Demand Response ELCC

CAISO
June 24, 2021

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In May 2020, E3 publicly released a study quantifying the reliability contribution of demand response in the CAISO
• This original study is contained in slides 4 – 37 of this presentation

In December 2020, E3 publicly released an update of the study based on new information provided by SCE
• This updated study results are contained in slides 38 – 43 of this presentation

In June 2021, E3 publicly released an update of the study, quantifying the ELCC based on DR bids placed by PG&E, SCE and SDG&E in 2020
• This updated study results are contained in slides 44 - 54 of this presentation
Outline for Today’s Meeting

+ Background on ELCC and RECAP
+ Performance of PG&E, SCE and SDG&E programs in 2020
+ Questions
Original Demand Response
ELCC Study

CAISO ESDER Stakeholder Meeting
May 27, 2020

Zach Ming, Director
Vignesh Venugopal, Consultant
California has a unique approach to capacity procurement, where the CPUC administers a Resource Adequacy (RA) program to ensure sufficient resources to maintain an acceptable standard of reliability, but the CAISO retains ultimate responsibility for the reliable operation of the electricity system.

The CAISO was concerned that demand response (DR) was being overcounted in the Resource Adequacy program based on observed demand response bid data.

The CAISO retained E3 to investigate the reliability contribution of DR relative to its capacity value in the CPUC administered RA program.

To the extent that DR is overvalued, the CAISO asked E3 to suggest solutions to issue.

E3 provided technical analysis to support the CAISO in this effort.
This report has been prepared by E3 for the California Independent System Operator (CAISO). This report is separate from and unrelated to any work E3 is doing for the California Public Utilities Commission. While E3 provided technical support to CAISO preparation of this presentation, E3 does not endorse any specific policy or regulatory measures as a result of this analysis. The California Public Utilities Commission did not participate in this project and does not endorse the conclusions presented in this report.
Outline

+ Refresher on March 3 CAISO stakeholder meeting presentation
+ Background on ELCC
+ Performance of Existing DR
+ Characteristics of DR Needed for ELCC
  • Time availability
  • # of calls / duration of calls
  • Penetration of DR
+ Incorporating DR ELCC into Existing CPUC RA Framework
+ Questions
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Agricultural and Pumping Interruptible</td>
<td>DR program to suspend agricultural pumping</td>
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<td>BIP</td>
<td>Base Interruptible Program</td>
<td>Participants are offered capacity credits for reducing their demand up to a pre-determined level in response to an event call</td>
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<td>CBP</td>
<td>Capacity Bidding Program</td>
<td>DR program where aggregators work on behalf of utilities to enroll customers, arrange for load reduction, receive and transfer notices and payments</td>
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<td>DR</td>
<td>Demand Response</td>
<td>Reductions in customer load that serve to reduce the need for traditional resources</td>
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<td>ELCC</td>
<td>Effective Load Carrying Capability</td>
<td>Equivalent perfect capacity measurement of an intermittent or energy-limited resource, such as DR</td>
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<td>LCA</td>
<td>Local Capacity Area</td>
<td>Transmission constrained load pocket for which minimum capacity needs are identified for reliability</td>
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<td>LIP</td>
<td>Load Impact Protocol</td>
<td>Protocols prescribed by the CPUC for accurate and consistent measuring (and forecasting) of DR program performance</td>
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<td>LOLP</td>
<td>Loss of Load Probability</td>
<td>Probability of a load shedding event due to insufficient generation to meet load + reserve requirements</td>
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<td>NQC</td>
<td>Net Qualifying Capacity</td>
<td>A resource’s contribution toward meeting RA after testing, verification, and accounting for performance and deliverability restrictions</td>
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<td>PDR</td>
<td>Proxy Demand Response</td>
<td>Resources that can be bid into the CAISO market as both economic day-ahead and real-time markets providing energy, spin, non-spin, and residual unit commitment services</td>
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<td>PRM</td>
<td>Planning Reserve Margin</td>
<td>Capacity in excess of median peak load forecast needed fore reliability</td>
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<td>RA</td>
<td>Resource Adequacy</td>
<td>Resource capacity needed for reliability</td>
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<td>RDRR</td>
<td>Reliability Demand Response</td>
<td>Resources that can be bid into CAISO market as supply in both economic day-ahead and real-time markets dispatched for reliability services</td>
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<td>SAC</td>
<td>Smart AC Cycling</td>
<td>Direct air conditioner load control program offered by PG&amp;E</td>
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<tr>
<td>SDP</td>
<td>Summer Discount Plan</td>
<td>Direct air conditioner load control program offered by SCE</td>
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<td>SEP</td>
<td>Smart Energy Program</td>
<td>SCE program wherein a smart thermostat provider adjusts A/C usage in response to an event</td>
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<td>LCR</td>
<td>Local Capacity Requirement</td>
<td>Resources procured by SCE (incl. DR) for local capacity needs in the LA Basin</td>
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<td>SubLAP</td>
<td>Sub-Load Aggregation Point</td>
<td>Defined by CQAISO as relatively continuous geographical areas that do not include significant transmission constraints within the area</td>
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Established disconnect between ELCC and NQC

Provided E3 thoughts on how to match CAISO and utility DR bid data as well as techniques to extend this data over multiple historic weather years. Both points were addressed with the 2019 data.
Key Questions to Answer

1) How are demand response programs performing today, relative to what they are being credited for?

