ATTACHMENT A

Revised Energy Division Staff Paper on Criteria for Effective Load Carrying Capability in Least-Cost Best-Fit Analysis for RPS Procurement

1. INTRODUCTION

Energy Division staff (staff) proposes that Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E) (collectively, the investor-owned utilities or IOUs) use Effective Load Carrying Capability (ELCC) to determine the Net Qualifying Capacity (NQC) in their respective least-cost best-fit (LCBF) methodologies and standardize the methodologies, inputs and assumptions used in calculating these ELCC values, to the extent possible.

ELCC is an output of probabilistic modeling, which assesses likely system needs and the potential for wind and solar resources to contribute to these needs. Specifically, the ELCC of a facility expresses how well it is able to meet reliability conditions and reduce expected reliability problems or outage events caused by capacity shortfalls. ELCC value can be compared to a derating factor applied to a generator's maximum output (Pmax) or nameplate capacity in order to determine its Resource Adequacy (RA) Qualifying Capacity (QC).

QC = ELCC (%) * Pmax (MW)

At the beginning of each renewables portfolio standard (RPS) solicitation cycle, the IOUs submit their respective RPS procurement plans and bidding protocol to the California Public Utilities Commission (Commission) for approval. Filed with each plan and bidding protocol is a detailed description of the IOU's LCBF methodology,[1] which is the methodology the IOU uses for ranking and selecting bids from its RPS procurement solicitations. In their respective LCBF valuations, the IOUs include the capacity benefits by valuing the RA benefits expressed in the form of an assigned NQC[2]

---

[1] RPS LCBF is a statutory requirement enacted by SB 1078 and codified by Public Utilities Code Section 399.13(a)(4)(A), which is "(a) process that provides criteria for the rank ordering and selection of least-cost and best-fit eligible renewable energy resources to comply with the California Renewables Portfolio Standard Program obligations on a total cost basis." The Commission first implemented a LCBF methodology in Decision (D.) 03-06-071 and D.04-07-029. The most recent key decision on LCBF is D.12-11-016.

[2] QC represents the gross amount of a resource's capacity, prior to an adjustment for deliverability that can be counted for meeting the Commission's RA procurement obligation.

Footnote continued on next page

of each offer bid. The IOUs have certain discretion in assigning values to different components of LCBF. SCE and SDG&E rely on the current RA NQC[3] to capture the RA benefits or capacity value of each bid offer. PG&E uses a form of ELCC to determine NQC values of renewables in its LCBF evaluation. Staff proposes that all three large IOUs use ELCC to determine the NQC value in their respective LCBF methodologies.

ELCC values will be more meaningful for statewide renewable planning and procurement if the IOUs use a standardize methodology. Therefore, the objective of this document is to provide IOUs the criteria and guidelines they must use when they develop a common methodology, inputs and assumptions, which the IOUs will use to calculate 20-year marginal ELCC values for all RPS-eligible resources for use in LCBF analysis.

To implement this approach, the IOUs should submit a joint proposal for an ELCC methodology, including standardized inputs and assumptions, draft ELCC values, and a benchmarking report (Joint Proposal). These ELCC values will be used for valuing capacity in LCBF evaluations for future RPS solicitations.

2. BACKGROUND

While the statutory mandate does not explicitly require the Commission to use ELCC for RPS procurement purposes, staff proposes that an ELCC methodology should be developed and used in LCBF for valuing capacity for two reasons.

First, an ELCC approach is a more reliable and accurate measure of the QC of renewables. Currently, the QC for wind and solar resources is calculated based on an exceedance methodology[4] to value the capacity contribution of renewable resources. ELCC measures resource capacity contributions across a year, not just during peak time, as is the case with the exceedance methodology. Additionally, ELCC studies are generally performed for all hours of the day at once and not for a specific pre-defined set of hours as used in the current exceedance methodology.

NQC is the amount of a resource's capacity that can actually be counted for RA compliance filings. (D.09-06-028 at 45)

[3] Pursuant to D.09-06-028, the current RA NQC is calculated utilizing the generating facility's peak capacity contribution factor.

