California Public Utilities Commission

March 25, 2016

Energy Division Proposal for Proceeding 14-10-010 Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Refinements, and Establish Annual Local and Flexible Procurement Obligations for the 2016 and 2017 Compliance Years

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Effective Load Carrying Capability of Wind and Solar Resources in the CAISO Balancing Authority and Resetting the Reserve Margin for Resource Adequacy Obligations

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List of Acronyms

CAISO	California Independent System Operator
CEC	California Energy Commission
COV	Coefficient of Variance
CPUC	California Public utilities Commission
ED	Energy Division
ELCC	Effective Load Carrying Capability
GT	Gas Turbine
GWh	Gigawatt-hour
LOLE	Loss of Load Expectation
LTPP	Long Term Planning Proceeding
MW	Megawatt
MWh	Megawatt-Hour
PG&E	Pacific Gas and Electric
RA	Resource Adequacy
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SERVM	Strategic Energy Risk Valuation Model
TEPCC	Transmission Expansion Policy Coordination Committee
WECC	Western Electricity Coordinating Council

Acknowledgements

Several people have contributed to preparing the data for this model, as well as reviewing outputs to ensure that the results are appropriate. In particular, Energy Division staff would like to acknowledge the work of Donald Brooks and Joanna Gubman from Energy Division, who worked to prepare and document the input assumptions, run the model, and prepare output reports. Kevin Carden from Astrape Consulting provided expert support in preparing the inputs, as well as reviewing all documentation and providing crucial editorial assistance on several versions of this draft study results report. This draft report was also reviewed by Michele Kito and Judith Ikle in Energy Division. Their help is much appreciated.

Executive Summary

Senate Bill 2 (1X) [1] requires the California Public Utilities Commission (CPUC) to assess the Effective Load Carrying Capability (ELCC) of wind and solar facilities within the Resource Adequacy (RA) program. Energy Division (ED) staff studied the California electric system using a vendor provided software called Strategic Energy Risk Valuation Model (SERVM). ED staff issued a draft report with results of their analysis on July 15, 2015 and held a workshop on August 20, 2015 to discuss the draft results and provide stakeholders the opportunity to review the results and data inputs. Data and reports are currently posted to the CPUC website on the ELCC modeling Project page.[2] The current modeling is mostly consistent with the *Inputs and Assumptions for ELCC Modeling* report posted there, but ED has refined its approach in some ways, as discussed further below.[3]

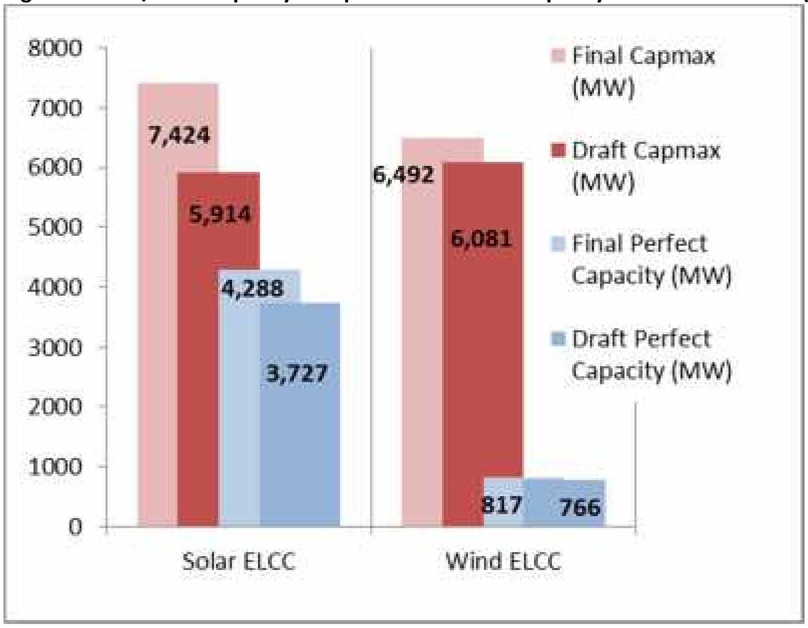
A portion of the ELCC work has been completed and is presented in this paper. Staff calculated the appropriate amount of generating capacity needed to ensure reliability to the standard of 0.1 Loss of Load Expectation (LOLE), then calculated the "average ELCC" of solar and wind generators in the California Independent System Operator (CAISO) area for 2017, although the values are not yet specific to location or individual technologies for different solar or wind types. ED also proposes to shape the ELCC values to specific months of the year and to phase in the ELCC values over three years to reduce contracting uncertainty with existing resources.

To maintain reliability in the CAISO aggregated area, with an average peak load of 48,060 MW, it was necessary to maintain 55,450 MW of effective capacity, translating to a ratio of 116.5% of annual peak load[4]. Since the current RA obligations are set at 115%-117% relative to peak load, ED staff does not propose any changes to the RA obligations, but instead has verified that the current RA obligations are valid as results of this LOLE modeling.

Average ELCC for solar resources in 2017 equaled approximately 57.8%; exchanging 7,424 MW of solar capacity for 4,288 MW of "Perfect Capacity" resulted in a probability weighted LOLE[5] of approximately 0.1 over all 165 cases run. When 6,492 MW of wind facilities were removed and 817 MW of "Perfect Capacity" was substituted, reliability was measured at approximately 0.1 resulting in an average ELCC of 12.6%. Figure 1 illustrates the magnitude of wind capacity versus "Perfect Capacity" and solar capacity versus "Perfect Capacity". Staff calculated locational factors that translate to locational ELCC for solar facilities only. Wind facilities were not studied due to time constraints. Solar facilities in Northern California had an ELCC of 46%, while solar facilities in Southern California had an ELCC of 68%. These locational ELCC values are further shaped by month to create monthly and locational solar ELCC values to apply to solar facilities within CAISO areas.

[1] SB2 (1X) from the first extraordinary session (Simitian)(Stat.2011,CH.11)
[2] ELCC/LOLE modeling project page linked here: http://www.cpuc.ca.gov/General.aspx?id=6265
[3] For more information on SERVM please consult *Inputs and Assumptions for ELCC Modeling* published to the CPUC website here: http://www.cpuc.ca.gov/General.aspx?id=6265
[4] Effective Capacity equals the equivalent amount of Perfect Capacity needed to produce the same effect on LOLE, and is a means of comparing one generator against another.
[5] LOLE values indicate the expectation of loss of firm load as an indicator of service reliability across a large electric system. High LOLE values indicate higher expectation of a loss of firm load. Traditionally, 0.1 (i.e. one loss of load event in ten years) has been the established metric.

Figure 1 Wind/Solar Capacity Compared to "Perfect Capacity" Draft versus Final (MW)



Revisions and Updates to Inputs and Modeling Methods since July 15 Draft Staff Paper

ED staff updated the data inputs and modeling methods used for the current analysis since the issuance of the July 15, 2015 Draft Staff Paper on ELCC for wind and solar facilities. ED staff updated unit performance characteristics based on an updated set of CAISO MasterFile data inputs, and completed the transition to the Transmission Expansion Planning Policy Committee (TEPPC) 2024 Common Case V1.5. In addition, ED staff reconsidered the transfer limitations between geographic areas, particularly those coming into CAISO areas, and elected to replace the set of transfer limitations that the CAISO used for the 2024 LTPP study with the Maximum Available Import Constraints into CAISO areas, since those constraints more closely mimic observed transfer patterns.[6] ED staff has been adding new (mostly renewable) generation as it achieves commercial operation and removing generation (mostly cogeneration and conventional) that has retired or planned to retire since July of 2015. ED staff has also retired significant generation since the July 15 paper in an attempt to lower the reliability of the current system to the target reliability margin. This enables ED staff to calculate an accurate capacity requirement (with the resulting reserve margin) to compare with the current RA obligations.

ED staff has specifically labeled direct imports into the CAISO (e.g. SCE's share of Palo Verde and Hoover, as well as any imported renewable generation contracted to provide energy and capacity to the CAISO area) and included that in the total capacity obligation for the CAISO. This allows for a complete accounting of the capacity consistently being used by the CAISO area to ensure reliability. ED staff also changed the scaling of historical load shapes to future load forecasts. Rather than scaling the entire load shape to the peak load forecast, ED staff scaled historical load shapes to future total energy (in MWh) and peak load, thus preserving any expected future correlation between overall load factor and peak

[6] 2016 Maximum Available Import Constraints linked to CAISO website here: http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=0EF1490E-D98D-4051-8FED-F037CB9DD34A

load. ED staff also elected to include an assumption from the CAISO 2024 LTPP study, that of requiring a minimum 25% of local thermal resources as a percent of load in the CAISO internal areas. Table 1 lists the peak load and total energy forecasts for each area, along with the minimum percent of thermal generation in the CAISO areas. The peak MW forecasts are equal to what was used for the draft analysis, but the energy (GWh) forecasts have been added. The Min Thermal Generation input is new as well. Table 2 lists the revised import and export constraints between each area.