   NQC

   ELCC

   hrs/call

   availability

   # of calls/yr

2) What characteristics of demand response are needed today and in the future?

3) How should a resource adequacy program be designed to allocate and credit both DR in aggregate and individual DR programs?
Background on ELCC and RECAP
Effective Load Carrying Capability (ELCC) is a measure of the amount of equivalent perfect capacity that can be provided by an intermittent or energy-limited resource.

- **Intermittent resources**: wind, solar
- **Energy-limited resources**: storage, demand response

Industry has begun to shift toward ELCC as best practice, and the CPUC has been at the leading edge of this trend.

1. Calibrate existing system to target LOLE standard
   
   *If necessary, add or remove “perfect capacity” to achieve target standard*

2. Add desired resource to portfolio
   
   *Addition of new source of generation will decrease LOLE relative to measurement in Step 1*

3. Remove perfect capacity until target LOLE is restored
   
   *Removal of perfect capacity results in increase in LOLE until original target is met*

A resource’s ELCC is equal to the amount of perfect capacity removed from the system in Step 3.
There are multiple approaches to measuring the ELCC of a resource(s)

- **Portfolio ELCC**: measures the combined ELCC of all intermittent and energy-limited resources on the system.

- **First-In ELCC**: measures the marginal ELCC of a resource as if it were the only intermittent or energy-limited resource on the system, thus ignoring interactive effects.

- **Last-In ELCC**: measures the marginal ELCC of a resource after all other intermittent or energy-limited resources have been added to the system, capturing all interactive effects with other resources.
“First-In” ELCC

- First-in ELCC measures the ability of a resource to provide capacity, absent any other resource on the system.
- This measures the ability of a resource to “clip the peak” and is often analogous to how many industry participants imagine capacity resources being utilized.

![Diagram showing load, perfect capacity, and DR](image-url)
“Last-In” ELCC

+ Last-in ELCC can be higher or lower than first in ELCC
  + Higher last-in ELCC means there are positive synergies with the other resources that yield a diversity benefit
  + Lower last-in means the resource is similar to other resources and competes to provide the same services, yielding a diversity penalty

+ Last-in ELCC measures the ability of a resource to provide capacity, assuming all other resources are on the system

Diagram showing:
- Solar
- Storage discharge
- Hydro
- Load
- Firm resources
- DR
E3 analyzed the value of DR to the CAISO system today (2019) and the future (2030) to assess how coming changes to the electricity system might impact value.

Primary changes are on the resource side (shown below) with modest changes to loads (49 GW 2019 peak load vs 53 GW 2030 peak load).

Source: CPUC Integrated Resource Plan (IRP) Reference System Plan (RSP)
Performance of Existing PG&E and SCE event-based DR Programs

Demand response (DR) resource adequacy qualifying capacity is currently calculated using the load impact protocols (LIP), which are performed by the utilities under the oversight of the CPUC

- LIP uses regression and other techniques to estimate the availability of demand response during peak load hours

E3 has analysis suggests that LIP overvalues the capacity contribution DR relative to ELCC by 30%+ for two reasons:

1) DR does not bid into the CAISO market, in aggregate, at levels equal to its NQC value
2) The times when DR is bid are either not at optimal times or not for long enough to earn full ELCC value

Load impacts are grossed up for transmission and distribution losses, as also the 15% PRM, owing to demand response being a demand reduction measure

\[ NQC = LI \times 1.15 \times (PRM) \times T&D \text{ loss factor} \]

Load impacts for the year 2019 are referenced from the CPUC’s RA Compliance documents

Load impacts are defined on an LCA level from 1 pm to 6 pm, Apr to Oct, and from 4 pm to 9 pm in the rest of the year, both with and without line losses

NQC values: the RA value DR receives based on CPUC LIP process, grossed up for PRM and T&D losses

Max bids: the maximum aggregate bids for all utility DR programs of interest in 2019

ELCC: the ELCC value based on the actual utility DR bids in 2019, accounting for the hours in which it was available

[2] CPUC 2019 IoU DR Program Totals
First-in ELCC of PG&E and SCE Programs

**PG&E**

0% ELCC for BIP and CBP Humboldt is a result of the program size being too small.

