**California Public Utilities Commission**

**January 15, 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

## 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]

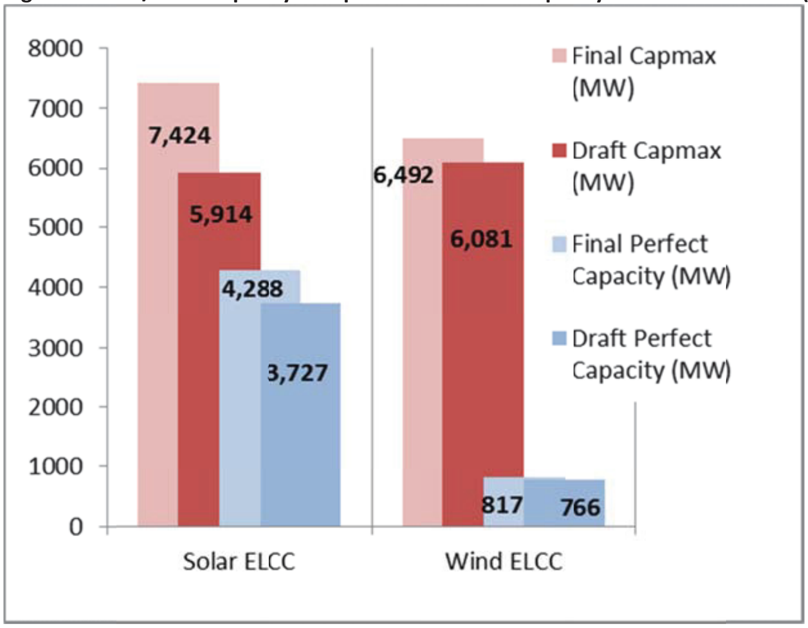
A portion of the ELCC work has been completed and is presented in this paper. Staff calculated the appropriate amount of generating capacity needed to ensure reliability to the standard of 0.1 Loss of Load Expectation (LOLE), then calculated the "average ELCC" of solar and wind generators in the California 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 generating capacity. This translates to a ratio of 116.5% of qualifying (effective) capacity relative to annual peak load. 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 [4] 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".

[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] 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.[5] 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

[5] 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.[6]

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.[7] Solar capacity (or wind capacity) is removed and replaced with a quantity of “Perfect Capacity” and the simulation is repeated. More “Perfect Capacity”[8] 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.

Solar 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.

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

[7] 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.