[4] The exceedance methodology measures the RA NQC based on the 30th percentile of renewable production during a specified peak time-window.

Second, the inaccuracies of the exceedance methodology are magnified as renewable penetration increases, e.g., beyond 33%. With an increasing penetration of renewable resources, it is prudent to align RPS procurement with future system reliability conditions for effective planning and procurement of renewables. ELCC achieves that objective by establishing the capacity value of renewable resources not in isolation like the current RPS standard which is manufacturer's nameplate capacity, but with respect to the entire electric system.

Staff does not recommend using ELCC values from the RA proceeding[5] for LCBF evaluation because the ELCC values calculated in the RA program are used for different purposes. First, RA ELCC values are used to assign capacity values to existing renewable resources, while LCBF requires multi-year ELCC values to determine which new RPS resources to procure. Second, ELCC values for LCBF purposes should have a long term 20-year focus due to the duration of RPS contracts, while RA ELCC values only cover 1-3 years. Third, RA ELCC values do not require distinctions between technology types and generator location, which are important factors for LCBF evaluation. Therefore, staff recommends that the IOUs develop a distinct ELCC methodology, informed by the guidelines and criteria in this document, for RPS LCBF evaluation purposes.

3. STATUS OF ELCC IN VARIOUS COMMISSION PROCEEDINGS

ELCC values are used for different purposes in different Commission proceedings. Attachment 1 outlines how ELCC is used in the various Commission proceedings, i.e., Resource Adequacy (RA), Long Term Procurement Plan (LTPP), RPS procurement, and the RPS Calculator.

3.1 ELCC IN RPS CALCULATOR AND RPS PROCUREMENT (R.15-02-020)

The RPS Calculator is a CPUC planning tool used to forecast renewable resource development in California. Versions 2.0 - 5.0 of the RPS Calculator assigned capacity values to resources based on their deemed NQC. The most recent version of the calculator (v. 6.2) uses an ELCC methodology to quantify each resource's contribution to system reliability.[6] Specifically, version 6.2 calculates 20-year marginal ELCCs for a

---

[5] SB 2 1X directed the Commission to determine the ELCCs of wind and solar resources, and to use the results to establish the capacity value of wind and solar resources for RA purposes. For more detail on the status of ELCC in the RA proceeding, see section 3.3, below.

[6] Version 6.2 of the RPS Calculator uses ELCC values developed by Energy+Environmental Economics (E3) to attribute capacity value to renewable generation.

variety of renewable technologies, which it uses when developing RPS portfolios reflecting different levels of renewable penetration (e.g., 33%, 40%, and 50% renewables).

With regard to RPS procurement, ELCC and exceedance methodologies are used concurrently. Specifically, the IOUs were directed to present two different bid rankings for their 2014 RPS shortlist reports. One ranking of all bids received was based on RA valuations calculated with NQC values based on the existing exceedance methodology and the other ranking was based on the NQC values using an ELCC methodology. The utilities could use their own ELCC values or rely on ELCC values developed by E3 for the RPS calculator.[7] The utilities followed this directive in their respective 2014 and 2015 RPS shortlist reports.

3.2 ELCC IN LTPP PROCEEDING (R.13-12-010)

The LTPP proceeding generally operates on a two-year cycle evaluating the need for new resources to meet system and local area reliability needs. The 2014 LTPP (R.13-12-010) proceeding is examining system and local reliability issues based on the proceeding's adopted set of planning assumptions and scenarios. The LTPP relies on the RPS Calculator for forecasting the portfolios of renewable resources used for supply side assumptions in the planning cycle. The 2014 LTPP relied on version 5.0 of the RPS Calculator for producing these portfolios. As mentioned earlier, version 5.0 of the RPS Calculator does not use an ELCC methodology to inform portfolio development. Future LTPP proceedings are expected to rely on version 6.2 and subsequent versions of the RPS calculator for producing RPS portfolios. Version 6.2 and subsequent versions of the RPS calculator will use an ELCC methodology when producing RPS portfolios.

For LTPP system reliability evaluations, NQC values for renewables, whether based on the exceedance methodology or the ELCC methodology, are not used because LTPP models physical resources directly (i.e., the installed capacity and physical attributes of the resource).

