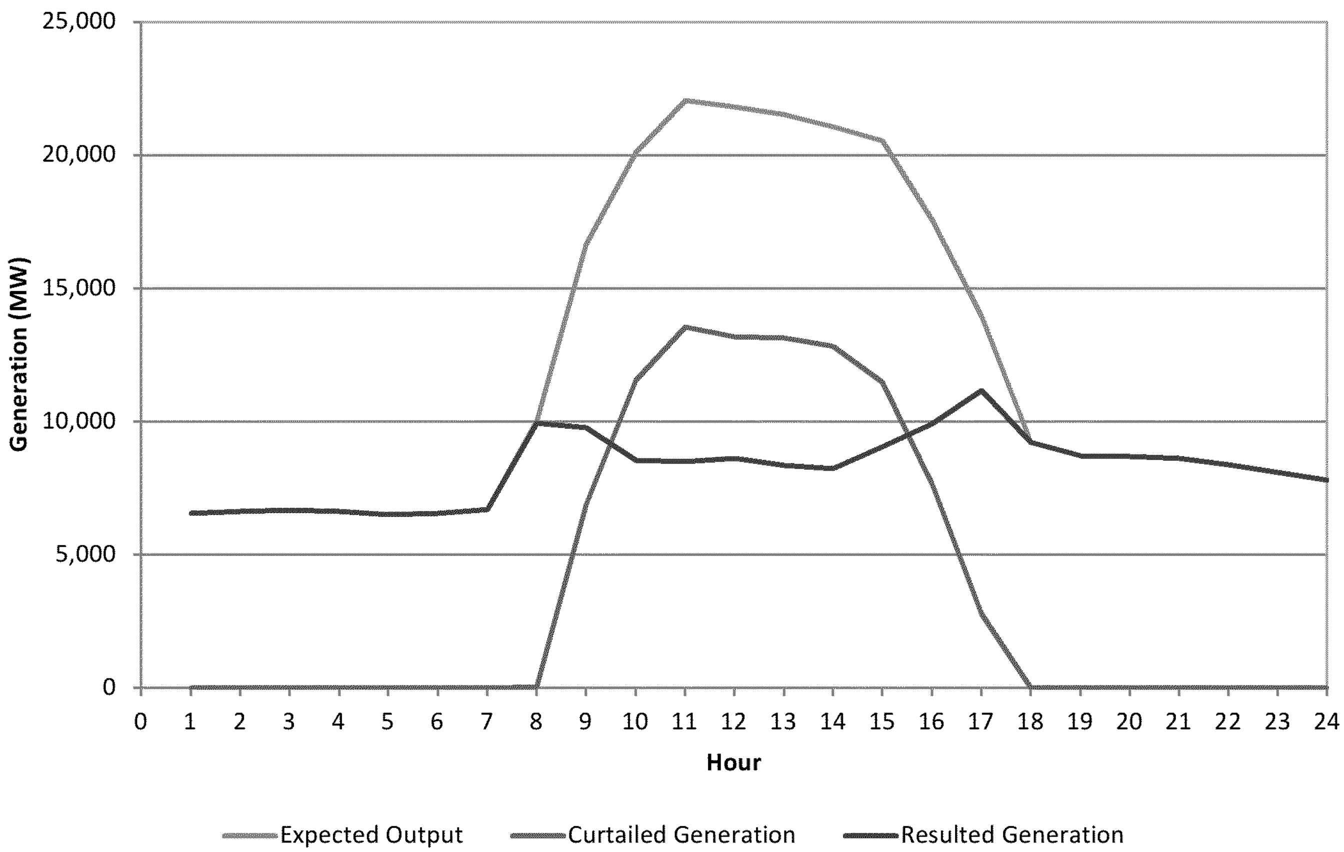
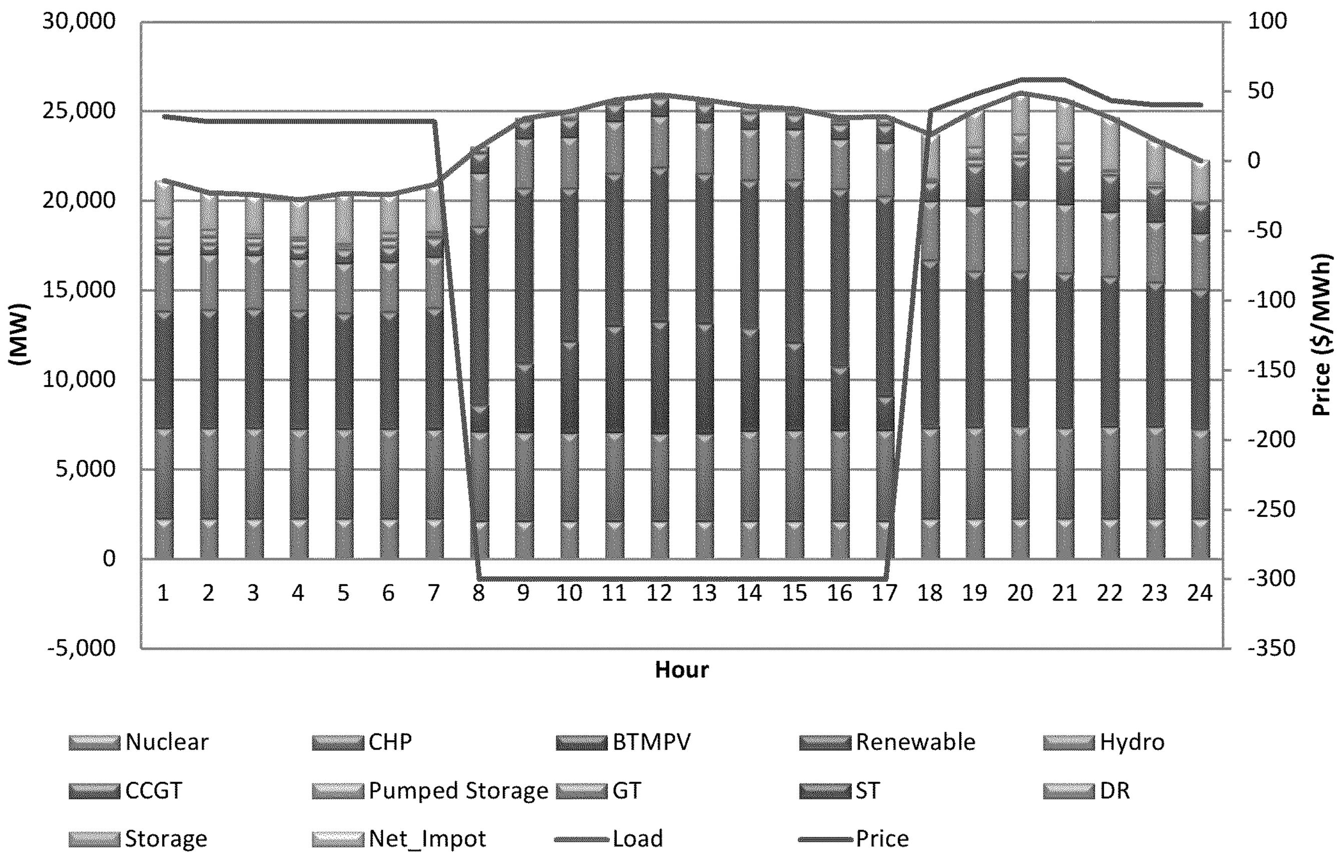
Curtailment occurred during the day – the events in April 2024, Expanded Preferred Resources scenario