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

## 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)**

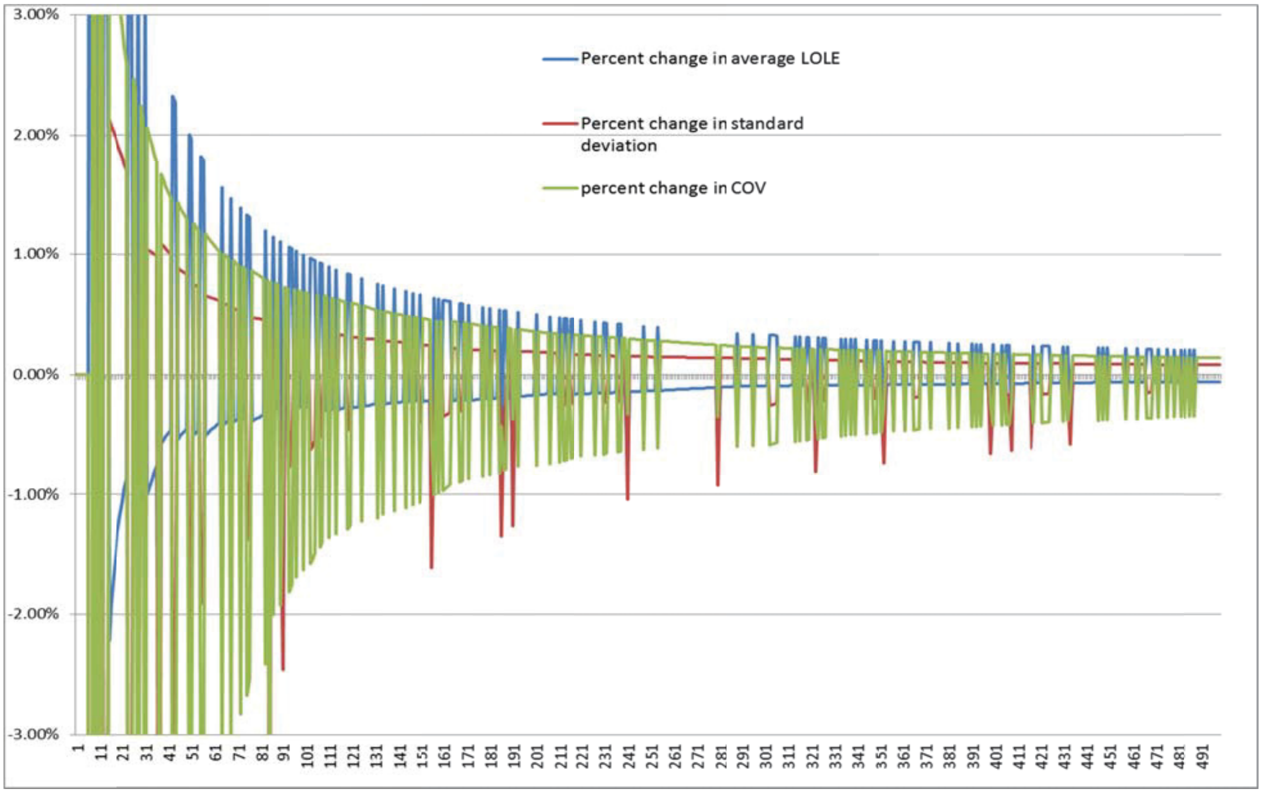
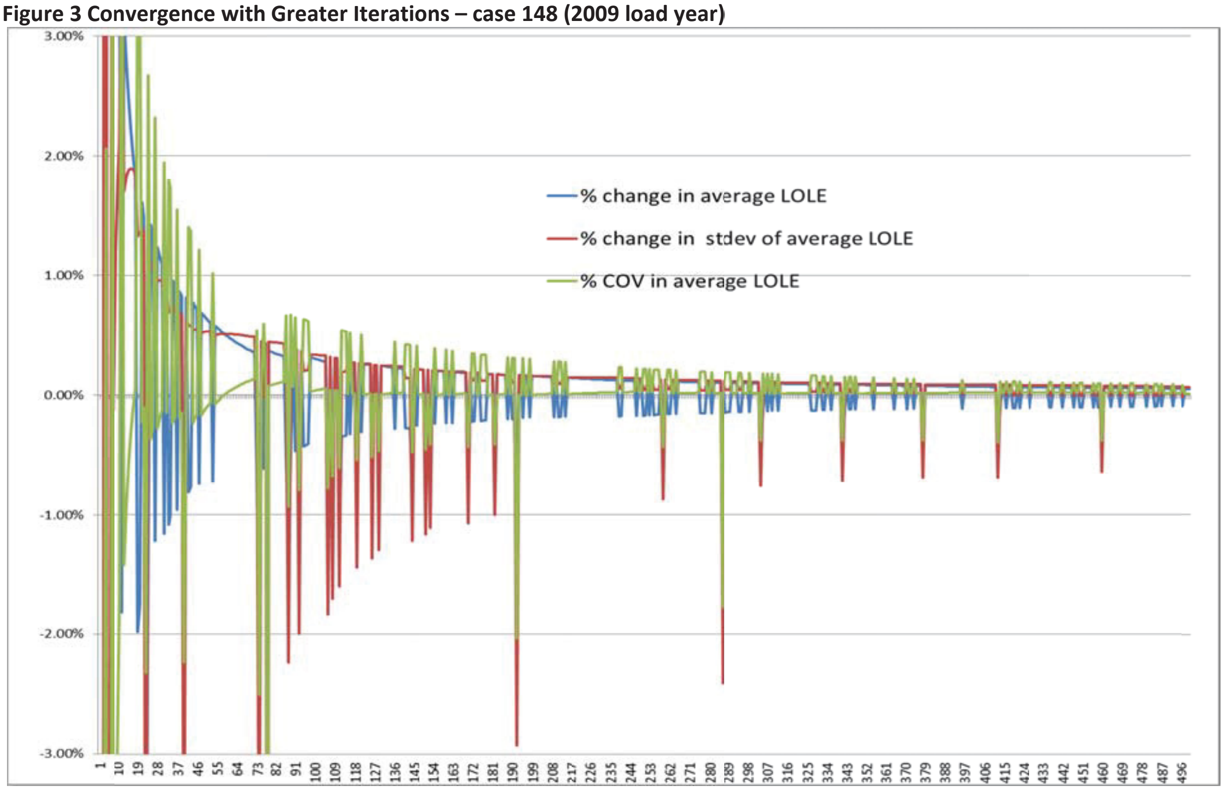



