R.12-03-014: Energy Division Workshop – Operating Flexibility Modeling

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California Public Utilities Commission

April 24, 2012

Remote Access

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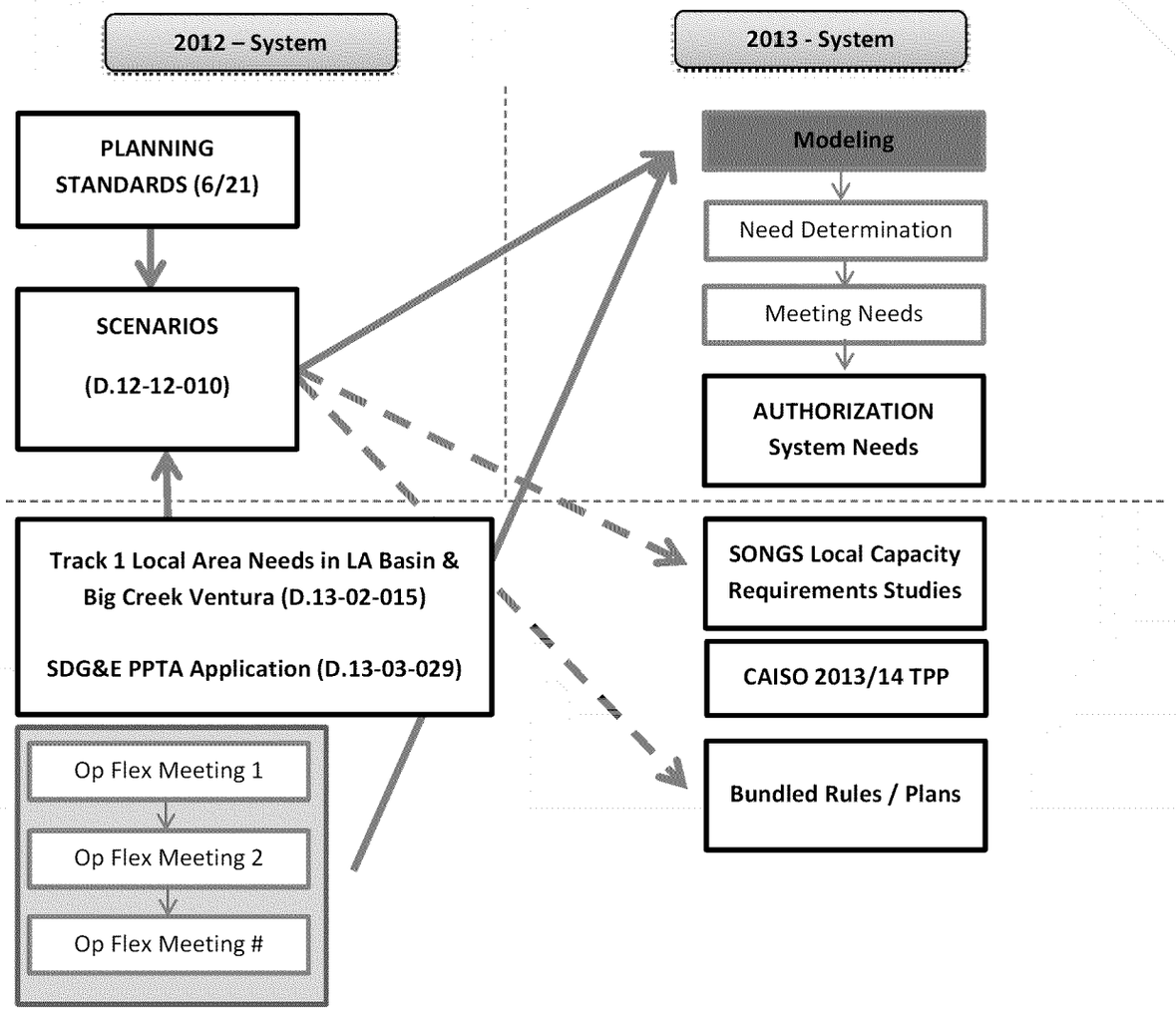
Agenda

Time	Item
10:00 - 10:10	Introduction, Schedule
10:10 – 12:00	Modeling Assumptions
12:00 – 1:00	Lunch
1:00 – 2:00	Modeling Assumptions (cont)
2:00 – 2:45	Preliminary Results
2:45 – 3:00	Break
3:00 – 3:45	Preliminary Results (cont)
3:45 – 4:00	Wrap-up / Next steps

Workshop Purpose

- Review current operating flexibility study methodology
- Review preliminary results on the 2012 LTPP base case
- Next steps for studies

Roadmap



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2012 LTPP Track 2 – Operational Flexibility Study

CPUC LTPP Track 2 Workshop

Shucheng Liu, Ph.D.
Principal, Market Development
April 24, 2013

About 2012 Long-Term Procurement Plan (LTPP) Track 2 study

- CPUC requested the ISO conduct an operational flexibility modeling study using the Standardized Planning Assumptions and Scenarios as determined in the CPUC Dec 24, 2012 decision (12-03-014).
- ISO proposed to conduct the operational flexibility study using a Plexos production cost simulation model.
- ISO plans to study: 1) Base scenario, 2) Replicating TPP scenario, 3) High DG + High DSM scenario, and 4) the Early SONGS Retirement sensitivity case.

Agenda

- Model assumptions and data sources
- Preliminary results of Base Scenario
- Proposed study schedules
- Response to stakeholder comments on study plan