Table 1 Peak Load and Total Energy for Each Region

Load Forecast Group	Region Description	Year	Peak Load (MW)	Energy (GWh)	Min Thermal Generation (% of Load)
Base	SDGE	2017	4,810	21,519	25
Base	PGE_Bay	2017	8,688	46,572	25
Base	PGE_Valley	2017	13,784	60,592	25
Base	SCE	2017	23,873	105,970	25
Base	LADWP	2017	6,709	30,053	
Base	SMUD	2017	4,819	18,318	
Base	TID	2017	664	2,747	
Base	IID	2017	1,095	4,193	
Base	Canada	2017	24,771	158,335	
Base	Arizona	2017	29,423	134,444	
Base	Mexico	2017	2,599	13,113	
Base	Colorado	2017	12,928	67,439	
Base	Montana	2017	1,812	11,918	
Base	New Mexico	2017	5,659	29,320	
Base	Nevada	2017	12,799	60,923	
Base	Pacific Northwest	2017	35,115	172,280	
Base	Utah	2017	15,525	78,795	

Table 2 Transfer Limits between Areas

	Region A	Region B	Capacity Limit In	Capacity Limit Out	Year
Max Avail Import Capacity	Arizona	New Mexico	7,222	7,222	2017
	Arizona	Utah	825	900	2017
	Canada	Montana	750	750	2017
	Canada	Pacific Northwest	3,500	4,350	2017
	Colorado	Arizona	485	485	2017
	Colorado	Montana	390	390	2017
	IID	SDGE	0	0	2017
	IID	SCE	462	462	2017
	IID	Arizona	478	478	2017
	LADWP	SCE	1,180	1,180	2017
	LADWP	Arizona	4,206	4,206	2017
	LADWP	Nevada	768	768	2017
	LADWP	Pacific Northwest	3,220	3,100	2017
	Mexico	SDGE	408	800	2017
	Nevada	Arizona	7,899	7,899	2017
	Nevada	Utah	1,359	821	2017
	New Mexico	Canada	400	400	2017
	New Mexico	Colorado	1,212	1,212	2017
	New Mexico	Montana	291	291	2017
	New Mexico	Pacific Northwest	5,685	5,685	2017
	New Mexico	Utah	904	904	2017
	Pacific Northwest	PGE_Valley	2,993	2,993	2017
	Pacific Northwest	Montana	2,200	1,350	2017
	Pacific Northwest	Nevada	623	623	2017
	Pacific Northwest	Utah	4,365	3,465	2017
	PGE_Bay	SMUD	0	230	2017
	PGE_Bay	TID	174	174	2017
	PGE_Valley	PGE_Bay	15,000	15,000	2017
	PGE_Valley	SCE	3,000	4,000	2017
	PGE_Valley	SMUD	15,232	15,232	2017
	PGE_Valley	TID	227	227	2017
	PGE_Valley	Nevada	40	40	2017
	SCE	SDGE	4,923	2,500	2017
	SCE	Arizona	3,737	3,669	2017
	SCE	Nevada	1,939	1,939	2017
	SDGE	Arizona	500	500	2017
	SMUD	TID	4,664	4,664	2017
	Utah	LADWP	2,600	2,600	2017
	Utah	Colorado	1,454	1,454	2017
	Utah	Montana	337	337	2017

These updates significantly alter the makeup of the generation fleet, so ED staff has posted the revised list of generators that are included in the 2017 Base Case. Revised data inputs are available on the CPUC website.[7]

Finally, ED staff has reassessed the convergence analysis performed in July and has increased the number of iterations to 200 from 120 for the modeling in this proposal.

Analytical Methods of Study

ELCC and LOLE studies are performed in a sequence of steps. There are several main parts. The first part consists of a convergence study, to establish the optimal number of iterations to study for each case. Once the adequate number of iterations to produce stable results is determined, the results of the study are expected to be stable and consistent. Second, initial studies are performed to calibrate the CAISO system to a LOLE result of 0.1 or one event in ten years. If there is less than 0.1 LOLE observed, the system is more reliable than intended; higher LOLE means a less reliable than intended system. LOLE studies are iterative; generators are added or subtracted to raise or lower the resulting LOLE level to 0.1.

Third, once the CAISO system is calibrated to the right LOLE levels, staff modeled the ELCC of wind and solar facilities for the 2017 study year.[8] Solar capacity (or wind capacity) is removed and replaced with a quantity of "Perfect Capacity" and the simulation is repeated. More "Perfect Capacity"[9] is added or subtracted until again the resulting LOLE equals 0.1.

The CAISO system is simulated via 165 separate cases. Each case is a unique combination of load shape year (load shapes from 1980 to 2012) and wind/solar/hydro weather influenced generation profiles corresponding to load years. Each year is modeled hourly. Each of the 33 years is modeled at five different load forecast uncertainty levels; 33 load years times 5 forecast levels equals 165 individual cases. Each case is run iteratively, to measure a pattern of reliability given the random variables that influence overall reliability such as generator outages. Each case results in an average reliability value over all the iterations of that particular case. Thus, a single study is made up of a number of cases (i.e. 165 cases), with multiple iterations (random draws of variables such as generator outages) for each case. The overall CAISO system is modeled over all 165 cases (with all 33 weather years, at five load forecast uncertainty points) and calibrated to an expected LOLE of 0.1.

Staff performed LOLE and ELCC studies by testing at varying levels of effective capacity until staff had determined bookends where LOLE resulted both above and below 0.1. Staff set up studies running at 120 iterations with a range of Perfect Capacity added isolate bookends where addition of Perfect Capacity raised the LOLE to greater than 0.1 and where LOLE was lowered below 0.1. When staff had developed the bookends, staff performed final confirmation studies at 200 iterations to pinpoint the correct level of capacity to meet 0.1 LOLE within an acceptable range between 0.09 LOLE and 0.11 LOLE.

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[7] ELCC/LOLE modeling project page linked here: http://www.cpuc.ca.gov/General.aspx?id=6265

[8] ELCC values represent the ratio of existing electric capacity in reality compared to idealized "Perfect Capacity" to measure the quantity of reliability benefit provided by the existing electric capacity in reality. Reliability benefit is measured as ability to offset LOLE events.

[9] "Perfect Capacity" is defined for this paper as a dispatchable resource with zero maintenance events, forced outages, or derates.

Facilities in CAISO are removed and the system is recalibrated by the addition or subtraction of "Perfect Capacity" in CAISO proportionate to where the facilities were removed. If 70% of the solar capacity is removed in SCE's territory, then 70% of the "Perfect Capacity" is replaced in SCE's territory and so on. The CAISO system is modeled iteratively until the desired 0.1 LOLE result across CAISO is again achieved. The process is repeated for wind resources.

Convergence Analysis

For the draft results published in July, ED staff performed convergence analysis on five cases all representing the same load year, the 2009 load shape that produced the most extreme LOLE results. ED staff modeled each of the five cases with 500 iterations and kept each iteration's reliability results. ED staff observed convergence as each incremental iteration's results are added to the sample of results. ED staff performed a similar analysis looking at percent change in standard deviation of LOLE and with the coefficient of variation (COV) of the LOLE which equals the standard deviation divided by the mean of the sample.

Analysis of the percent changes of average LOLE, standard deviation of average LOLE, and COV of LOLE illustrated the pattern of convergence of all three metrics. Although the patterns of convergence are slightly different for each case modeled, ED staff observed a similar pattern in each and chose a threshold where it can be expected that all cases would have converged around a satisfactorily stable result.

In July 2015, ED staff selected a threshold number of iterations that converged each of the eight cases to within a range between -2% and 2% change in standard deviation; the same 120 iterations appears to converge the average change in LOLE to within a range of plus or minus 2%. While that level of confidence was initially assumed to be sufficient as a balance between confidences in the study results and processing time, ED staff realized that the results were not as stable as desired; more convergence was necessary.

For this proposal, ED staff reassessed convergence, and after considering comments from parties and others, chose to increase the confidence levels of the study. As a result, all studies were modeled at 200 iterations. The convergence results illustrated below demonstrate more stable convergence at 200 iterations than 120 iterations. This level of iterations, however, may be insufficient to obtain convergence when additional variables, such as load, wind and solar uncertainty parameters, are studied. ED staff will again reassess the pattern of convergence and may again increase the number of iterations to gain the required confidence level in the model. However, for this ELCC and RA obligations proposal, ED staff conducted all LOLE modeling to the level of 200 iterations.

Convergence Results

ED staff simulated the five cases using the 2009 load shape (which was the load shape that created the highest level of LOLE) at the level of 500 iterations. Each case produced similar patterns of convergence between 150 and 200 iterations. Cases converged between plus or minus 1% as the number of iterations approach 200.

Three sample cases are shown below, each a combination of load and weather dependent generation (wind, solar, and hydro). The charts below illustrate the pattern of convergence as measured by percent change in LOLE, percent change in standard deviation of average LOLE, and percent change in COV of average LOLE. Results initially fluctuated significantly, but variation measured as the percent change decreased as more iterations were added to the sample. ED staff is confident that a stable result is produced with 200 iterations.