For LTPP local reliability assessments, capacity value at peak hours are necessary inputs. Traditionally, the capacity value of renewables at peak hours has been based on NQC values calculated with the exceedance methodology. Future LTPP proceedings may consider whether local reliability assessments should model capacity value of renewables at peak hours based on exceedance, ELCC, or some other methodology.

---

[7] http://www.cpuc.ca.gov/RPS_Calculator/.

The LTPP proceeding also produces long-term forecasts of system RA. For this purpose, the NQC values of forecasted supply are tabulated with forecast demand. The NQC values for renewables are a component of forecasted supply. To the extent that the RPS Calculator and the RA proceeding can produce a portfolio-wide NQC value for renewables using the ELCC methodology, the LTPP long-term forecast of system RA can use that NQC value to represent renewables.

On February 19, 2016, the Commission opened a new Rulemaking (R.16-02-007) to implement the integrated resource planning requirements of SB 350 and address issues for the 2016 procurement planning cycle.[8] This proceeding will be the successor to R.13-12-010. The Rulemaking specifically references this staff paper (October 9, 2015 version) as relevant to planning and procurement tasks in the LTPP proceeding.

> In addition, the current RPS proceeding (R.15-02-020) released a staff proposal on October 9, 2015 and sought party comment on the use of capacity values specific to long-term planning purposes, as distinct from the shorter-term use in the resource adequacy context. Staff proposed using a slightly modified form of the ELCC methodology current under development in an ongoing way in the resource adequacy proceeding (R.14-10-010). This analysis is relevant to the planning and procurement tasks contemplated in this proceeding as well, and we will need to coordinate the work of this proceeding closely with the issues in the RPS rulemaking.[9]

3.3 ELCC IN RA PROCEEDING (R.14-10-010)

SB 2 1X directed the Commission to determine the ELCC values for wind and solar resources and to use the results to establish the capacity value of wind and solar resources for RA purposes. In accordance with the statute, D.14-06-050 directed Energy Division to further develop its ELCC proposal such that an ELCC based QC methodology could be considered by the end of 2014.

On July 8, 2015, staff issued a proposal describing the inputs and assumptions for use in probabilistic reliability modeling titled *Probabilistic Reliability Modeling Inputs and Assumptions*.[10] Staff also issued a paper which provided the results of the modeling in

---

[8] See Pub. Util. Code §§ 454.51 and 454.52.

[9] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K663/158663325.PDF (at 20-21).

[10] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6570.

the form of 2016 ELCC averages for solar and wind generators in the CAISO.[11] The average 2016 ELCC value for solar resources was approximately 63% and 12.6% for wind resources. On January 15, 2016, an Administrative Law Judge Ruling circulated an Energy Division Staff proposal for the 2016 RA Decision. Staff proposed that the average 2017 ELCC value for solar resources be 57.8% and 12.6% for wind.[12]

These RA ELCC values are not specific to generator location or specific wind and solar technologies. These values also do not represent the value these facilities have in each individual month of the year.

4. ATTRIBUTES OF ELCC VALUES FOR USE IN LCBF EVALUATION

For the purpose of ELCC values for use in LCBF evaluation, staff recommends the following guidelines and criteria.

4.1 RELIABILITY STANDARD

Numerous techniques are used to approximate the capacity value of conventional and renewable generators. Reliability based methods are widely accepted and use a standard power system reliability index, and loss of load probability (LOLP)[13] to determine how a generator affects the reliability of the system. LOLP is defined as the probability that generator or transmission-related outage leaves the system with insufficient capacity to serve the load in a given period. ELCC is calculated using LOLP analysis, which yields a single percentage value for a generator. Conceptually, the ELCC for a given technology category, region, and month is a comparison of the amount of generation capacity of that category and in that region to the amount of perfect generation required to yield the same monthly Loss of load event (LOLE) if the capacity in question is excluded from modeling.