Model Assumptions and Data Sources

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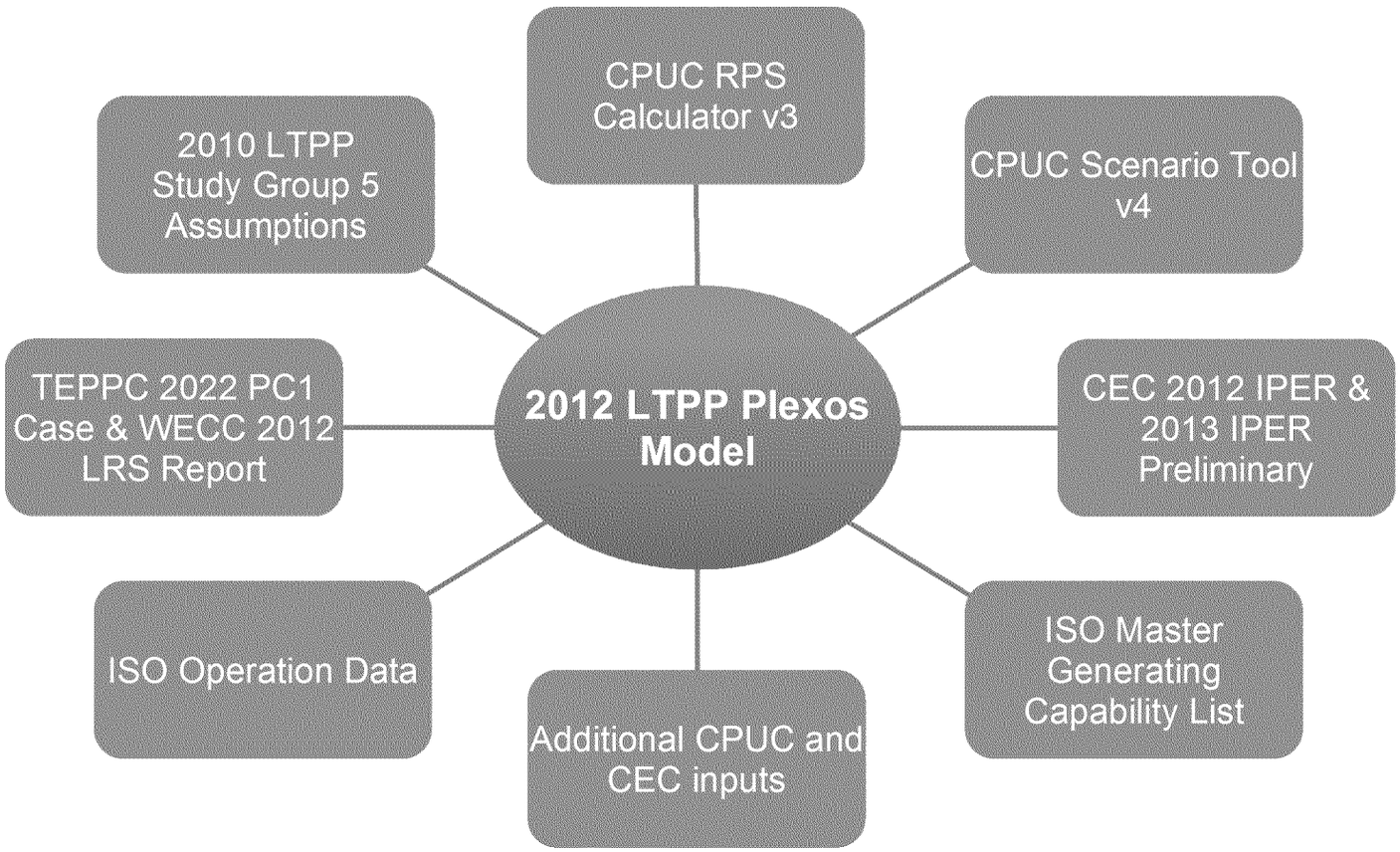
The Plexos production cost simulation model uses data from several sources.



Assumptions from 2010 LTPP Study Group 5 analysis – reserve requirements

- WECC reserve requirements
  - Spinning = 3% of load
  - Non-spinning = 3% of load
  - Regulation = 1% of load (outside CA)
  - Load following up and down were based on the ISO 2012 Energy Imbalance Market study assumption (outside CA)
  - Regulation and load following requirements outside CA will be updated according to TEPPC 2022 PC1 Case

Assumptions from 2010 LTPP Study Group 5 analysis – CO_2 cost modeling

CEC new forecast

- In CA as a generation cost adder:

  CO_2 Cost Adder = $24.13/MTon

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

  Hurdle Rate = 0.435 MTons/MWh * 24.13 $/MTon = $10.50 /MWh

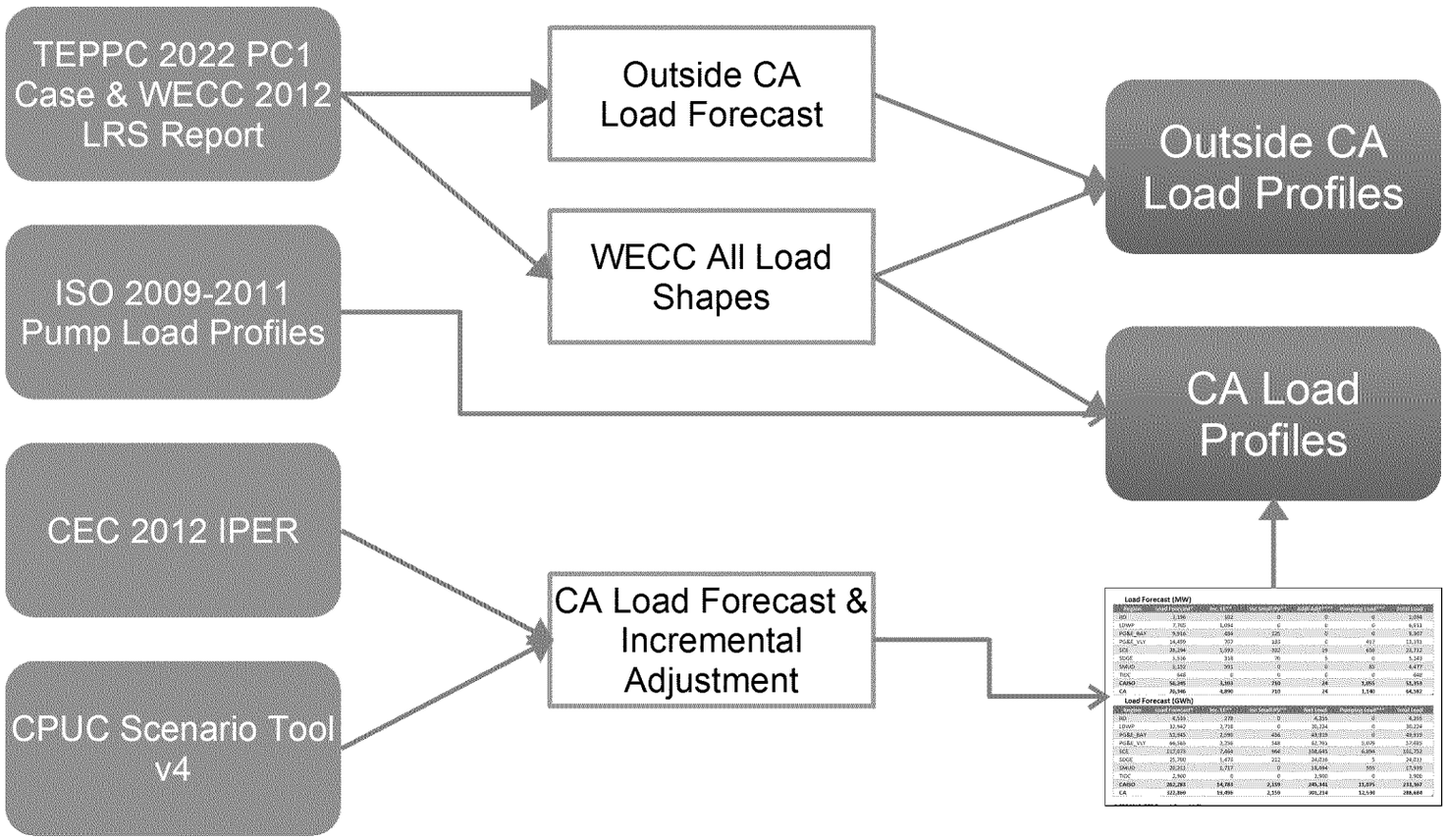
- BPA to CA hurdle rate:

  Hurdle Rate = 20% x $10.50 = $2.10/MWh

  – Refer to ARB rules

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

Load forecasts and load shapes are drawn from multiple data sources.