Figure 2 Convergence with Greater Iterations – case 146 (2009 load year)

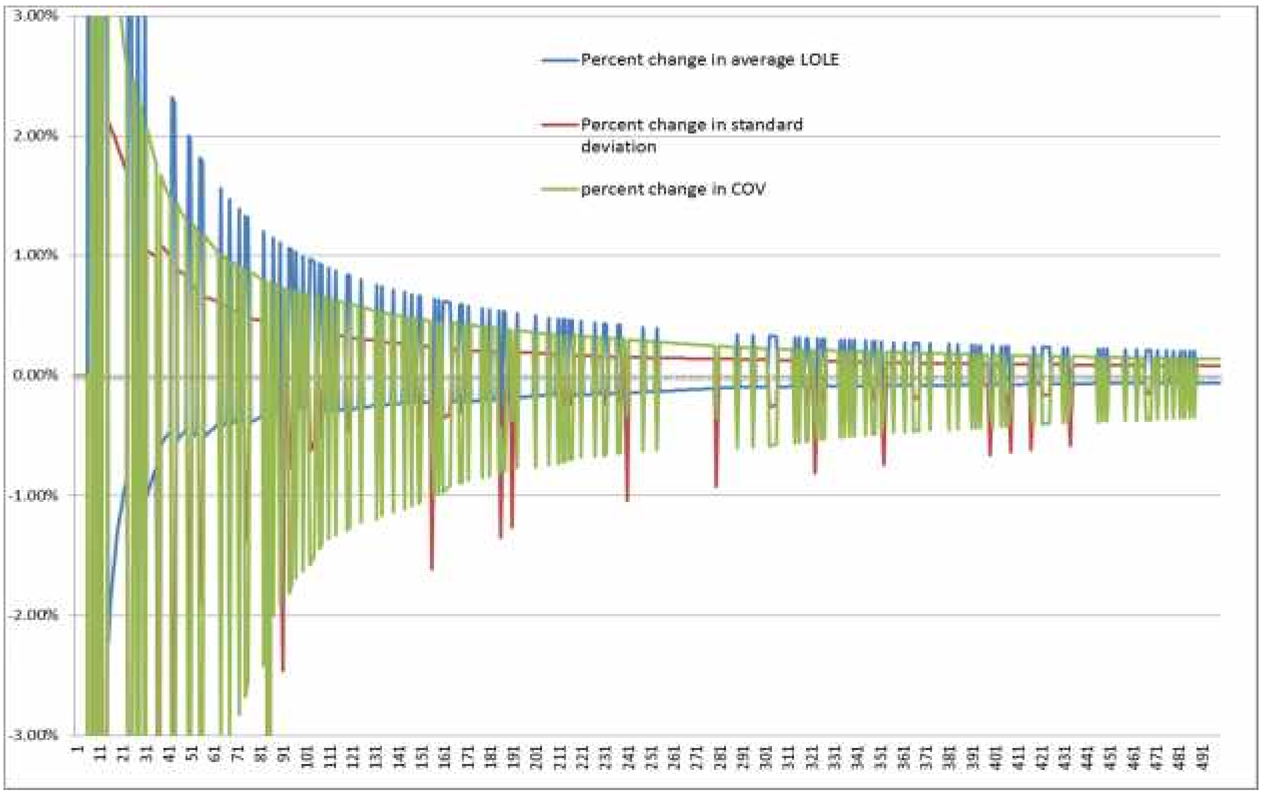
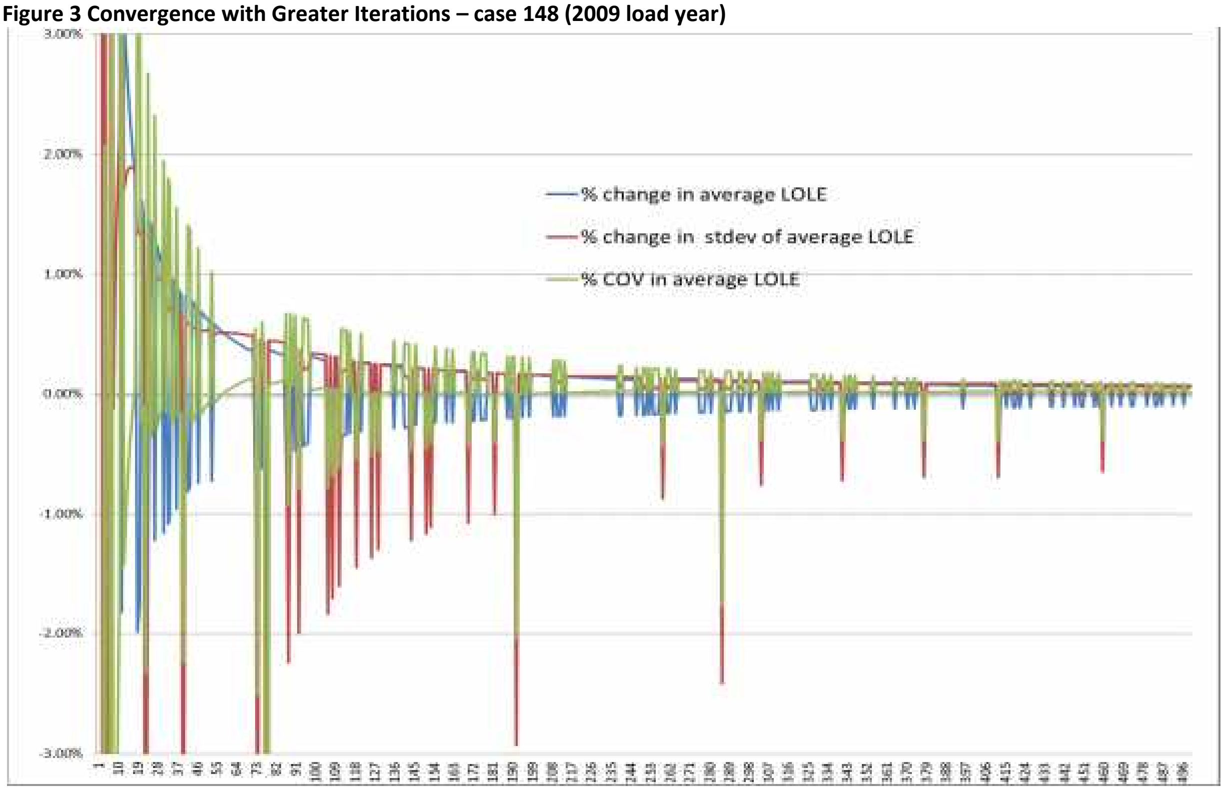


Figure 3 Convergence with Greater Iterations – case 148 (2009 load year)



ELCC Study Process

Once convergence and the number of iterations have been determined, the overall CAISO system is calibrated to result in a probability weighted LOLE result of 0.1[10] across all 165 cases modeled, taking away capacity or adding capacity in specific increments, then remodeling the CAISO system. This process is repeated, removing increments of perfect capacity or adding increments of perfect capacity, until the probability weighted LOLE observed over the 165 cases again equals 0.1. With the current system, 4,716 MW of actual existing power plants were removed to lower the probability weighted average expected LOLE of the CAISO system to an “annual LOLE” of 0.1. A list of the removed capacity is included below.

[10] Actual LOLE results are often dependent on the error in the data inputs and convergence. Staff attempted to calibrate to a LOLE of 0.1 exactly, but accepted LOLE between 0.09 and 0.11.

Table 3 List of Removed Capacity in Base Case

Power Plants removed	Capmax (MW)	Area
Encina Unit 3	110	SDGE
Encina Unit 4	300	SDGE
Encina Unit 5	330	SDGE
Encina GT	14.5	SDGE
Glen Arm peakers unit 1	22.07	SCE
Glen Arm peakers unit 2	22.3	SCE
Alamitos Unit 4	335.67	SCE
Alamitos Unit 5	497.97	SCE
Alamitos Unit 6	495	SCE
Broadway Unit 3	65	SCE
Etiwanda Unit 3	320	SCE
Etiwanda Unit 4	320	SCE
Goleta Ellwood	54	SCE
Redondo Beach Unit 5	178.87	SCE
Redondo Beach Unit 6	175	SCE
Oakland Power Plant Unit 1	55	PGE_Bay
Oakland Power Plant Unit 2	55	PGE_Bay
Oakland Power Plant Unit 3	55	PGE_Bay
Pittsburg Power Plant Unit 5	312	PGE_Bay
Pittsburg Power Plant Unit 6	317	PGE_Bay
Pittsburg Power Plant Unit 7	682	PGE_Bay

Once the CAISO system resulted in a probability weighted average expected LOLE of 0.1, a similar process was repeated to gauge the ELCC of wind and solar facilities. For purposes of this ED proposal, all wind facilities were tested together, and all solar facilities were tested together, although there are multiple technology groups with different performance profiles, in each area of the model. With ELCC studies, the entire wind (or solar) group in CAISO was removed, and the system was re-simulated to produce a 0.1 LOLE over the 165 cases by addition or subtraction of chunks of "Perfect Capacity." The attributes of "Perfect Capacity" are provided in Table 4 below.

Table 4 Resource Characteristics of Perfect Capacity

Variable description	Description	Value of Variable
Capmax	Maximum generation level	204.2 MW
Capmin	Minimum capacity level (PMin)	1 MW
Availability	Percentage factor (1- percent of time unit is unavailable)	0.999 (indicating perfect availability)
Time to fail	User can specify a distribution of values for how long a resource will run before it fails. Outage events are randomly drawn from this distribution. High values mean greater reliability and low values the opposite.	90000 (never fail)
Time to repair	Given in hours, this variable is how long a resource is out when it is on outage. Users can specify a number of hours for planned and forced outages separately.	0 (repairs instantly)
Startminutes	Time in minutes for the plant to start up	2 minutes
Ramp Rate	Ramping rate in MW per minute	24 MW/min
Maintenance periods	Unit specific variable users can use to specify more than one maintenance period for each year	None
Startup probability	Users can specify what the probability is for resources to successfully start up	1 (never fails on startup)

Less attention was paid to areas outside of CAISO, but transfers between external regions and CAISO regions were evaluated, and effective reserve margins of those external regions were increased or decreased (by addition of load to those regions) until transfers between regions were consistent with historical patterns.