**Figure 3 Convergence with Greater Iterations – case 148 (2009 load year)**



## 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[9] 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.

**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 resimulated 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.

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[9] 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 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. Make an estimate of 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. 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.

## 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.[10] 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 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.

[10] Link to the EIA form 923 data page here: http://www.eia.gov/electricity/data/eia923/

**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 $\mathrm{mean_t}\, X_t = r$, then

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

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

$$\mathrm{mean_t}\, Y_t = p \Rightarrow \mathrm{mean_t}(aX_t + b) = p \Longrightarrow b = p - a(\mathrm{mean_t} X_t) \Longrightarrow b = p - ar$$

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

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

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

$$a = \frac{q - \frac{ps-qr}{s-r}}{s} = \frac{\frac{qs-qr-ps+qr}{s-r}}{s} = \frac{qs-ps}{s(s-r)} = \frac{q-p}{s-r}$$

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. Adjusted scaled load shapes will be posted to the CPUC website.[11]

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

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

**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 |

## 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 5 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 4 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 4 Solar Capacity versus Perfect Capacity (MW)**

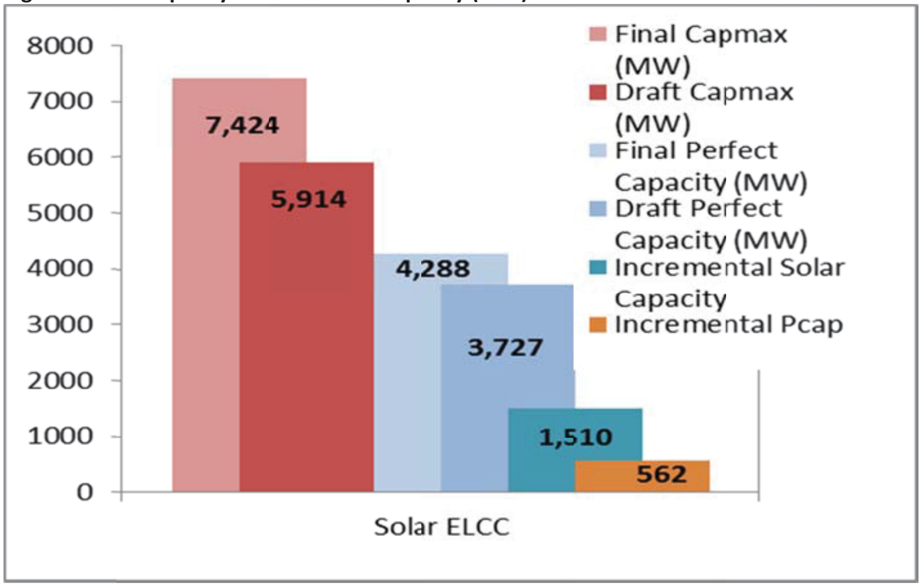



**Figure 5 Geographical Distribution of Solar and Perfect Capacity in CAISO**

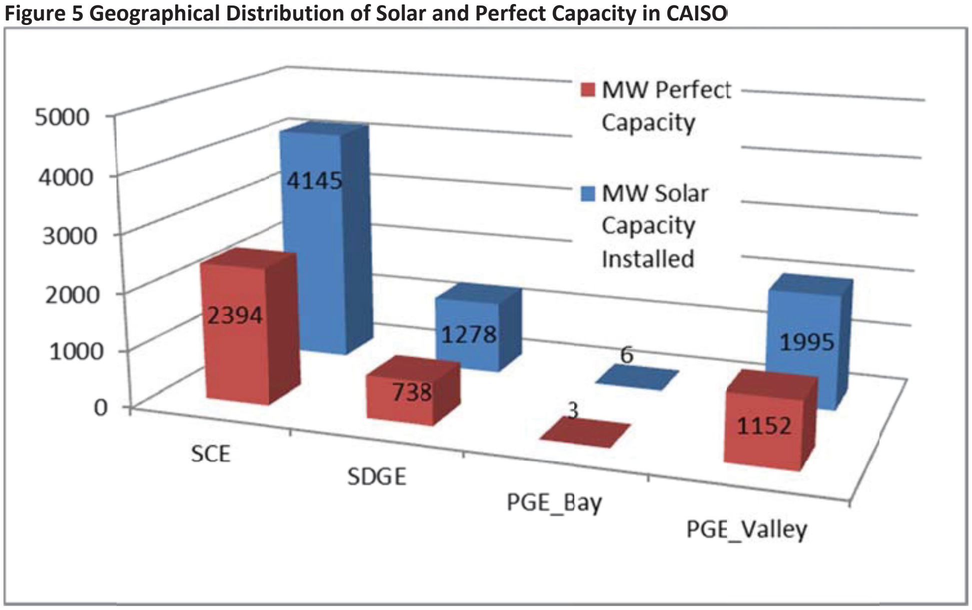



Table 8, below illustrates the distribution of LOLE events across the 12 months of each year and across the areas in the study. The CAISO row serves as the aggregate of the other areas, and each row sums to the total LOLE observed in that area. The total of the CAISO row sums to 0.102 LOLE. Solar facilities 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 |

## Wind ELCC

Staff conducted multiple rounds of studies to determine the ELCC of wind facilities within the CAISO. When wind facilities 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 6 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 6 Wind Capmax versus Perfect Capacity in CAISO**

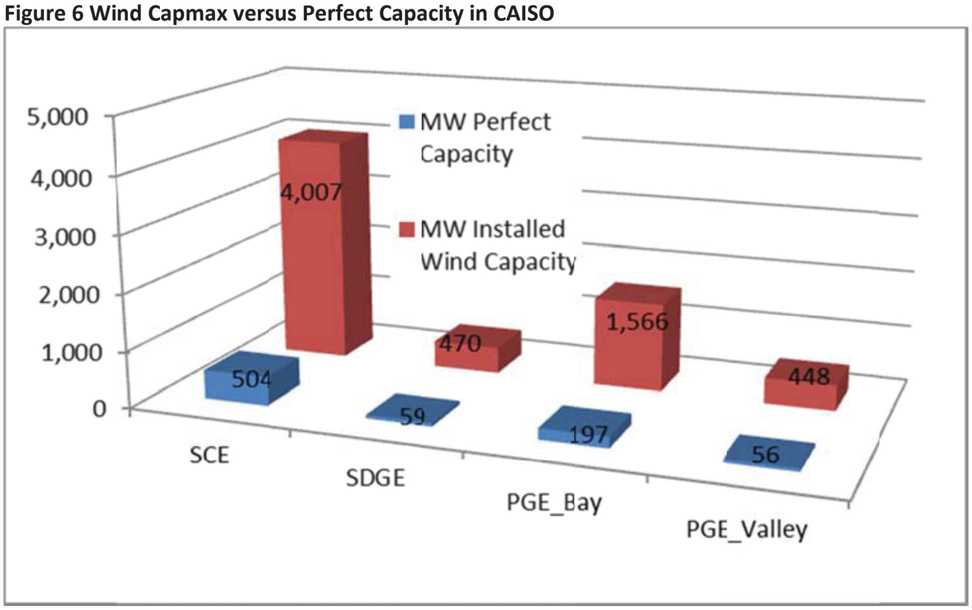



Table 10 below illustrates the distribution of LOLE events across the 12 months of each year and across the areas in the study resulting from ELCC of 12.6%. The CAISO row serves as the aggregate of the other areas, and each row sums to the total LOLE observed in that area. Results highlight the preponderance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