CA load forecasts are adjusted by incremental demand-side resources and pump load.

Load Forecast (MW)

Region	Load Forecast*	Inc. EE**	Inc Small PV**	Addl Adjt****	Pumping Load***	Total Load
IID	1,196	102	0	0	0	1,094
LDWP	7,705	1,094	0	0	0	6,611
PG&E_BAY	9,916	484	125	0	0	9,307
PG&E_VLY	14,499	707	183	0	417	13,191
SCE	26,294	1,593	332	19	638	23,712
SDGE	5,536	318	70	5	0	5,143
SMUD	5,152	591	0	0	85	4,477
TIDC	648	0	0	0	0	648
CAISO	**56,245**	**3,103**	**710**	**24**	**1,055**	**51,353**
CA	**70,946**	**4,890**	**710**	**24**	**1,140**	**64,182**

Coincident Peak
CAISO=50,156 MW
CA=60,612 MW

Load Forecast (GWh)

Region	Load Forecast*	Inc. EE**	Inc Small PV**	Net Load	Pumping Load***	Total Load
IID	4,533	278	0	4,255	0	4,255
LDWP	32,942	2,718	0	30,224	0	30,224
PG&E_BAY	52,945	2,590	436	49,919	0	49,919
PG&E_VLY	66,565	3,256	548	62,761	5,076	57,685
SCE	117,073	7,464	964	108,645	6,894	101,752
SDGE	25,700	1,473	212	24,016	5	24,011
SMUD	20,211	1,717	0	18,494	555	17,939
TIDC	2,900	0	0	2,900	0	2,900
CAISO	**262,283**	**14,783**	**2,159**	**245,341**	**11,975**	**233,367**
CA	**322,869**	**19,496**	**2,159**	**301,214**	**12,530**	**288,684**