Figure 1: ELCC is based on a comparison of the actual and "perfect" capacities yielding identical LOLEs.[14]

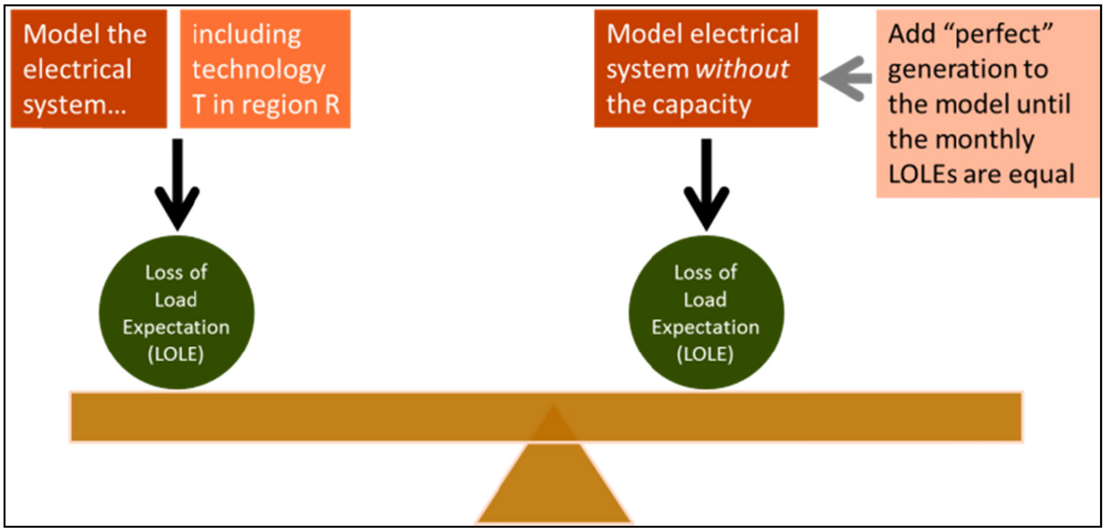
---

[11] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6554.

[12] http://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=157698018.

[13] "LOLP" is a generic term as referring to the type of generation system adequacy modeling that can produce metrics such as LOLP, Lost of Load Expectation, Loss of Load Frequency, and Expected Unserved Energy.

[14] Source for figure 1: Staff Proposal for Effective Load Carrying Capacity and Qualifying Capacity Calculation Methodology for Wind and Solar Resources (Resource Adequacy Proceeding R.11-10-023, January 16, 2014).



ELCC is an effective tool in determining what kind of renewables (wind, solar, bioenergy or geothermal) would be best suited to the system by simulating system future reliability conditions and matching the usefulness of a resource's operating characteristics to the system reliability conditions. The ELCC values should be calculated using LOLP analysis, reflecting a base case that meets a 1-day-in-10-year industry standard. This signifies the risk of having one outage due to insufficient availability of capacity to meet loads no more than one day every 10 years.

In the LTPP proceeding, the Commission issued a ruling requesting comments on the staff Proposal -*Proposed Revisions to LTPP Modeling Methodology*.[15] In the proposal, staff defines "loss of load event" as follows:

> Loss of load event in stochastic models shall be defined to occur when effective operating reserves deplete to 2.5% of hourly load or less (1% regulation +1.5% spinning reserves). (Page 14)

In the RA proceeding, staff issued a document describing inputs and assumptions in the RA ELCC- *Probabilistic Reliability Modeling Inputs and Assumptions*. In the proposal, staff defines "loss of load event" as follows:

> LOLE studies measure events where there is curtailment of firm load due to lack of generation resources. ED staff measured loss of load at the point where minimum operating reserves plus load are higher than the available resources. In other words, ED staff assumed firm load is

---

[15] http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=155876463.

> curtailed at 103% of load or at the point where it became impossible to maintain firm load and 3% operating reserves. (Page 8)

The Commission has not adopted either definition. The IOUs should use a consistent definition of LOLE to calculate ELCC values. If and when the LTPP proceeding adopts a definition for LOLE, the IOUs should adopt the same definition to ensure consistency across proceedings.