In summary, average annual portfolio ELCC values for all solar and wind facilities in CAISO were calculated using the following steps:

1. Create the capacity portfolio that brings the CAISO area as a whole to a LOLE of 0.1 given the loads and resources that are expected to exist in the 2017 study year. Ensure that LOLE is not concentrated inaccurately in only one area, and that it is spread to at least one other area.
2. Perform a study and save all required output reports.
3. Remove all facilities of interest (either wind or solar depending on the ELCC study) in CAISO, but not those outside of CAISO.
4. Perform a study and save all required output reports.
5. Estimate the amount of "Perfect Capacity" needed to replace the removed facilities distributed proportionately among regions where the facilities were removed.
6. Perform a study and save all required output reports. If the LOLE of the new system is not yet equal to 0.1, repeat steps 3 and 4 until LOLE equals 0.1 either by adding incremental (if LOLE is greater than 0.1) or removing incremental (if LOLE is less than 0.1) MW of "Perfect Capacity".
7. Once LOLE equals 0.1, find the ELCC by calculating a ratio of nameplate MW removed to "Perfect Capacity" nameplate MW added. The result is the average ELCC of the CAISO portfolio of all the studied facilities. The resulting annual ELCC value will be a percentage less than 1.

8. Test locational or technological groupings of resources. Similar quantities of resources are removed from each area or each technology grouping and the ELCC of each individual group is calculated. Similar quantities are tested to measure just the locational effect, not the effect of declining ELCC due to changes in penetration.
9. Shape annual ELCC values to month specific values using a method that calibrates their value relative to the reliability conditions that exist outside of the annual peak.

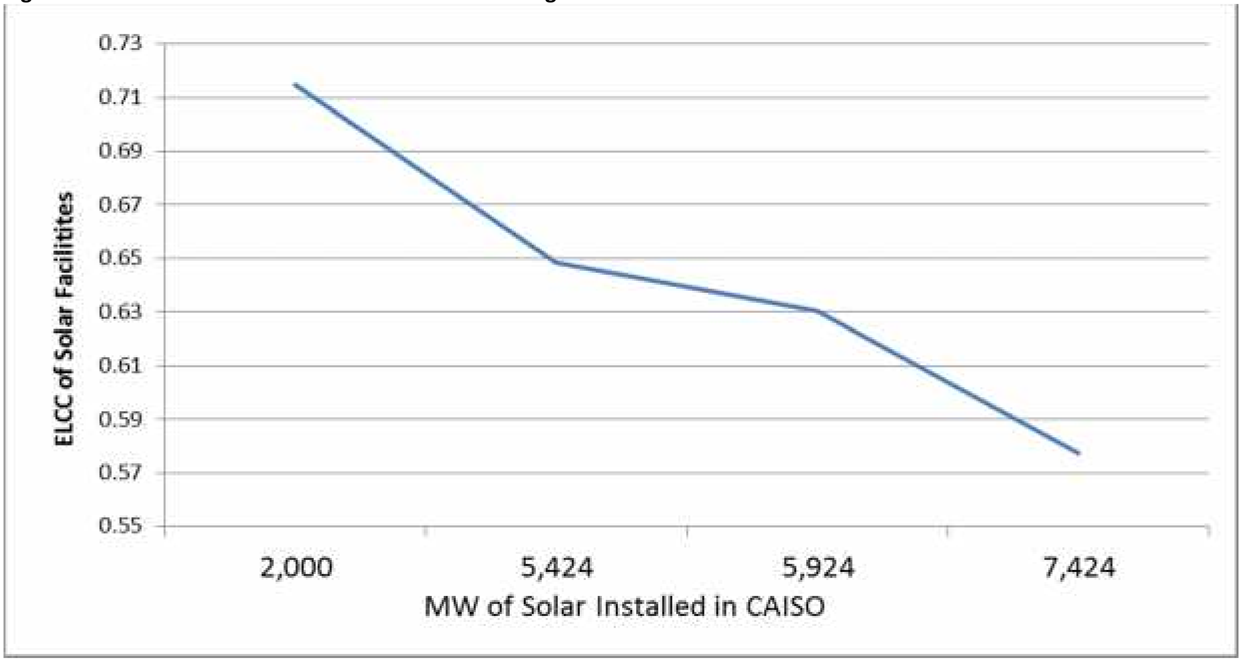
Methods to Calculate Locational and Technological Granularity

Staff has calculated and proposes for adoption a set of locational adjustment factors to shape the average ELCC to the value provided by generation in different parts of California. Two factors affect a generator's locational value. First, solar and wind facilities produce energy based on the local weather. Wind and solar patterns differ between different sites in California. Second, generation located in a region with an excess of generation capacity will not offset outages, as the other generation in the region will be able to pick up the slack and that generator may be less valuable. Regions with relative capacity scarcity may need the energy produced to offset emerging outage events more than regions with capacity surplus.

Staff realized however that due to asymmetric installation of wind and solar facilities across California, the pure locational value of capacity is complicated by the effects of resource penetration. Figure 4 reflects the effects of increasing proportion of solar facilities and the effect on ELCC. In broad terms, as more solar capacity is added to the fleet, the net load peak shifts to later in the day when less solar generation is available resulting in a declining ELCC for solar PV. However, for wind, the shift in net load peak results in increasing ELCC since wind output is on average higher later in the day.

To further illustrate, if all solar facilities in Southern California (5423.77 MW total in SCE and SDGE areas) were removed, the resulting amount of Perfect Capacity required to recalibrate at 0.1 LOLE would reflect the now very low penetration of solar in the system. Comparing that amount of Perfect Capacity to the solar removed would result in a larger ELCC than the same exercise with a smaller batch of solar capacity in Northern California (2,000 MW in total), purely for reasons of relative penetration levels. The effect of penetration levels would obscure the comparison of locational value between Southern and Northern California. For this reason staff tested similar amounts of capacity in each area.

Figure 4 Effect of Solar Penetration on Levels on Average Solar ELCC[11]



Calibration to the EIA Form 923 Database and CAISO PLEXOS 2024 Results

ED staff ran hourly simulations to assess the dynamics of the model and the patterns of dispatch, load, generation, and other important variables. ED staff worked to calibrate the hourly simulation to actual historical patterns, and located several key patterns that would indicate more or less realistic simulation results. ED staff calibrated the ED database and simulated the 2012 calendar year in order to generate results that could be compared with existing historical data. In this instance, ED staff simulated 2012 historical load and wind, solar, and hydro data, then compared total energy (MWh), total fuel use (MMBtu by fuel), and total load (in MWh) in each SERVM region between ED's simulation of 2012 and the 2012 EIA form 923 fuel use and generation data.[12] ED staff also compared imports and exports into and out of CAISO with the ISO's historical OASIS data. Detailed calibration results will be provided at a later time.

Once ED staff determined they had adequately simulated the 2012 historical year with confidence, ED staff began running studies to determine the appropriate capacity levels needed to maintain the aggregate CAISO area at a probability weighted average LOLE of 0.1 across all 165 cases modeled at 200 iterations. ED Staff determined the adequate mix of capacity to ensure 0.1 LOLE first, then performed the solar and wind ELCC studies to quantify resources for their capacity contributions.

Results

The CAISO system was calibrated by adding or subtracting existing resources until the simulation resulted in a probability weighted average LOLE of 0.1 in the CAISO for 165 cases at 200 iterations. This study was called the Base Case and represented the adequate RA obligations for the 2017 RA compliance year. ED staff began with a Base Case that resulted in a probability weighted average LOLE

[11] Source - ED staff analysis
[12] Link to the EIA form 923 data page here: http://www.eia.gov/electricity/data/eia923/

less than 0.1. To raise the LOLE to the standard accepted LOLE reliability level of 0.1, ED staff removed existing generators as discussed earlier. ED staff retired generators and iteratively modeled the system until reaching a probability weighted average expected 0.1 LOLE over 200 iterations, and ensuring that LOLE was spread across more than one area in the model. ED staff made the judgment call that it was possible to retire generation in one area and model, but that it would not necessarily result in accurate or robust results.

Table 5 lists the capacity that was included in the study in each of the study areas in the "Base Case." Overall, the CAISO system, considering dedicated imports (including 629 MW from SCE's share of Palo Verde and 390 MW from SCE's share of Hoover) and the ELCC of wind and solar resources, resulted in a probability weighted LOLE of 0.1 with a summer peak load of 48,060 MW and 56,029 MW of effective resources. In total, wind and solar facilities delivering to CAISO provided 5,105 MW of "effective" capacity.