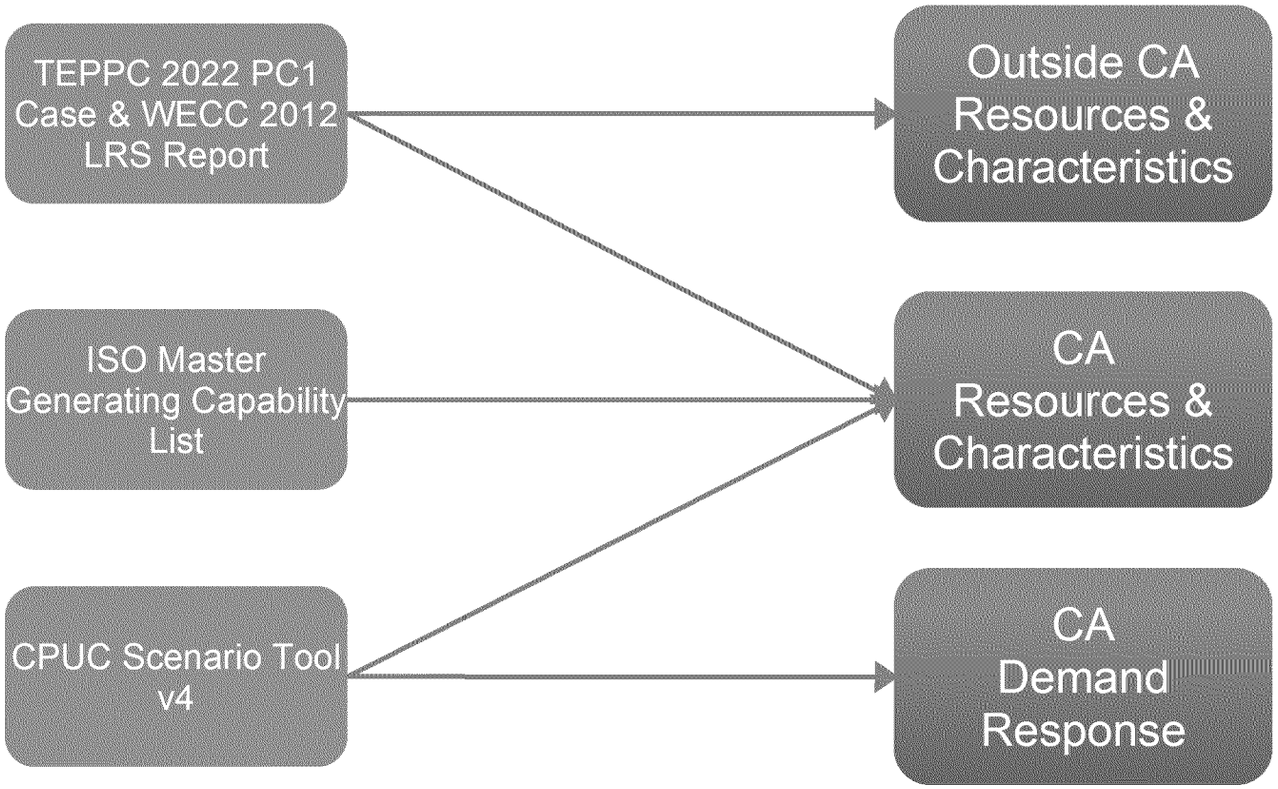
* CEC 2012 IPER Form 1.5a and 1.5b

** CPUC Scenario Tool V4 and CEC IPER 2013 Preliminary

*** CPUC Scenario Tool V4 and 2009-2011 average of ISO operation data

**** CPUC Dec 24, 2012 decision

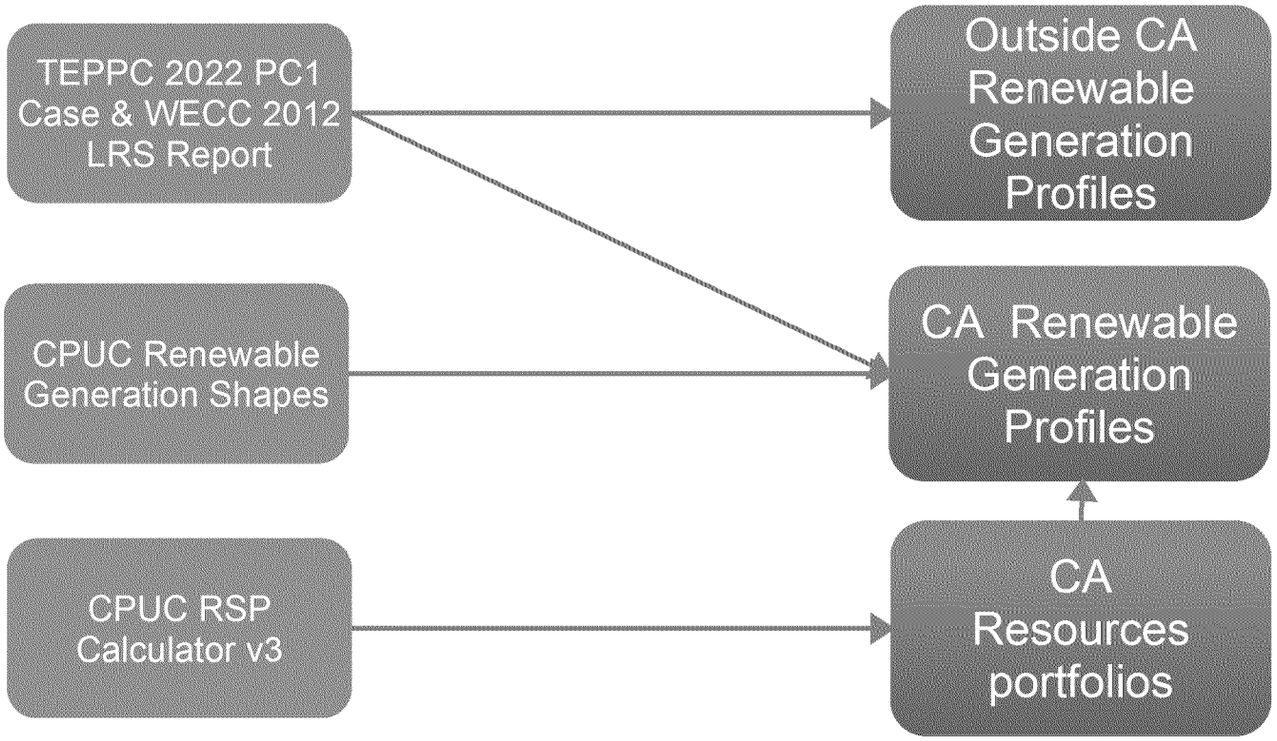
Generation resource operating characteristics are primarily taken from TEPPC 2022 PC1 Case.



CEC and CPUC recommended assumptions for Southern California local capacity resources.

- CPUC Track 1 decisions
  - SDG&E 343 MW
  - SCE 1,400 – 1,800 MW
    - <1,200 MW gas fired resources
    - >150 MW preferred resources
    - <600 MW preferred resources or storage
    - >50 MW storage
- CEC and CPUC recommendation
  - SDG&E - 343 MW GT
  - SCE - 900 MW CCGT, 100 MW GT, 50 MW storage

CA renewable generation portfolios follow the CPUC scenario definitions.



CPUC RPS Calculator determines CA RPS net short.

Item	All Values in GWh for the Year 2022	Formula	Base	Replicating TPP	High DG + High DSM
1	Statewide Retail Sales - June 2012 IEPR12 Final		301,384	301,384	301,384
2	Non RPS Deliveries (CDWR, WAPA, MWD)		12,530	12,530	12,530
3	Retail Sales for RPS	3=1-2	288,854	288,854	288,854
4	Additional Energy Efficiency		19,543	0	27,457
5	Additional Rooftop PV		2,159	0	5,480
6	Additional Combined Heat and Power		0	0	7,486
7	Adjusted Statewide Retail Sales for RPS	7=3-4-5-6	267,152	288,854	248,431
8	**Total Renewable Energy Needed For RPS**	**8=7* 33%**	**88,160**	**95,322**	**81,982**
	Existing and Expected Renewable Generation				
9	Total In-State Renewable Generation		40,305	40,305	40,305
10	Total Out-of-State Renewable Generation		13,950	13,950	13,950
11	Procured DG (not handled in Calculator)		1,110	1,110	1,110
12	**Total Existing Renewable Generation for CA RPS**	**12=9+10+11**	**55,364**	**55,364**	**55,364**
13	**Total RE Net Short to meet 33% RPS In 2022 (GWh)**	**13=8-12**	**32,796**	**39,957**	**26,618**

Source: CPUC RPS Calculator v4

CA renewable portfolio for Base Scenario has a mix of various types of renewable resources.

Existing Renewable Portfolio

Type	Capacity (MW)	Energy (GWh)	Out of State Energy	In State Energy
Biogas and Biomass	1,084.8	8,041.0	1,603.7	6,437.3
Geothermal	2,190.1	16,589.4	1,887.1	14,702.2
Small Hydro	1,329.1	7,228.3	39.7	7,188.6
Solar PV	1,005.5	2,329.1	822.0	1,507.1
Large Solar PV	150.0	343.4	194.0	149.4
Small Solar PV	48.0	73.9	0.0	73.9
Solar Thermal	738.0	1,413.4	0.0	1,413.4
Wind	5,456.2	19,346.6	9,405.2	9,941.4
Total	**12,001.7**	**55,365.1**	**13,951.7**	**41,413.4**

RPS (New) Renewable Portfolio

Type	Capacity (MW)	Energy (GWh)	Out of State Energy	In State Energy
Biogas	136.2	954.5	0.0	954.5
Biomass	56.8	422.9	0.0	422.9
Geothermal	687.8	4,965.3	1,199.7	3,765.6
Small Hydro	0.0	0.0	0.0	0.0
Large Solar PV	5,577.8	12,767.3	1,632.6	11,134.7
Small Solar PV	2,134.9	4,309.6	0.0	4,309.6
Solar Thermal	1,402.0	3,399.3	0.0	3,399.3
Wind	2,148.9	5,976.9	1,496.0	4,480.9
Total	**12,144.3**	**32,795.8**	**4,328.3**	**28,467.5**

CA renewable portfolio for Base Scenario has some additional assumptions.

New Large Scale Solar PV

Type	Capacity (MW)	Energy (GWh)
Crystalline Tracking	1,168	2,729
Thin-Film	4,410	10,038
Total	**5,578**	**12,767**

New Solar Thermal

Type	Capacity (MW)	Energy (GWh)
Solar Thermal without Storage	1,252	2,926
Solar Thermal with Storage*	150	473
Total	**1,402**	**3,399**

*Riverside East
Rice Solar Energy (formerly "Solar Reserve (Rice Solar)")

Study	Dynamic Schedule	Intra-Hour (15-min) Schedule	Hourly Schedule	Unbundled RECs
2010 LTPP	15%	15%	40%	30%
2012 LTPP	15%	35%	20%	30%

CEC provided staff forecast of natural gas prices.