High renewable curtailment during the day on March 24, 2024 – Expanded Preferred Resources scenario



No ISO net import in hours of curtailment on March 24, 2024 – Expanded Preferred Resources scenario



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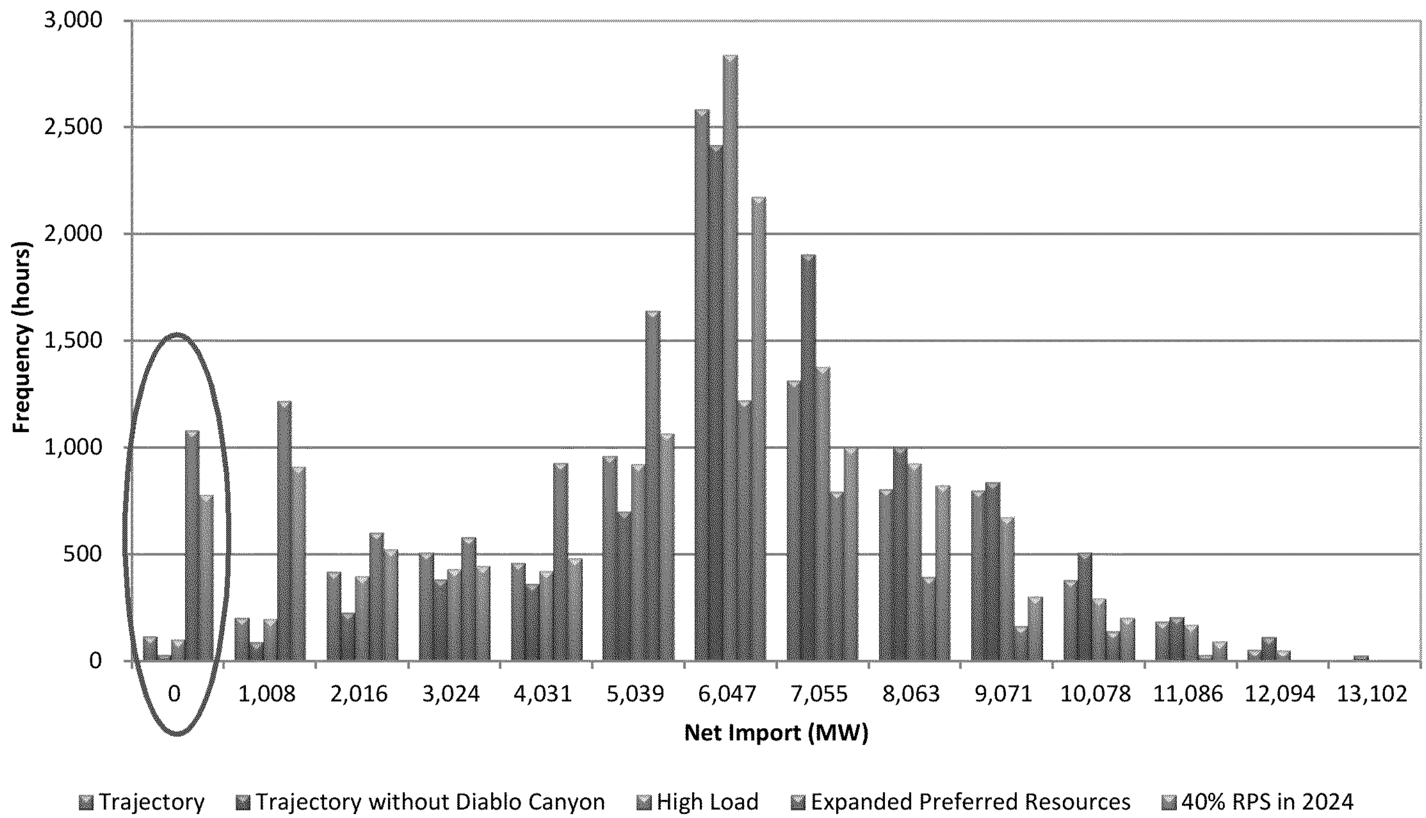
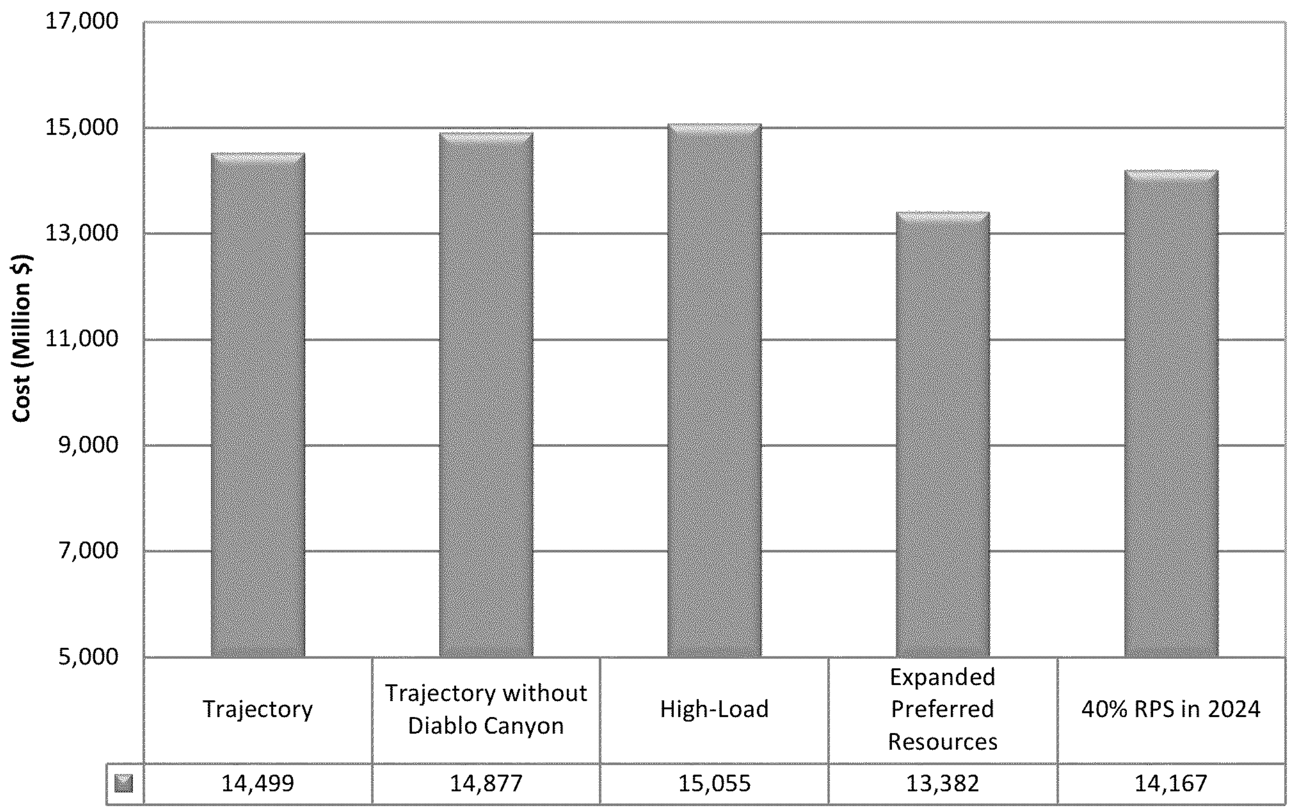
Histogram of the ISO net import – high frequency of potential net export in high RPS scenarios