Table 5 Resource Breakdown – Base Case

Region	SDGE	PGE_Bay	PGE_Valley	SCE	CAISO
Year	2017	2017	2017	2017	2017
Annual Peak Load	4,812	8,695	13,787	23,878	48,060
Total Nameplate Resources	5,538	7,604	24,828	24,915	62,885
Total Effective Resources	4,907	6,226	23,709	20,888	56,029
Nuclear Resources	0	0	2,300	623	2,923
Fossil Resources	3,227	4,388	9,052	11,337	28,004
Peaking Resources	1,074	1,467	2,798	2,866	8,205
Run of River Hydro Resources	0	0	374	132	505
Scheduled Hydro Resources	0	0	5,586	972	6,558
Emergency Hydro Resources	0	0	461	200	661
Pumped Storage Resources	40	0	1,218	590	1,848
Demand Response Resources	43	177	731	1,270	2,220
Renewable Resources	798	201	1,208	2,898	5,105
Effective Capacity /Peak Load	102.17%	71.24%	171.95%	89.90%	116.58%

When the Base Case was modeled, 13 of the 33 weather shapes produced deminimus LOLE (0.000 when rounded to the third decimal place); eight of the 33 load shapes produced LOLE greater than 0.005, and the remaining load shapes resulted in LOLE in between these values. Peak loads in each load shape varied based on the relevant historical weather patterns. The peak loads ranged from 7% higher than normal peak in extreme years to 10% below normal peaks in mild years.

A single scaling factor was calculated by dividing the target peak for 2017 by the average of the peak loads from the raw load shapes. ED staff also scaled load shape such that total energy matched 2017 forecast total energy by region using an algorithm that maintains the peak values. The algorithm will take a given a load forecast shape, X_t, and create a linear transformation, $aX_t + b = Y_t$ such that $\max_t Y_t = q$ and $\mathrm{mean}_t\, Y_t = p$. That is, we can pick the average and peak and get a load shape based on the original X_t with a given energy (mean) and peak (max) value.

If you take the peak for the original load forecast to be $\max_t X_t = s$ and the energy to be $\text{mean}_t X_t = r$, then

$$a = \frac{q-p}{s-r} \text{ and } b = \frac{p-q}{s-r}$$

This comes from some basic substitution:

$$\max_t Y_t = q \Longrightarrow \max_t(aX_t + b) = q \Rightarrow a = \frac{q-b}{\max_t X_t} = \frac{q-b}{s}$$

And

$$\text{mean}_t Y_t = p \Rightarrow \text{mean}_t(aX_t + b) = p \Longrightarrow b = p - a(\text{mean}_t X_t) \Longrightarrow b = p - a$$

Substitute for a in the second equation gives the answer for b:

$$b = p - \left(\frac{q-b}{s}\right)r \Rightarrow b - \frac{b}{s} = b\left(1 - \frac{r}{s}\right) = b\left(\frac{s-r}{s}\right) = \frac{p\ -q}{s} \Rightarrow b = \frac{p\ -q}{s}\left(\frac{s}{s-r}\right) = \frac{\boldsymbol{p}\ -\boldsymbol{q}}{\boldsymbol{s}-\boldsymbol{r}}$$

Substituting for b in the first equation gives the answer for a:

$$a = \frac{q - \dfrac{p\ -q}{s-r}}{s} = \frac{\dfrac{q\ -q\ -p\ +q}{s-r}}{s} = \frac{q\ -p}{s(s-r)} = \frac{q-p}{s-r}$$

This produces a function that produces a linear transformation of a load shape using the energy and peak from the existing shape to the targeted energy and peak forecasts. [13] Adjusted scaled load shapes will be posted to the CPUC website.

Table 6 illustrates the distribution of LOLE events across the 12 months of the year by study area. The CAISO row serves as the aggregate of the other areas, and each row sums to the total LOLE observed in that area. The total of the CAISO row sums to approximately 0.1 LOLE. LOLE is concentrated in SCE area, and in the third quarter of the year. All of the LOLE events are attributable to Southern California, and none to Northern California.

Table 6 Base Case LOLE Values by Month and Region

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAISO	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.061	0.009	0.002	0.000	0.000
SCE	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.038	0.001	0.000	0.000	0.000
SDGE	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.034	0.008	0.002	0.000	0.000
PGE_Bay	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.000	0.000	0.000	0.000
PGE_Valle	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7 illustrates both the distribution of LOLE in the CPUC Calibrated LOLE Case (today's default system calibrated to LOLE of 0.1) and the disproportionate impact of a small number of load shapes on the outcome. In this table, each column lists the LOLE observed for that weather year, and the columns total the LOLE events observed in each area of the model. The CAISO column totals to 0.1045 LOLE. The

[13] This description of the load stretching algorithm was provided by the Northwest Power and Conservation Council (http://www.nwcouncil.org/) and for questions please contact Ben Kujala at bkujala@nwcouncil.org

eleven load shapes with the highest amount of LOLE account for around 90% of total LOLE observed in the entire study.

Table 7 Calibrated CAISO LOLE Case LOLE Ranked by Load Year and Region

Load Year	CAISO	SCE	SDGE	PGE_Bay	PGE_Valley
2009	0.021	0.017	0.010	0.000	0.000
1998	0.017	0.013	0.007	0.000	0.000
2006	0.016	0.012	0.005	0.003	0.000
1985	0.007	0.006	0.001	0.000	0.000
1992	0.006	0.003	0.004	0.000	0.000
1981	0.005	0.002	0.004	0.000	0.000
1980	0.005	0.000	0.005	0.000	0.000
2007	0.005	0.000	0.004	0.000	0.000
1983	0.004	0.001	0.003	0.000	0.000
2010	0.004	0.000	0.003	0.000	0.000
1994	0.003	0.002	0.002	0.000	0.000
1990	0.002	0.000	0.002	0.000	0.000
2000	0.002	0.000	0.002	0.000	0.000
1991	0.002	0.000	0.002	0.000	0.000
2012	0.002	0.001	0.001	0.000	0.000
2011	0.001	0.001	0.001	0.000	0.000
1996	0.001	0.000	0.001	0.000	0.000
2003	0.001	0.000	0.000	0.000	0.000
1982	0.001	0.000	0.000	0.000	0.000
1984	0.001	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000	0.000

Average CAISO-wide Solar ELCC

Staff conducted multiple rounds of studies to determine the ELCC of solar facilities within the CAISO. When solar facilities were removed and "Perfect Capacity" was substituted, LOLE results were calibrated to within the acceptable range of 0.1 (LOLE of 0.098) at an ELCC of 57.75% with 200 iterations. Figure 6 illustrates the quantity and location of the 7,424 MW of solar facilities removed as well as the 4,288 MW of "Perfect Capacity" added to CAISO to calculate the ELCC. Figure 5 illustrates the changes since the July 2015 ELCC Draft Results. The 1,510 MW of new solar capacity added since July resulted in an increased need for 562 MW of Perfect Capacity; the incremental new solar added since July resulted in a reduced incremental ELCC of about 37%.

Figure 5 Solar Capacity versus Perfect Capacity (MW)