Additional CPUC and CEC Inputs

- Comparison of natural gas price forecasts for 2012 and 2010 LTPP studies

Natural Gas Prices (2010 $/MMBTU)

CEC Forecast			2010 LTPP Model		
	PG&E BB	PG&E LT		PG&E BB	PG&E LT
Jan-22	4.23	4.39	Jan-20	6.07	6.23
Feb-22	3.99	4.14	Feb-20	6.04	6.20
Mar-22	3.90	4.06	Mar-20	5.87	6.03
Apr-22	4.02	4.17	Apr-20	5.43	5.59
May-22	4.15	4.30	May-20	5.41	5.57
Jun-22	4.21	4.37	Jun-20	5.46	5.62
Jul-22	4.28	4.43	Jul-20	5.53	5.69
Aug-22	3.96	4.11	Aug-20	5.57	5.73
Sep-22	3.92	4.07	Sep-20	5.59	5.75
Oct-22	4.07	4.23	Oct-20	5.66	5.82
Nov-22	4.40	4.55	Nov-20	5.92	6.08
Dec-22	4.45	4.60	Dec-20	6.17	6.33

CEC also provided CO_2 price forecast.

CEC 2012 IPER & 2013 IPER Preliminary

- CEC 2013 IPER preliminary forecast
  - $24.13/Mton (or $21.89/Ston) in 2012 dollars

  vs.
  - $36.30/Ston in 2010 dollars for 2010 LTPP Study

Transmission path ratings and wheeling charges are primarily from TEPPC 2022 PC1 Case.

TEPPC 2022 PC1 Case & WECC 2012 LRS Report

- WECC path ratings and wheeling charges
  - TEPPC 2022 PC1 Case
- Southern California Import Transmission (SCIT) and CA simultaneous import limit
  - SCIT calculation tool
- CA import hurdle rate
  - $10.50 /MWh adder to wheeling charge of import into CA (except import from BPA)
  - $2.10/MWh adder to wheeling charge of import from BPA into CA

Step 1 regulation and load following requirement calculation uses t-30 minute forecast errors.

Solar Forecast Errors (as percentage of installed capacity)

Study	Case	Type	Persistent	Hour	0<=CI<0.2	0.2<=CI<0.5	0.5<=CI<0.8	0.8<=CI<=1
2010 LTPP	Trajectory	Customer Side PV	T-1 hour	Hour12-16	1.6%	3.3%	3.1%	1.6%
2010 LTPP	Trajectory	DG PV	T-1 hour	Hour12-16	2.2%	4.7%	3.9%	1.8%
2010 LTPP	Trajectory	Large PV	T-1 hour	Hour12-16	3.5%	6.9%	5.6%	2.3%
2010 LTPP	Trajectory	Solar Thermal	T-1 hour	Hour12-16	6.0%	10.9%	10.8%	3.0%
2012 LTPP	Base	Small PV	t-30 min	Hour12-16	1.6%	4.1%	4.9%	1.5%
2012 LTPP	Base	DG PV	t-30 min	Hour12-16	1.4%	2.7%	2.4%	1.2%
2012 LTPP	Base	LGPV	t-30 min	Hour12-16	3.0%	4.3%	3.7%	1.6%
2012 LTPP	Base	Solar Thermal	t-30 min	Hour12-16	4.1%	7.4%	5.7%	1.9%

Wind Forecast Errors (as percentage of installed capacity)

Study	Case	Type	Persistent	Hour	Spring	Summer	Fall	Winter
2010 LTPP	Trajectory	Wind	T-1 hour	All	4.0%	3.8%	3.2%	3.1%
2012 LTPP	Base	Wind	t-30 min	All	2.3%	2.2%	1.9%	2.1%

Load Forecast Errors (standard deviation, MW)*

Study	Case	Load	Time	Hour	Spring	Summer	Fall	Winter
2010 LTPP	Trajectory	HASP	T-1 hour	All	545	636	540	682
2010 LTPP	Trajectory	RTD	t-5 min	All	216	288	277	231
2012 LTPP	Base	RTPD	t-30 min	All	228	333	410	252
2012 LTPP	Base	RTD	t-5 min	All	103	189	258	118

* 2010 LTPP load forecast errors are based on the ISO 2010 operation data, 2012 LTPP based on the ISO 2012 operation data

Using t-30 min forecast errors resulted in lower load-following requirements.

2012 LTPP Base Scenario Monthly Maximum Requirements (MW)

Month	Regulation Up	Regulation Down	Load Following Up	Load Following Down
Jan	987	1,365	2,961	3,497
Feb	967	1,337	2,986	3,192
Mar	685	701	2,449	3,110
Apr	670	767	2,511	2,972
May	674	800	2,489	2,752
Jun	700	878	2,058	2,251
Jul	700	1,035	3,085	2,685
Aug	697	964	3,030	2,672
Sep	1,289	1,056	2,690	3,245
Oct	1,307	1,056	2,873	3,742
Nov	1,251	1,068	2,877	3,776
Dec	956	1,341	2,922	3,520

Annual Maximum Regulation and Load-following Requirements (MW)

Study	Case	Regulation Up	Regulation Down	Load Following Up	Load Following Down
2010 LTPP	Trajectory	1,219	991	3,564	4,122
2012 LTPP	Base	1,307	1,365	3,085	3,776

Over-generation modeling method changed to capture negative energy prices.

- Model regulation-down and load following-down requirements as hard constraint (cannot be violated)
- Set Dump-Power price to -$300/MWh
- In case of over-generation
  - High positive load following-down price
  - -$300/MWh energy price

Additional updates will be implemented.