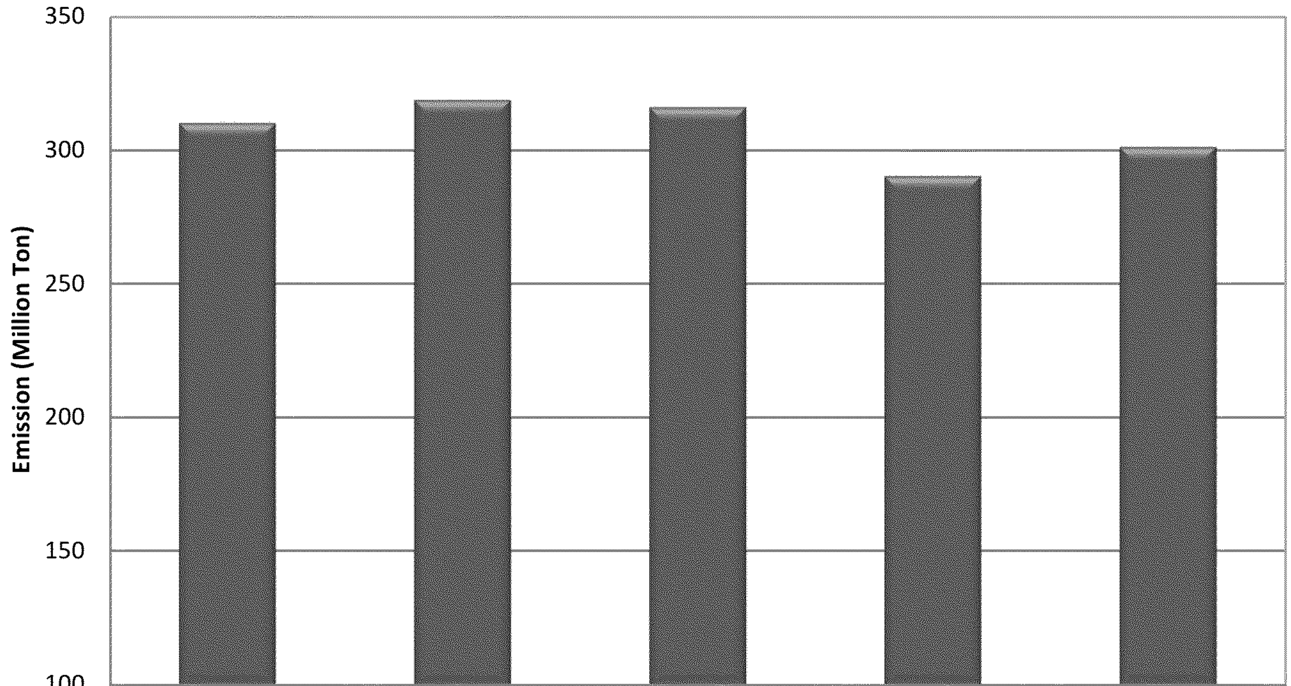


WECC total production cost*



* Production costs are adjusted for comparison purpose, see discussion on slide 56