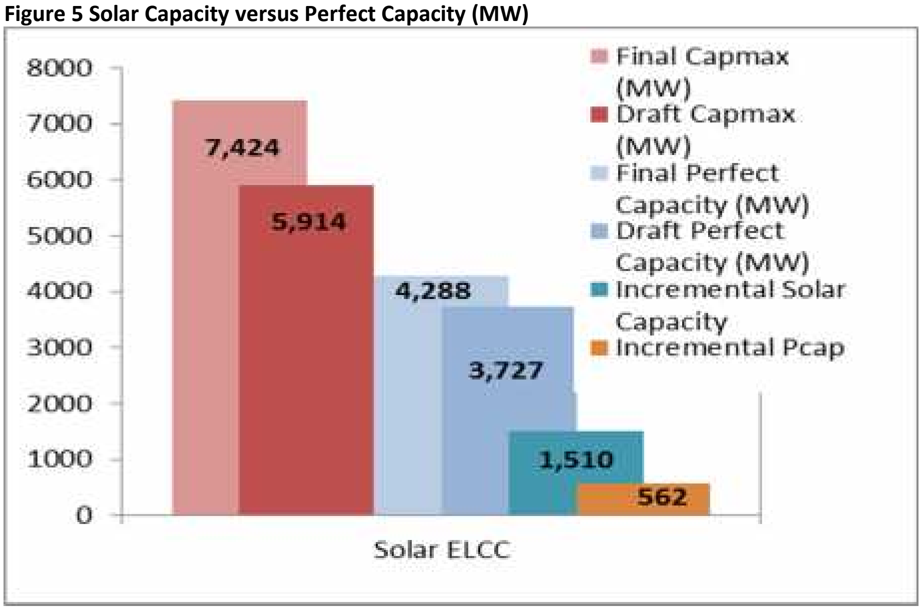


Figure 6 Geographical Distribution of Solar and Perfect Capacity in CAISO

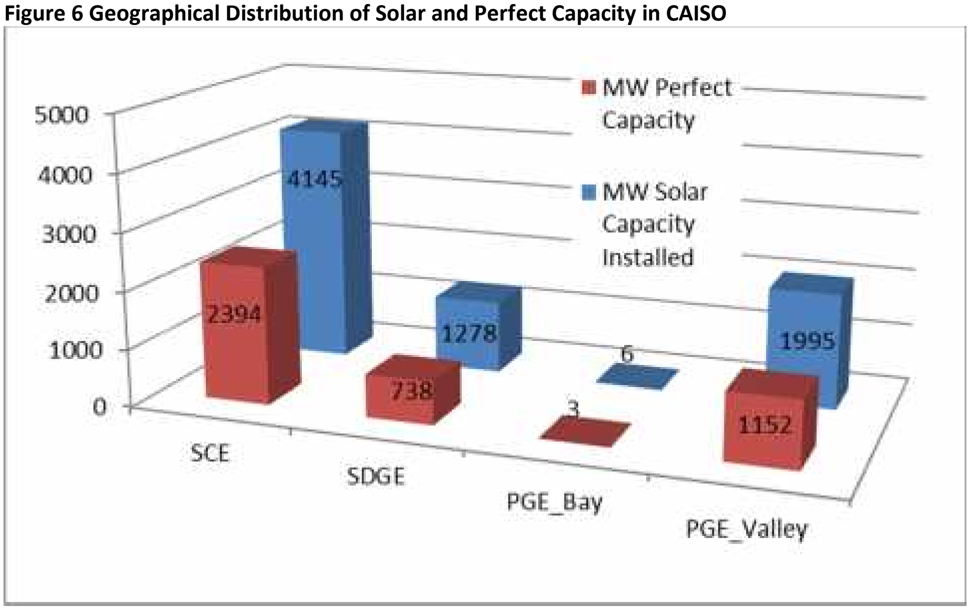


Table 8, below illustrates the distribution of LOLE events across the 12 months of each year and across the areas in the study. The CAISO row serves as the aggregate of the other areas, and each row sums to the total LOLE observed in that area. The total of the CAISO row sums to 0.102 LOLE. Solar facilities are all removed, and Perfect Capacity is added back until the CAISO area is recalibrated to a LOLE of 0.1. ED staff found that the preponderance of LOLE events is attributable to the SCE area, and that PG&E areas are responsible for near zero of the LOLE events. Each row totals to the total LOLE observed in that area over the whole study.

Table 8 Solar ELCC LOLE values by month and region

Month	1	2	3	4	5	6	7	8	9	10	11	12
CAISO	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.053	0.004	0.000	0.000	0.000
SCE	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.045	0.002	0.000	0.000	0.000
SDGE	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.016	0.003	0.000	0.000	0.000
PGE_Bay	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
PGE_Valle	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 9 breaks down LOLE by load year and ranks each load year for the Solar ELCC study. In this table, each column lists the LOLE observed for that weather year, and the columns total the LOLE events observed in each area of the model. The CAISO column totals to 0.102 LOLE.

Table 9 LOLE ranked by Load Year and Region - Solar ELCC

Load Year	CAISO	SCE	SDGE	PGE_Bay	PGE_Valley
2009	0.022	0.021	0.006	0.000	0.000
2006	0.017	0.016	0.003	0.001	0.000
1985	0.016	0.016	0.001	0.000	0.000
1998	0.012	0.011	0.002	0.000	0.000
1992	0.006	0.005	0.003	0.000	0.000
2007	0.004	0.002	0.003	0.000	0.000
1994	0.004	0.003	0.001	0.000	0.000
1981	0.004	0.003	0.002	0.000	0.000
1980	0.003	0.000	0.002	0.000	0.000
2011	0.002	0.002	0.000	0.000	0.000
2012	0.002	0.002	0.000	0.000	0.000
1990	0.002	0.001	0.001	0.000	0.000
2010	0.001	0.000	0.001	0.000	0.000
1996	0.001	0.001	0.000	0.000	0.000
1983	0.001	0.000	0.000	0.000	0.000
1995	0.001	0.001	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000
1982	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000
2003	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000	0.000

Locational Factors - Breakdown of Solar ELCC to Areas

After completing the calculations to determine the average CAISO-wide ELCC of the entire solar fleet, staff calculated relative factors to attribute ELCC values to each location. Two factors impact the relative value of solar capacity in each area of the CAISO; first, solar production is dependent on local insolation patterns and second, value of a resource is dependent on the capacity balance in that area. Areas with a surplus of capacity overall might not be impacted by a reduction of that surplus to the same extent that an area with capacity deficit or a small surplus will be affected by the removal of that capacity. Thus it is important to study similar amounts of capacity in each area to ensure proper comparison. The preponderance of solar facilities are located in one area in the CAISO; 5,424 MW of solar facilities are located in Southern California (SCE and SDGE areas), while only 2,000 MW of solar facilities are located in Northern California.

As demonstrated in Figure 4, the marginal ELCC of solar declines as penetration increases, therefore calculating the average locational ELCC requires the consideration of ELCC at each increment of solar penetration. Staff's approach consisted of calculating the marginal ELCC of solar at each location assuming the 2,000 MW addition was the first block of solar capacity and then assuming the addition was the last block of solar capacity. Although the decline in marginal ELCCs may not be linear, staff calculated the average ELCC as the average of the marginal ELCC for the first addition and the marginal ELCC for the last addition. These values are then proportionately allocated so that the total capacity value matches the value calculated using the entire solar portfolio.

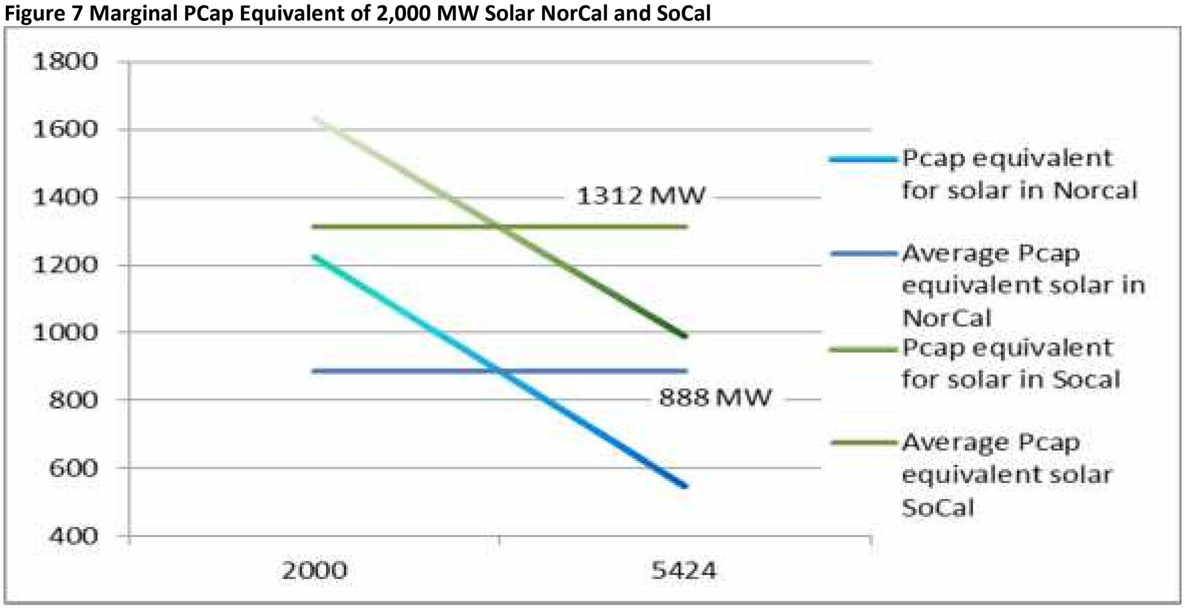
To calculate the marginal ELCC of the first addition, all solar resources were removed, 2,000 MW were added back into Northern California, then Perfect Capacity was added proportionately across the CAISO areas relative to the location of the solar capacity removed until LOLE again equaled 0.1. The process was repeated to test the ELCC of solar capacity in Southern CAISO by removing all solar in CAISO, putting 2,000 MW back in Southern CAISO areas (SDGE and SCE) relative to the proportion of installed solar capacity currently in those two areas, and Perfect Capacity was added back to return the CAISO to LOLE of 0.1.

When 2,000 MW of solar capacity was put back into Northern CAISO areas, an additional 2,983 MW of Perfect Capacity was needed to bring LOLE back to 0.1. This means that when there is zero penetration of solar capacity in CAISO (all solar removed) the 2,000 MW of solar capacity added to Northern CAISO offset 1,225 MW of Perfect Capacity (4,288 MW – 3,063 MWs) giving a marginal ELCC of 61%. The same operation performed by starting from zero penetration and adding 2,000 MW of solar capacity to Southern CAISO required the addition of 2,655 MW of Perfect Capacity, offsetting 1,634 MW and producing a marginal ELCC of 82%.

For the last addition marginal ELCC, 2,000 MW solar blocks were removed from the full portfolio case in NorCal and SoCal areas. When 2,000 MW of solar is removed from NorCal, 550 MWs of Perfect Capacity are needed to return reliability to LOLE of 0.1, while when 2,000 MWs are removed from SoCal, 990.5 MWs of Perfect Capacity are needed. That translates to ELCC values of 27.5% for NorCal areas and the SoCal areas had an ELCC of 49.05%.

Averaging the first addition capacity equivalence (61% and 82%) and last addition capacity equivalence (27.5% and 49.05) yields 44.4% and 65.6% for NorCal and SoCal areas respectively. Proportionately allocating these values results in locational ELCCs of 39.25% and 65.6% for Northern and Southern California respectively.[14]

Figure 7 Marginal PCap Equivalent of 2,000 MW Solar NorCal and SoCal



Marginal ELCC calculations were performed instead of average ELCC calculations for the entire region because performing average calculations would confuse the effects of location with the effect of penetration. Simulations using the entire portfolio by region would have unfairly biased the results for the region with lower installed capacity since the starting point would reflect the reliability benefit provided by the installed solar capacity in the other region. This method isolates the effect of greater penetration, and results in absolute ELCC values of the 2,000 MW chunk of solar that were lower than the average 57.75% ELCC of the entire 7,424 MW of solar in the resource fleet. The relative amount of Perfect Capacity selected in either Northern or Southern California reflects only the relative value of capacity in these two areas, on the assumption that comparing identical points on the marginal ELCC curve relative to each other will “cancel out” the non-locational factors affecting value of solar capacity.