- Ramp rates calculated based on the Master File data
- Forced and planned outage rates based on the ISO 2006-2010 operation data or NERC GASDS data
- Reserve sharing across Balance Authority Areas
- SCIT and CA import limits based on improved SCIT tool
- More detail modeling of solar thermal with storage

Preliminary Results of Base Scenario

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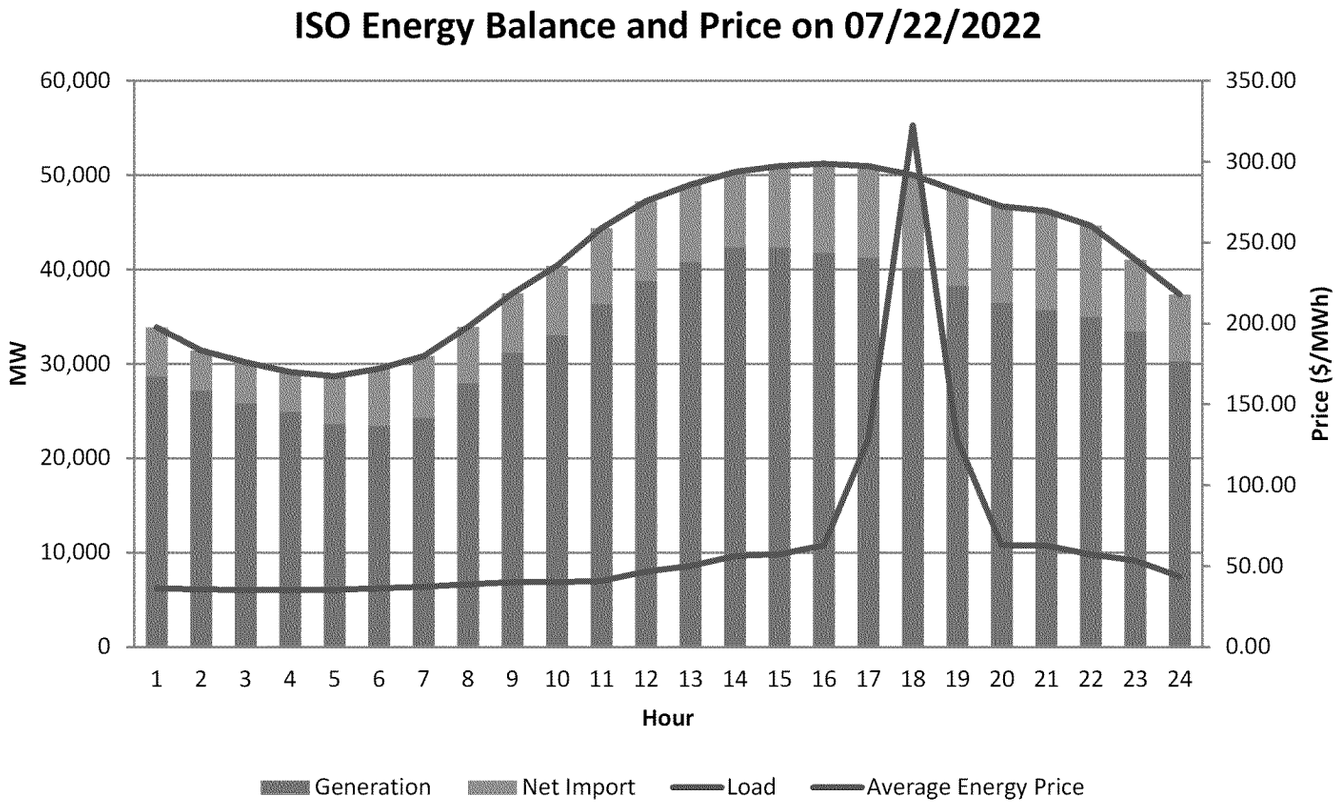
Preliminary results of Base Scenario do not show any shortage or over-generation.

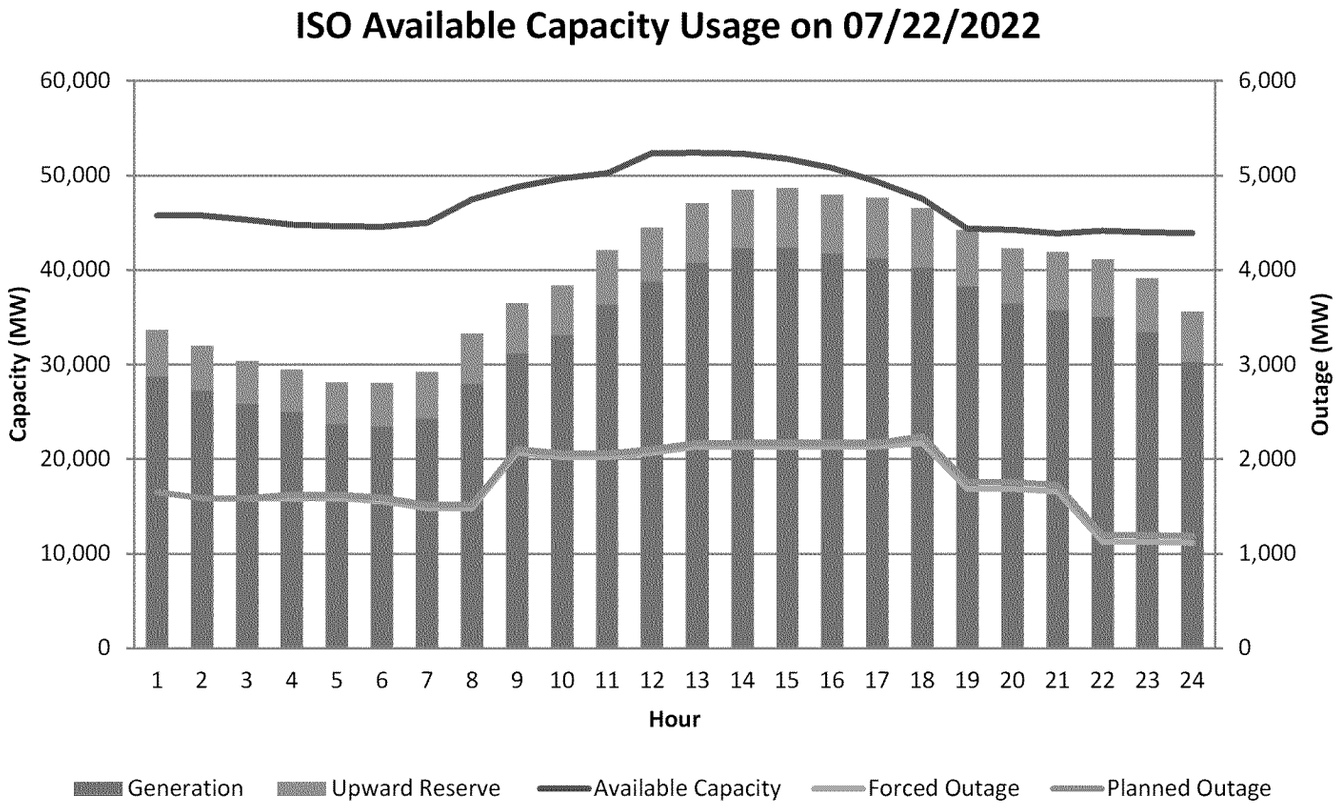
- Conducted Need Run simulations for March and July
- Found no upward shortage or over-generation
- Utilizes all import capability and almost all available capacity* on peak-load day
- Exports energy for some hours in March