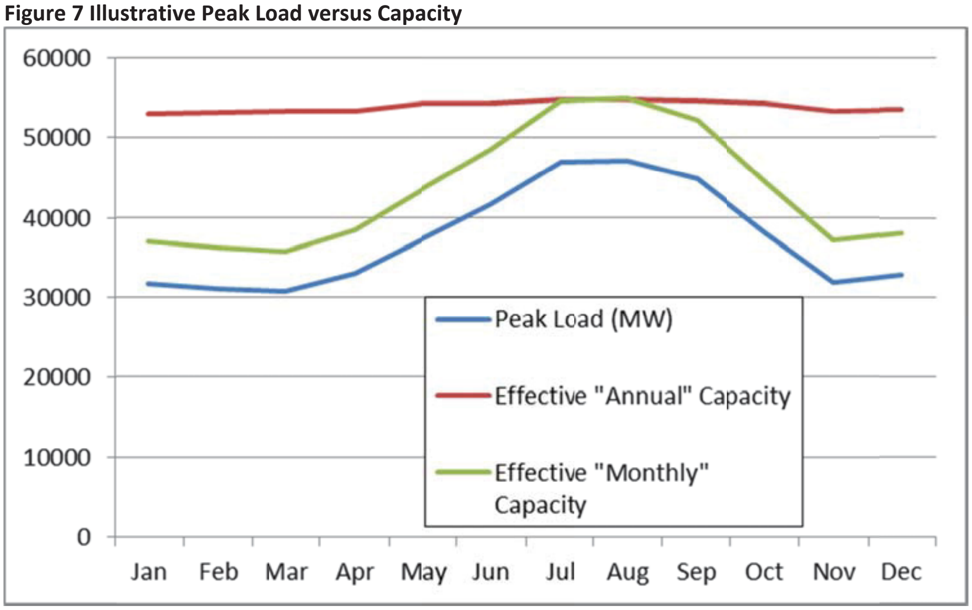
| Load Year | CAISO | SCE | SDGE | PGE_Bay | PGE_Valley |
|---|---|---|---|---|---|
| 2009 | 0.017 | 0.014 | 0.009 | 0.000 | 0.000 |
| 2006 | 0.010 | 0.007 | 0.005 | 0.001 | 0.000 |
| 1998 | 0.009 | 0.006 | 0.005 | 0.000 | 0.000 |
| 1985 | 0.009 | 0.008 | 0.001 | 0.000 | 0.000 |
| 2007 | 0.007 | 0.001 | 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 |

## Derivation of 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 7.

**Figure 7 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 9 compares the proposed composite ELCC/technology factor with the simple technology factor for PV solar facilities and Figure 8 compares the proposed ELCC/technology factors and simple technology factors for wind. Table 13**Error! Reference source not found.** presents this information as a data table.