Additionally, the IOUs should also continue to rely on the various reliability metrics, definitions, and standards currently being developed in the LTPP proceeding,[16] to the extent possible. Ongoing work in the LTPP Rulemaking[17] is addressing various reliability metrics and definitions, e.g., how to count events (one hour or multiple hours within one day; both count as "one day") and what threshold should be crossed before counting that an event has happened (unserved energy only, or loss of some amount of operating reserves). These definitions and metrics should be the basis of the LOLP analysis.

4.2 MARGINAL ELCC VALUES FOR MULTIPLE YEARS

In the RA proceeding, ELCC is calculated on a portfolio wide basis and then allocated to individual projects. However, RPS procurement requires an approach that recognizes marginal contribution from a new resource depending on the portfolio of all other resources when the new resource is added. The IOUs should use marginal ELCC value for RPS procurement. Table 1 is an illustrative template that the IOUs can use for reporting the marginal ELCC values in their Joint Proposal.

ELCC values should be calculated for multiple years in the future as needed to account for expected changes in the electric system (e.g., contracts from prior solicitations coming online, expected retirements of generators, changes in the shape of load, growth of load) that may occur over the term of a renewable contract. The time horizon for the ELCC values would span from the earliest online date of projects in the solicitation to the last prospective contract expiration in order to account for impacts on ratepayers.

---

[16] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M148/K825/148825409.PDF.

[17] R.13-12-010, Phase 1B.

Table 1. Illustrative Template for Marginal ELCC Values in Joint Proposal

<table>
<tr><th>ID</th><th>Tech/Location</th><th>2015</th><th>2016</th><th>2017</th><th>…</th><th>2038</th><th>2039</th><th>2040</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td rowspan="3" colspan="3">Marginal ELCC Values
(% of Nameplate)</td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>19</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

The IOUs should also standardize the methodology for calculating marginal ELCC values to the extent possible and technically advisable. For each solicitation, the IOUs should calculate marginal ELCC values for the length of the contracts being evaluated. The physical system modeled would include procurement up through that year (appropriately discounted for expected failure rates), but would not include subsequent procurement. The idea is that by making optimal marginal decisions at each step, the utilities would work their way toward a cost-effective renewables portfolio.

5. GUIDELINES FOR STANDARDIZING ELCC METHODOLOGY

In order to derive meaningful results, the IOUs should develop a common methodology to calculate ELCC values. The three IOUs may retain some differences but basic processes for the ELCC calculation methodology should be standardized. A standardized methodology will provide more transparency and enable consistency with LCBF evaluation across IOUs.

The IOUs should include the ELCC methodology in the Joint Proposal. This methodology should inform the calculation of final ELCC values. Specifically, among other topics, the Joint Proposal should address the following:

a. Modeling generation from wind and solar resources based on region, weather, and technology type (based on historical and /or forecasted data)

b. Pre-processing of data including normalization

c. Key data sources (e.g. specific data sources from CAISO or WECC)

d. Key definitions (e.g. desired reliability level, definition of outage etc.)

e. Setting monthly ELCC values for resources

f. Methodology to calculate ELCC for specific years (transitive year or using the data set for a base year)

6. COMMON INPUTS AND ASSUMPTIONS FOR ELCC METHODOLOGY

The IOUs should standardize model inputs and assumptions for calculating ELCC to the extent possible. Reasonable sources of common planning assumptions are the most recently adopted *Standardized Planning Assumptions* in the LTPP Rulemaking[18] and the assumptions used for calculating ELCC in the RA proceeding.[19] For example, the IOUs could rely on the LTPP rulemaking for planned resource additions, demand forecast, and potential scenarios, and the RA proceeding for outage rates, technology and geographic combinations etc.

The IOUs should include an inputs and assumptions table in the Joint Proposal that includes common definitions, values and citations. The list below (not exhaustive) includes potential assumptions that should be common among all utility ELCC methodologies. To the extent a key assumption is missing from this list, the IOUs should add to this list, including the reason for the addition.

a. Outage rates of system resources

b. Resource inputs and use limitations

c. Contribution of hydro resources toward meeting system loads

d. ELCC values at the appropriate level - system, local, service territory, or any other level

e. Planned resource additions and resource retirement (e.g. authorized LTPP procurement, energy storage targets)

f. Contribution of imports toward meeting system loads

g. Accounting for all prior procurement, including prospective resources that have not yet come online (with some risk adjustment at the discretion of the utilities)

h. Data sources for weather and weather region definitions

i. Data sources for historical load and projected load, including load shapes

---

[18] As of May 2015, the most recent LTPP planning assumptions are described here: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M147/K780/147780118.PDF.