To move from relative Locational Factors to locationally specific ELCC values, Locational Factors are multiplied by the average ELCC of the entire solar fleet.

[14] .444*2,000*allocation_factor + .656*5424*allocation_factor = .578*7,424; allocation_factor = .1.037; Northern California ELCC = 44.4% * allocation factor = 46%; Southern California ELCC = 65.6% * allocation_factor = 68%

Average CAISO-wide Wind ELCC

Staff conducted multiple rounds of studies to determine the ELCC of wind facilities within the CAISO. When all wind facilities in CAISO and those that imported directly in to CAISO were removed and "Perfect Capacity" was substituted, LOLE results were calibrated to within the acceptable range of 0.1 at an ELCC of 12.6% with 200 iterations.

Figure 8 illustrates the distribution of wind capacity in CAISO, as well as the distribution of "Perfect Capacity" added to CAISO to recalibrate the LOLE back to the acceptable range.

Figure 8 Wind Capmax versus Perfect Capacity in CAISO

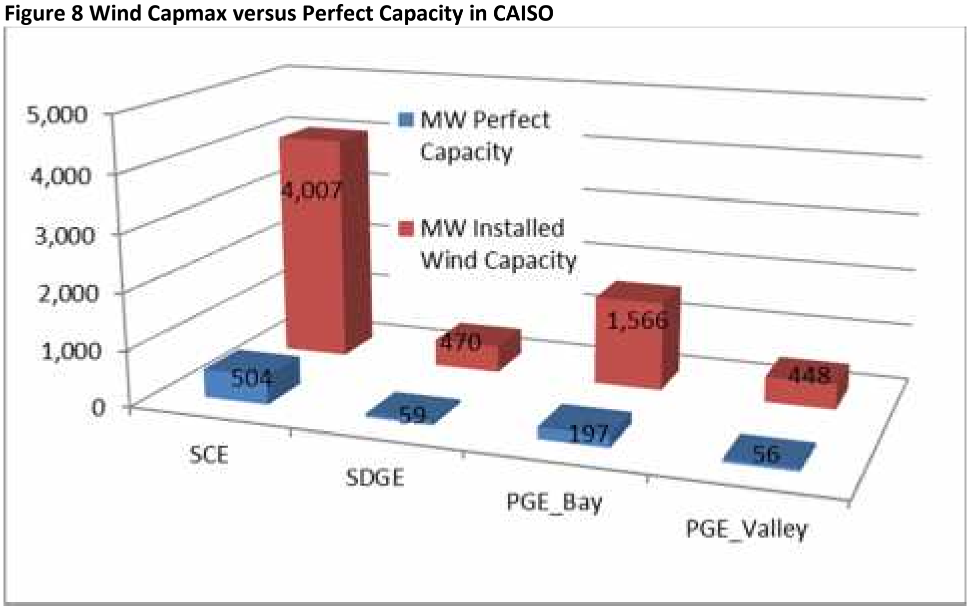


Table 10 below illustrates the distribution of LOLE events across the 12 months of each year and across the areas in the study resulting from ELCC of 12.6%. The CAISO row serves as the aggregate of the other areas, and each row sums to the total LOLE observed in that area. Results highlight the preponderance of LOLE events attributable to the SCE area, although some LOLE is now observed in PGE's areas.

Table 10 Wind ELCC LOLE Values by Month and Region

Month		1	2	3	4	5	6	7	8	9	10	11	12
CAISO		0.000	0.000	0.000	0.000	0.000	0.002	0.026	0.049	0.009	0.001	0.000	0.000
SCE		0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.025	0.001	0.000	0.000	0.000
SDGE		0.000	0.000	0.000	0.000	0.000	0.002	0.012	0.033	0.008	0.001	0.000	0.000
PGE_Bay		0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000
PGE_Valley		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11 breaks down LOLE by load year and ranks each load year resulting from "Perfect Capacity" levels equal to the midpoint of the ELCC range specified above. At an ELCC level of 12.6%, LOLE is equal to approximately 0.086. In this table, each column lists the LOLE observed for that weather year, and the columns total the LOLE events observed in each area of the model.

Table 11 LOLE Ranked by Load Year and Region - Wind ELCC

Load Year	CAISO	SCE	SDGE	PGE_Bay	PGE_Valley
2009	0.017	0.014	0.009	0.000	0.000
2006	0.010	0.007	0.005	0.001	0.000
1998	0.009	0.006	0.005	0.000	0.000
1985	0.009	0.008	0.001	0.000	0.000
2007	0.007	0.001	0.006	0.000	0.000
1980	0.006	0.000	0.006	0.000	0.000
1992	0.004	0.001	0.003	0.000	0.000
2010	0.004	0.000	0.004	0.000	0.000
1981	0.003	0.002	0.003	0.000	0.000
1990	0.003	0.001	0.003	0.000	0.000
1994	0.003	0.001	0.002	0.001	0.000
1983	0.003	0.001	0.002	0.000	0.000
2000	0.001	0.000	0.001	0.000	0.000
1991	0.001	0.000	0.001	0.000	0.000
2012	0.001	0.000	0.001	0.000	0.000
2011	0.001	0.001	0.001	0.000	0.000
1984	0.001	0.000	0.001	0.000	0.000
1996	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.000	0.000	0.000	0.000
1982	0.000	0.000	0.000	0.000	0.000
2003	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000

Locational Factors - Breakdown of Wind ELCC to Areas

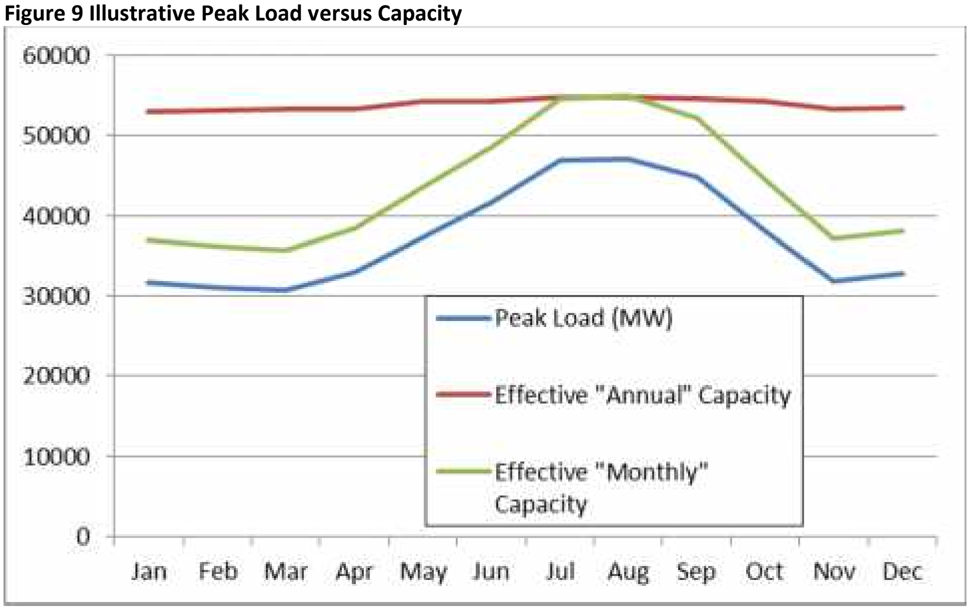
This work is still in progress and is not finished at this time. ED does not propose any locational factors for wind ELCC at this time.

Proposed Locational and Monthly ELCC values

In general, LOLE studies are performed to determine the total amount of effective capacity (in MW) necessary to be available for all months of the year in order to reliably meet load at 0.1 LOLE. This means that a MW quantity of effective capacity is assumed to be made available to the system for the entire year. In essence, the capacity has a year-long capacity contract and is expected to remain online throughout the year.

The current CPUC administered RA program, however, allows for a varying MW quantity of effective capacity to be made available each month, seeking to preserve a block of capacity in reserve above the peak load of each month. This means that there is a significantly decreased level of effective capacity available in off-peak months relative to the "annual" RA obligations studied generally. An illustration of these dueling concepts of RA obligation is presented in Figure 9.

Figure 9 Illustrative Peak Load versus Capacity



In order to study conditions similar to the month specific RA obligation imposed by the CPUC, it is necessary to test LOLE in each month, with a MW quantity of effective capacity in each month totaling the month specific peak load plus the same set percentage of reserves. ED staff attempted to perform a LOLE analysis that simulated this condition. The differences between peak loads and capacity levels were adjusted by reducing the effective capacity of thermal generators, while leaving renewable, hydro, and nuclear capacity unaffected. In essence, the level of dispatchable capacity was lowered, and energy generated by renewable, nuclear, and hydro capacity made up a larger portion of the total energy supporting the system. This was done to preserve the effect of differing proportions of energy from different energy sources in each month. Other methods of creating a "monthly" value such as adding load in off-peak months would blur this effect. The results in Table 12 are illustrative and do not represent results that ED is proposing to adopt. The table does reflect a key question, however; the 0.1 LOLE metric commonly applied on "annual" LOLE studies is not applicable to a "Monthly" LOLE worldview.