WECC total CO_2 emission



	Trajectory	Trajectory without Diablo Canyon	High-Load	Expanded Preferred Resources	40% RPS in 2024
	310	318	316	290	301

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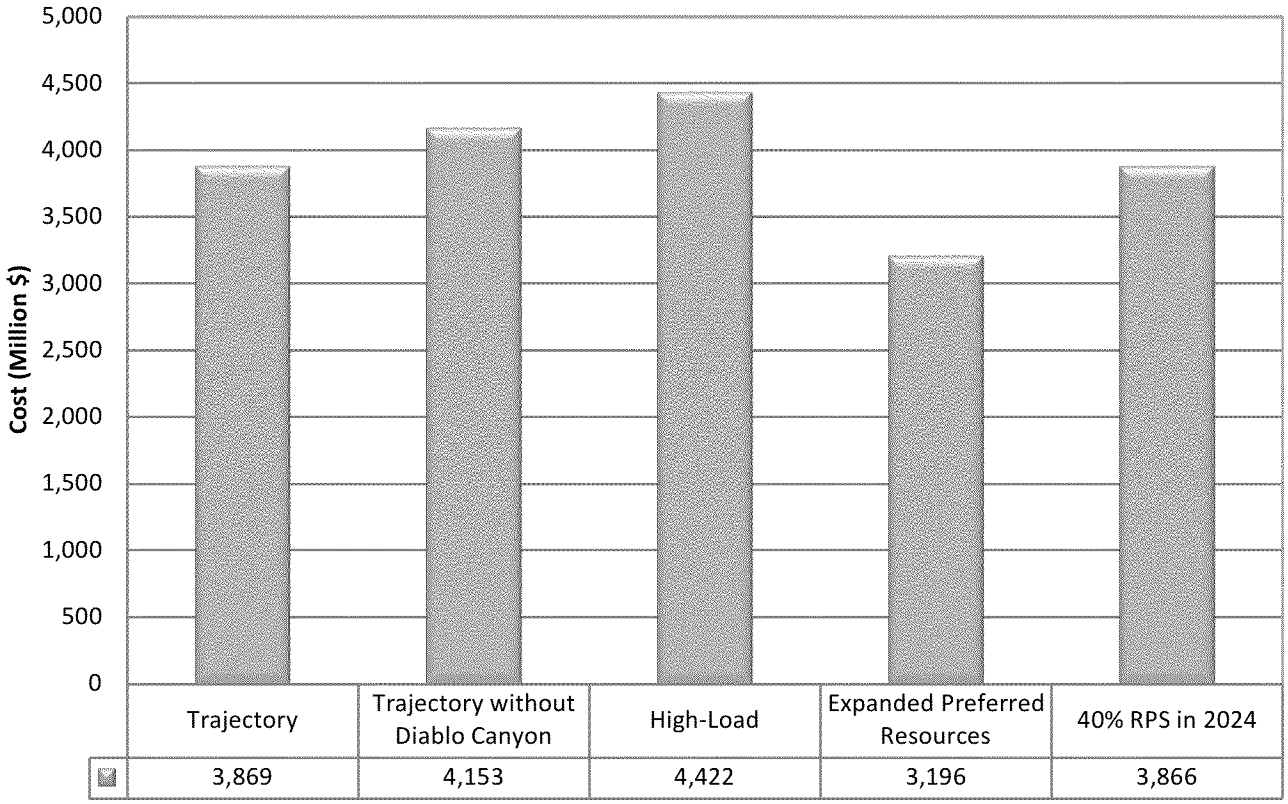
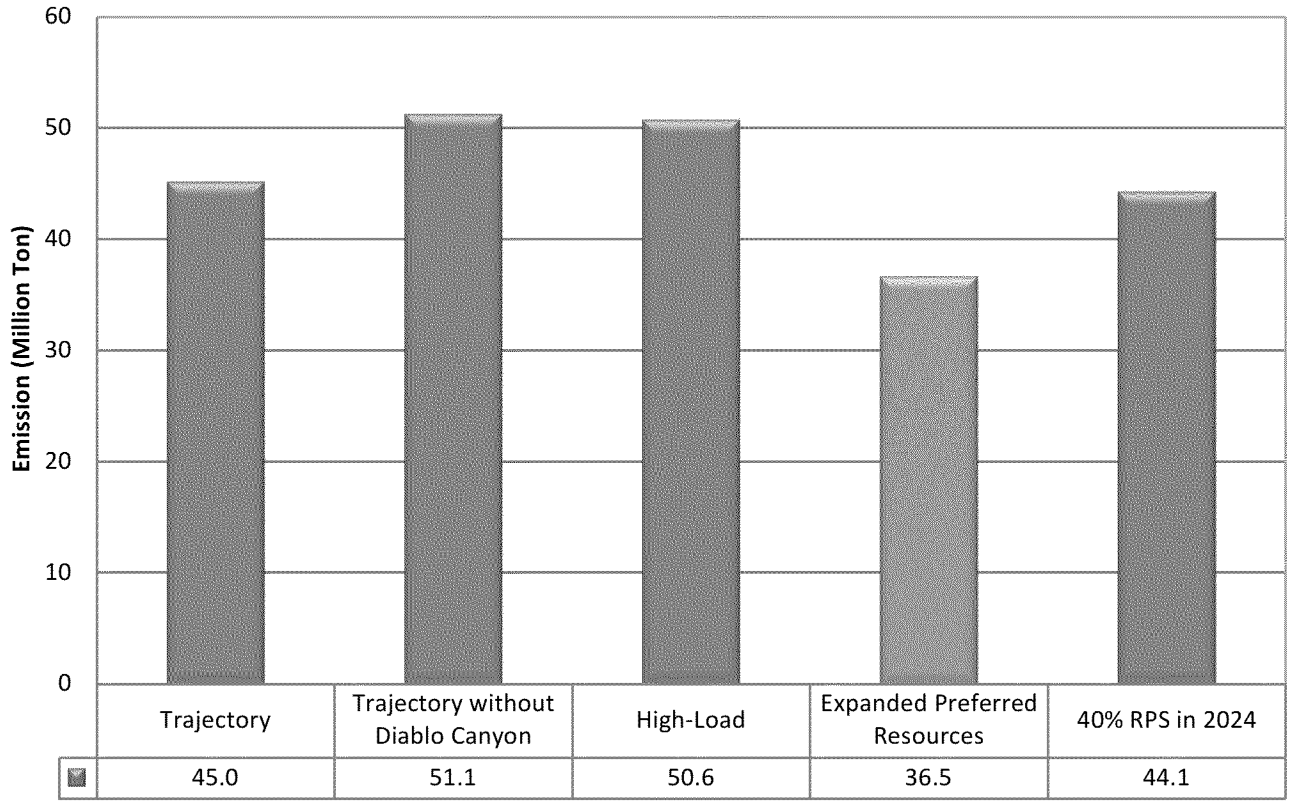
California production cost*



* Production costs are adjusted for comparison purpose, see discussion on slide 56

California CO_2 emission



Notes about the simulation results

- Price cap – values are based on the ISO scarcity pricing design and applied when there is upward or downward shortfalls
  - Energy $2,000/MWh
  - Load following-up and load following-down $650/MWh
  - Non-spinning $700/MWh
  - Spinning $800/MWh
  - Regulation-up and regulation-down $1,000/MWh

Notes about the simulation results (cont.)

- Negative production cost
  - Caused by the -$300/MWh variable cost of the curtailable solar and wind generation resources
  - Won't affect comparison of production costs of two scenarios
  - May change back to positive production cost by adding $300/MWh x Generation by the curtailable resources (which then assumes the resources has $0/MWh generation cost)

Next Steps

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Next steps

- Phase 1a - now to November 13, 2014
  - Develop a stochastic production simulation model
  - Conduct Monte Carlo simulations for the Trajectory scenario
  - File testimony with stochastic results
- Phase 1b - additional studies to evaluate
  - Impact of Track 4 resources
  - Renewable curtailment scenarios
  - Procurement alternatives to meet capacity and flexibility needs

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Thank you!

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