[19] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6570.

j. Technology and geographic combinations (possible alignment with current RA technology and geography combinations)

k. Operating/production costs for system resources

l. Treatment of flexibility

m. Natural gas price forecast

n. Variable generation data that would help inform calculations of capacity value

o. Renewable penetration levels and related scenarios

p. Common years to calculate ELCC values

q. Assumptions for years 11-20

r. Hourly profiles for different weather years for load, and wind and solar generation. Realistic hourly profiles are essential to identify resource deficient hours and to estimate the size and frequency of those deficiencies.

s. Intra-hour and 5-minute forecast errors for load, and for wind and solar generation. Intra-hour forecast error and variability are important to quantify flexible capacity deficiencies.

7. JOINT IOU ELCC-LCBF BENCHMARKING EXERCISE

One of the goals of this proposal is to have the final ELCC methodology and associated values align to the extent possible and technically feasible across IOUs and Commission proceedings (e.g., RA counting rules). Consequently, the IOUs must include a benchmarking report in the Joint Proposal that compares and contrasts their respective ELCC values and the RPS calculator and RA ELCC values. If variances in ELCC values are observed across the different proceedings or across utilities, the IOUs must include a potential explanation and solution for addressing the variances.

8. FREQUENCY OF UPDATING ELCC-LCBF VALUES

Since the proposed ELCC inputs and assumptions will likely change with each 2-year LTPP planning cycle (see section 6), benchmarking and updating of ELCC values should be done every two years.

9. PROPOSED NEXT STEPS

SCE, SDG&E, and PG&E should submit their Joint Proposal 90 days from today which would consist of the following:

1. Joint methodology (see Section 5)
2. Common inputs and assumptions (see Section 6)

3. Draft ELCC values (see section 4.2 for format)
4. ELCC benchmarking report (see Section 7)

Parties would then comment on the Joint Proposal. Following receipt of those comments, Energy Division staff would hold a workshop to discuss the Joint Proposal. The IOUs should continue to engage in discussions with the Energy Division staff before release of the Joint Proposal.

Attachment 1

Renewable ELCC Values are Needed in Three CPUC Proceedings

- Values are used for a different purpose in each proceeding

Resource Adequacy

- ELCC is used to assign capacity credit to renewable resources for RA procurement
- Calculate portfolio wide ELCC and allocate to individual projects
- Short-term focus: 1-3 years out
- Historical data from resources in the ground
- *Model: SERVM*

LTPP

- Establishes total renewable capacity contribution to calculate residual system need
- Calculate portfolio wide ELCC-based capacity contribution
- Long-term focus: 10-20 years out
- Need historical and projected data
- *Model: SERVM and RPS Calculator*

RPS Procurement

- Estimates contribution from new resources in order to inform renewable procurement
- Marginal contribution from new resource depends on portfolio
- Long-term focus: 10-20 years out
- Need historical and projected data
- *Model: Utility models*

ELCC Process Flow Chart

RPS Procurement

- Utilities look out 20 years and procure RPS energy
- Requires forecast of ELCCs that will be used in RA proceeding

RPS Calculator

- RPS Calculator fills in with generic projects to reach RPS target
- Requires forecast of ELCCs used in RA proceeding

Resource Adequacy

- RA calculates actual NQC to apply to each renewable project
- Only considers existing portfolio

LTPP

- Uses values from RA for existing resources and RPS Calculator for new renewable resources
- Evaluates alternative mitigation strategies for reliability issues

Other CPUC Proceedings

- Use system-wide ELCC-derived values at future penetrations to value demand-side programs based on their specific characteristics
  - Energy Efficiency
  - Demand Response
  - Load Shifting
  - Energy Storage
  - Distributed PV

(END OF ATTACHMENT A)