Table 12 Draft Monthly LOLE Results

Month		1	2	3	4	5	6	7	8	9	10	11	12
CAISO		0.003	0.001	0.000	0.031	0.025	0.000	0.032	0.061	0.009	0.002	0.001	0.003
SCE		0.000	0.000	0.000	0.027	0.010	0.000	0.021	0.038	0.001	0.000	0.000	0.000
SDGE		0.003	0.001	0.000	0.031	0.001	0.000	0.013	0.034	0.008	0.002	0.000	0.002
PGE_Bay		0.000	0.000	0.000	0.000	0.022	0.000	0.004	0.002	0.000	0.000	0.000	0.001
PGE_Valley		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

LOLE in the peak months now coupled with increased LOLE in the off-peak months exceeds 0.1. An alternative method of lowering LOLE in peak months so as to evenly spread that LOLE to offpeak months would result in higher effective capacity requirements in peak months, which would unreasonably raise costs. It is also possible to preserve the LOLE levels of the peak months while also adopting differing "reserve margins" in offpeak months to ensure that no new LOLE is created. An example might be that the summer "reserve margin" is set at 15% to 17% (months of May through October) while LSEs are required to maintain a "reserve margin" of 18% to 20% in offpeak (November through April) months. Once the new baseline LOLE is calculated for each month, the same incremental analysis is performed; renewable capacity is removed and perfect capacity is added by month until the monthly LOLEs match the new baseline LOLE values. The monthly ELCC then is the perfect capacity required each month divided by the nameplate renewable capacity for the respective technology.

Parties are encouraged to comment on the proper means of studying the effects of monthly LOLE levels and provide alternative methodologies during the proceeding.

ED staff proposes to phase ELCC in across the next three years as a means of generating monthly factors and to provide LSEs time to adjust their procurement. ED staff proposes to continue calculation of the exceedance method for wind and solar facilities for the 2017 and 2018 RA compliance year. The ELCC values proposed in this document would be adjusted to the technology factors each year by creating a weighted average. In 2017, ELCC values would be given a one third weight, and in 2018 ELCC values would be given a two thirds weight. The proposed 12.6% annual average ELCC for wind (or 57.8% for solar) would be multiplied by one third and added to two thirds multiplied by the applicable monthly technology factor. Figure 11 compares the proposed composite ELCC/technology factor with the simple technology factor for PV solar facilities and Figure 10 compares the proposed ELCC/technology factors and simple technology factors for wind. Table 13 presents this information as a data table.

Figure 10 Proposed Phased in Composite Wind Monthly Factors versus 2016 Technology Factors

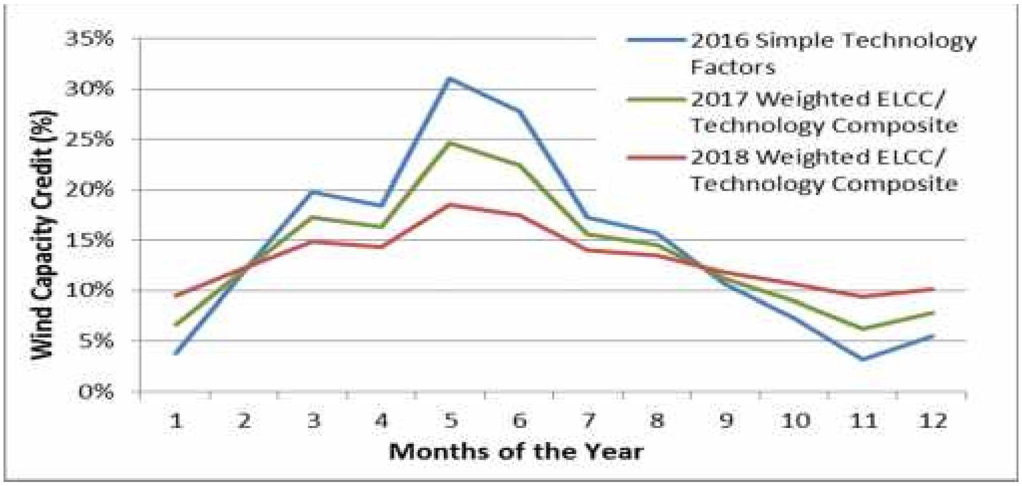


Figure 11 Proposed Phased in Composite Solar Monthly Factors versus 2016 Technology Factors

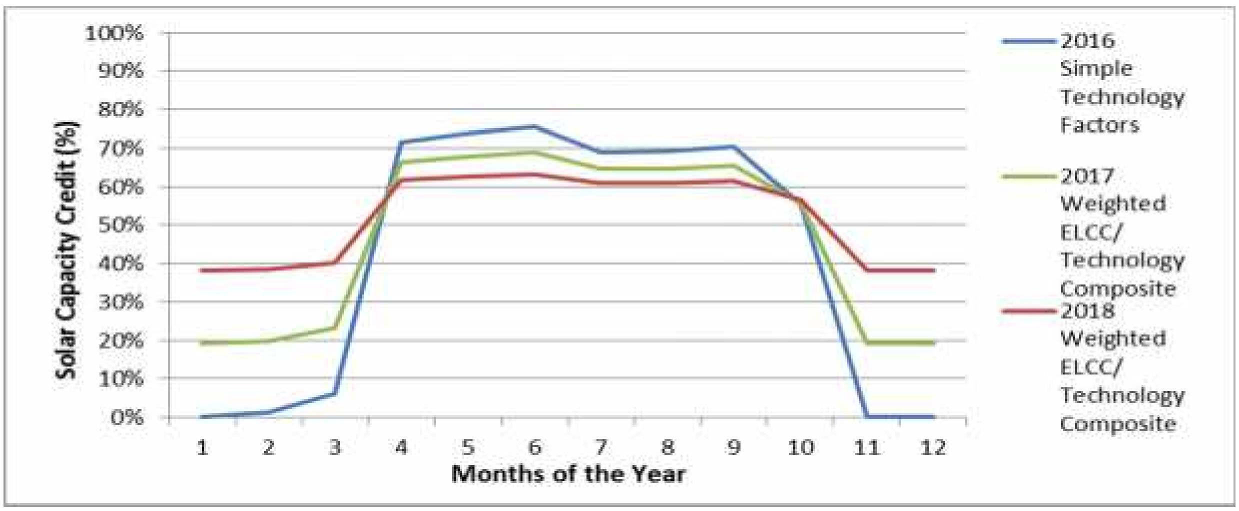


Table 13 Proposed Monthly Wind and Solar Factors for 2017 and 2018

	Average Wind Factors			Average Solar Factors		
Month of the year	**2016 Simple Technology Factors (%)**	**2017 Weighted ELCC/ Technology Composite**	**2018 Weighted ELCC/ Technology Composite**	**2016 Simple Technology Factors (%)**	**2017 Weighted ELCC/ Technology Composite**	**2018 Weighted ELCC/ Technology Composite**
January	3.80%	6.67%	9.57%	0.24%	19.22%	38.20%
February	11.98%	12.06%	12.27%	1.26%	19.89%	38.53%
March	19.86%	17.27%	14.87%	6.23%	23.17%	40.17%
April	18.43%	16.33%	14.40%	71.68%	66.36%	61.77%
May	31.05%	24.65%	18.56%	73.97%	67.88%	62.53%
June	27.77%	22.49%	17.48%	75.67%	69.00%	63.09%
July	17.29%	15.57%	14.02%	69.10%	64.66%	60.92%
August	15.72%	14.54%	13.50%	69.24%	64.75%	60.96%
September	10.68%	11.21%	11.84%	70.45%	65.55%	61.36%
October	7.26%	8.95%	10.71%	55.59%	55.75%	56.46%

November	3.23%	6.29%	9.38%	0.14%	19.15%	38.16%
December	5.55%	7.82%	10.15%	0.11%	19.13%	38.15%

Table 14 illustrates the proposed 2017 Locational and Monthly ELCC values, resulting from the combination of the monthly and locational factors.

Table 14 Proposed 2017 Weighted ELCC/Composite Locationally adjusted Factors

	NorCal	SoCal
Locational ELCC Factors	**46%**	**68%**
Jan	28%	35%
Feb	28%	36%
Mar	30%	38%
Apr	59%	66%
May	60%	67%
Jun	61%	68%
Jul	58%	65%
Aug	58%	65%
Sep	58%	66%
Oct	52%	59%
Nov	28%	35%
Dec	28%	35%

Next Steps and Implementation in the RA Proceeding

ED staff has identified several important next steps to update data inputs and to enable further studies.

- ED staff is in the process of updating hydro shapes to better allocate hydro impacts between areas in the CAISO and areas outside of the CAISO. The revised hydro shapes also incorporate the low hydro years recently experienced by California, thus making them more indicative of present conditions. Hydro shapes once updated and uploaded into the SERVM database will be posted to the CPUC website.
- ED staff is also revising the area definitions of regions external to California, and reallocating load and resources to better match with balancing authority definitions.
- Finally, ED staff has received updated wind and solar shapes, which differentiate between solar PV and solar thermal facilities.

In addition to updated data and more realistic economic dispatch patterns, this proposal also would benefit from more stakeholder input. This proposal represents a significant departure from previous methods of determining QC for wind and solar generators; the proposal to allocate ELCC to individual months is a work in progress, and novel given the history of how ELCC studies are generally performed. ED staff looks forward to discussing this proposal with parties at the upcoming RA workshops.