* Available Capacity = Rated Capacity – Planned Outage – Forced Outage
Rated Capacity of renewable resource = generation profile value

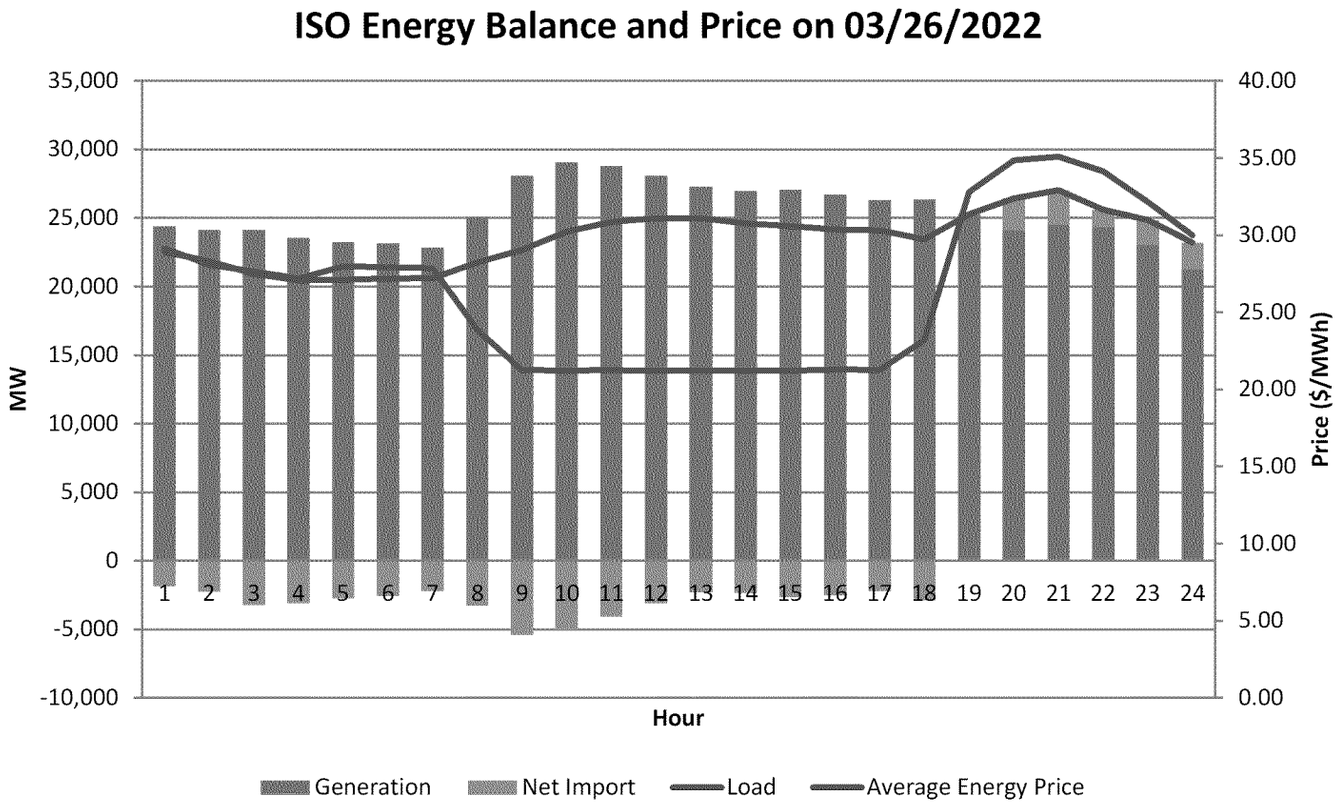
ISO reaches maximum import capability on peak-load day.



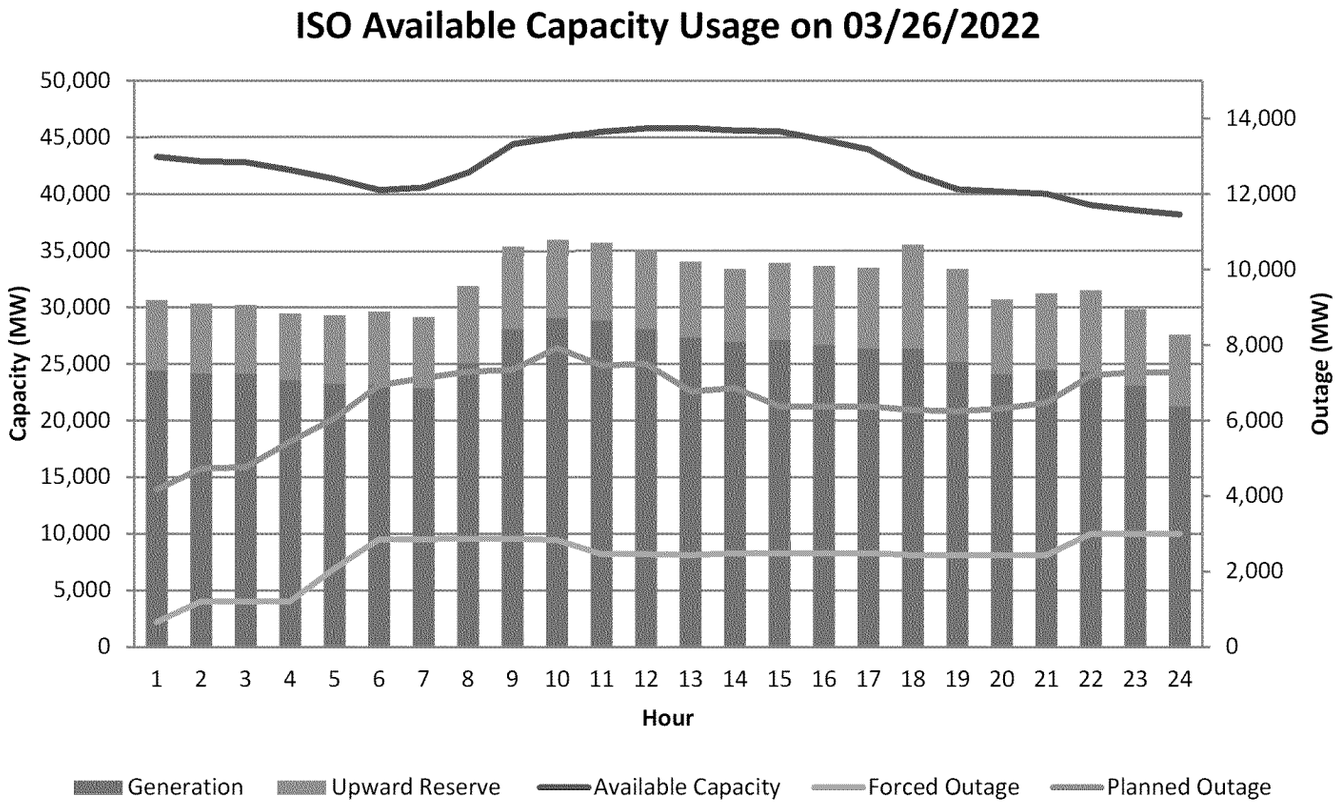
Almost all available capacity is utilized on peak-load day.