**Figure 8 Proposed Phased in Composite Wind Monthly Factors versus 2016 Technology Factors**

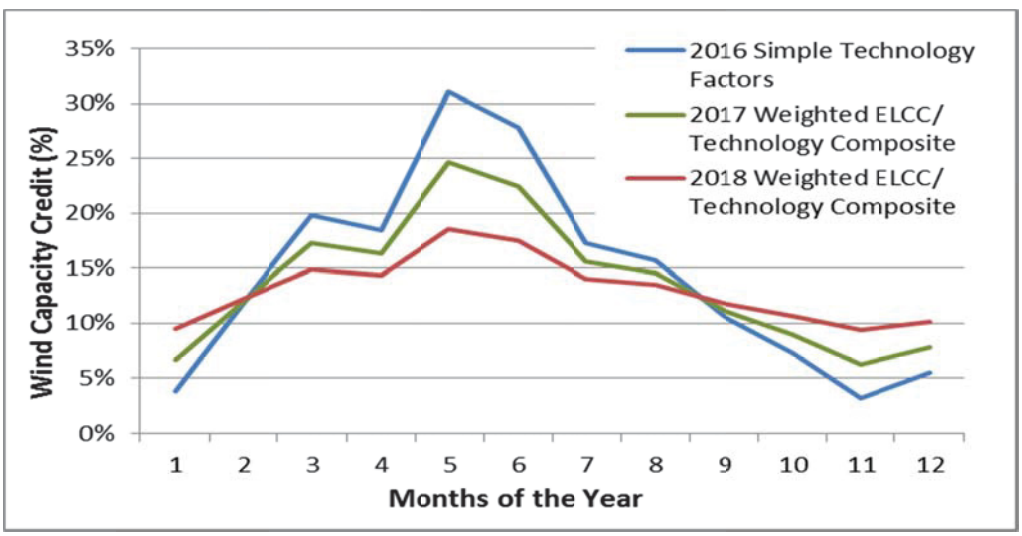


**Figure 9 Proposed Phased in Composite Solar Monthly Factors versus 2016 Technology Factors**

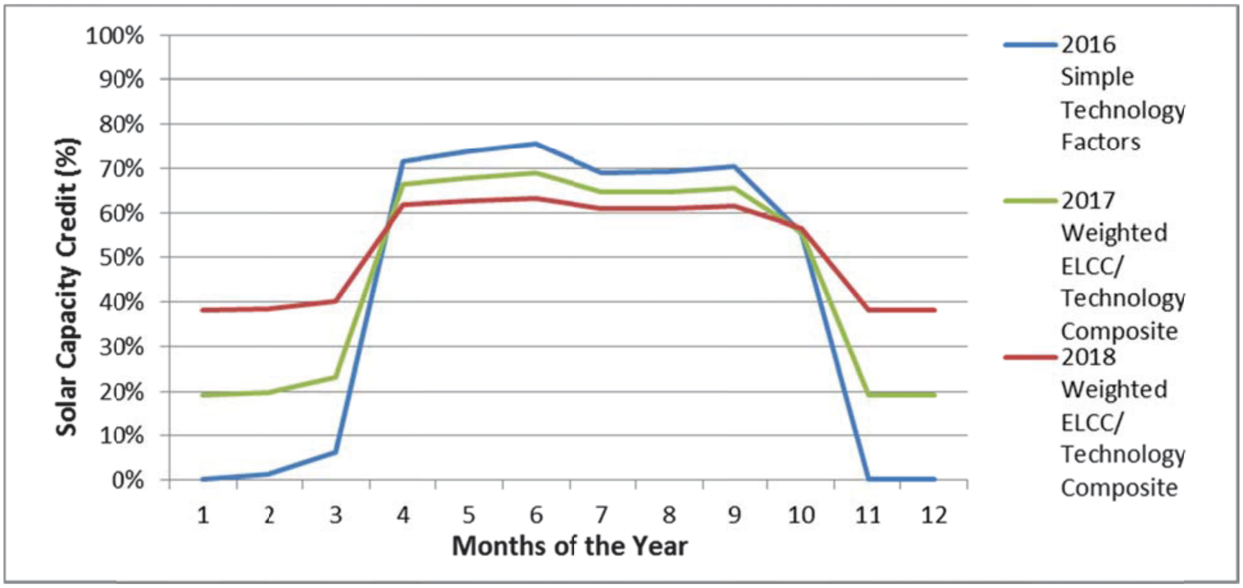



**Table 13 Proposed Wind and Solar Factors for 2017 and 2018**

| | Wind Factors | | | 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% |

## 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.