ISO has net export for most hours of March 26, 2022.



Sufficient capacity is available on March 26, 2022.



Planned Study Schedule

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ISO plans to complete simulations by:

- May 2013
  - Full-year deterministic simulation of Base Scenario
- July 2013
  - Deterministic simulation of other two scenarios and early SONGS retirement sensitivity case
- August 2013
  - Stochastic simulation of one or two scenarios
- November 2013
  - Deterministic simulation of 2018 case

Response to Stakeholder Comments on Study Plan

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ISO investigated changing Step 1 regulation and load following requirement calculation to a 15-min interval.

- Stakeholder comments
  - May reduce a conservative bias
  - Potentially underestimates flexible capacity requirement
  - Does not match with production cost simulation interval
- ISO Response
  - Hourly interval aligns with operational practice
  - ISO plans to keep hourly interval in Step 1 calculation

ISO suggested using t-30 minute forecast errors in Step 1 calculation.

- Stakeholder comments
  - It could be useful
  - It should go down to t-15 minutes
  - Forecast error should be calculated over the hour
- ISO Response
  - ISO performs last load forecast before real-time unit commitment at t-30 minutes
  - t-30 minute forecast covers the next hour
  - ISO plans to use t-30 minute forecast errors in Step 1 calculation

ISO proposed to conduct full-year hourly deterministic production cost simulations.

- Stakeholder comments
  - Is a good baseline simulation and can be easily replicated by other parties
  - Should be combined with stochastic simulations
  - May focus only on months with potential shortage or over-generation
- ISO response
  - ISO will conduct full-year hourly deterministic simulations for the three scenarios and one sensitivity case requested by the CPUC

ISO suggested hourly stochastic simulations for selected months.

- Stakeholder comments
  - May not be necessary
  - Better reflect the day-ahead unit commitment process and require less computing power
- ISO response
  - ISO is evaluating the options to augment the deterministic results using stochastic simulations

ISO solicited input about conducting 5-min stochastic simulations without load following requirements.

- Stakeholder comments
  - Support the approach
  - Need more information
  - Do not see much value in running a limited stochastic analysis using Plexos
  - Tie identified need to specific criteria, such as 1-in-10
- ISO response
  - ISO is evaluating the options to augment the deterministic results using stochastic simulations

ISO presented capacity weighted-average ramp rates calculated by technology and vintage.

- Stakeholder comments
  - Classify resources on the basis of size or on the basis of particular technologies within a technology (such as LMS100, LM6000 etc.)
- ISO response
  - ISO is refining the calculation based on available information

ISO calculated forced and planned outage rates based on operational data.

- Stakeholder comments
  - Benchmark against an industry standard
  - Feed annual outage rate into the model and optimize it over months
- ISO response
  - ISO is refining the calculation and will compare the rates with that from NERC GADS database
  - Model uses annual outage rates
  - ISO will assess method to optimize planned outage over months

Model has two methods to capture flexibility or capacity shortages in simulation.

- Stakeholder comments
  - Use the perfectly flexible resource instead of generic GT units
  - Use finer tiered-cost structure with 100 MW generic GT units
- ISO response
  - ISO will keep both tiered-cost structure and perfectly flexible resource methods
  - The cost tiers will be refined

Stakeholders suggest modeling reserve sharing.

- Stakeholder comments
  - Consider what the ISO proposed in Transmission Planning Process for reserve sharing across Balance Authority Areas
- ISO response
  - ISO will implement reserve sharing in the model

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Thank you!

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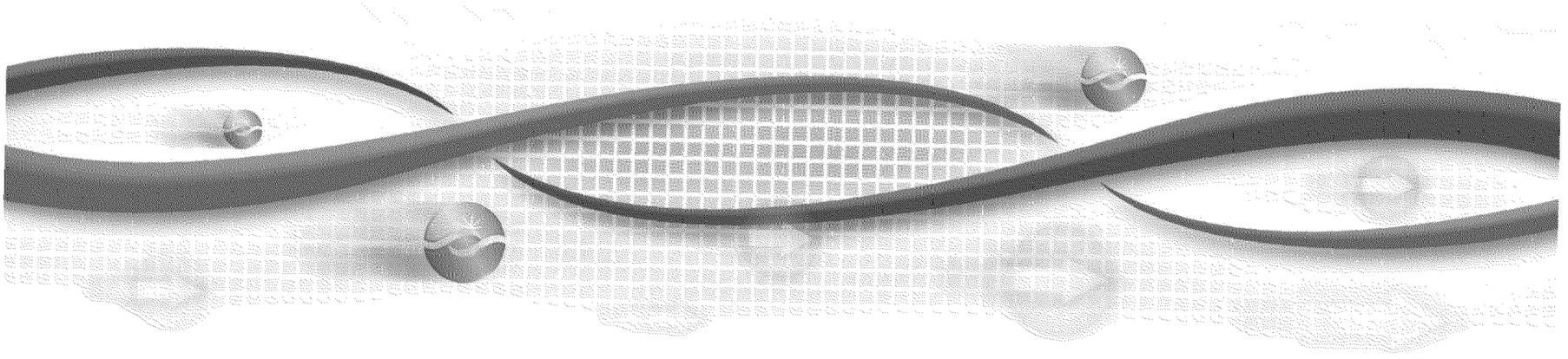

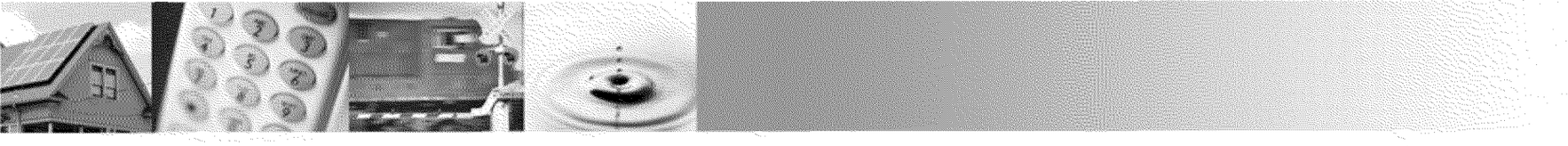

Wrap Up & Next Steps

Thank you!
For Additional Information:

www.cpuc.ca.gov
www.GoSolarCalifornia.ca.gov
www.CalPhoneInfo.com