These results just focus on utility event-based DR, not DRAM programs.

Pmax is max bid placed in the given month.

**SCE**
+ Month/hour (12x24) loss of load probability heat maps provide a quick overview of “high risk” hours

+ Key findings from this project are showing that strong interactions between storage and DR may elongate the peak period by 2030

**LOLP in 2019**

Historical LOLP hours driven by gross peak load during summer afternoons, but an abundance of solar energy has now reduced the LOLP in these hours

Current LOLP hours have been shifted later into the evening and later in summer due to solar

**LOLP in 2030**

LOLP hours will continue to shift later into the evening as solar and storage increase

LOLP hours may elongate back into the afternoon as storage proliferates and market signals encourage it to wait to discharge during later hours
RECAP: Renewable Energy Capacity Planning Model

+ RECAP evaluates adequacy through time-sequential simulations over many years

**Inputs**

- **Load**
  - Hourly load for many weather years
- **Dispatchable Generation**
  - Capacity
  - FOR
  - Maintenance
- **Renewables**
  - Capacity
  - Hourly generation profiles for many weather years
- **Hydro**
  - Hydro availability for many hydro years
  - Max/min constraints
- **Storage**
  - Capacity
  - Duration
  - Roundtrip efficiency
  - FOR
- **Demand Response**
  - Capacity/ Hourly Availability
  - Max # of calls
  - Duration of each call

**Outputs**

- **LOLE**
  - Loss of load expectation
  - days/yr of total expected lost load
- **ALOLP**
  - Annual loss of load probability
  - % probability of having a single loss of load in any given year
- **EUE**
  - Expected unserved energy
  - MWh/yr of energy that cannot be served
- **ELCC**
  - Effective load carrying capability
  - Equivalent quantity of ‘perfect capacity’ for a variable or energy-limited resource
- **TPRM**
  - Target planning reserve margin
  - PRM required to achieve a specified reliability threshold (i.e. LOLE, ALOLP, or EUE)
Historically, DR is dispatched as a resource of “last resort” which is how RECAP dispatched DR.

A system with high penetrations of storage require much more coordination in the dispatch of DR and storage in order to achieve maximum reliability.

**E3 RECAP Model Methodology**

- **Step 1**: Calculate Hourly Load
- **Step 2**: Calculate Renewable Profiles
- **Step 3**: Calculate Available Dispatchable Generation
- **Step 4**: Hydro Dispatch
- **Step 5**: Calculate Available Transmission
- **Step 6**: Dispatch Storage
- **Step 7**: Dispatch Demand Response
- **Step 8**: Calculate Loss of Load
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**E3 RECAP Model Methodology**

1. **Step 1**
   - Calculate Hourly Load

2. **Step 2**
   - Calculate Renewable Profiles

3. **Step 3**
   - Calculate Available Dispatchable Generation

4. **Step 4**
   - Hydro Dispatch

5. **Step 5**
   - Calculate Available Transmission

6. **Step 6**
   - Dispatch Storage

7. **Step 7**
   - Dispatch Demand Response

8. **Step 8**
   - Calculate Loss of Load
Last Resort vs. Optimal Dispatch

DR as Resource of Last Resort

When DR is dispatched as the resource of last resort, there is loss of load

DR Dispatch to Delay Storage Discharge

Preemptively dispatching DR to delay storage discharge eliminates loss of load event

Key takeaway: DR should be dispatched to delay storage discharge on days with potential loss of load
### Call and Duration ELCC Results

#### First-in ELCC

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<thead>
<tr>
<th>ELCC (% of nameplate)</th>
<th>Max annual calls</th>
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<td>2019</td>
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<td>70%</td>
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#### Last-in ELCC

<table>
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<th>ELCC (% of nameplate)</th>
<th>Max annual calls</th>
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<td>2019</td>
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<td>74%</td>
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<td>6</td>
<td>77%</td>
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<td>8</td>
<td>77%</td>
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#### Max call duration (hrs)

- **No interactions with storage – therefore no expected significant differences**
- **Significant degradation in last-in ELCC in 2030 is driven by saturation of energy-limited resources, primarily storage**

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Energy + Environmental Economics
Average ELCC = Total Effective Capacity / Total Installed Capacity

Incremental ELCC = $\Delta$ Effective Capacity / $\Delta$ Installed Capacity

ELCC generally decreases as DR capacity on the system increases:

- Similarity in hours of operation and characteristics limits the incremental value that more of the exact same resource type can add to the system.
- Degradation gets more severe as call constraints become more stringent.
ELCC generally decreases as DR capacity on the system increases:

- Similarity in hours of operation and characteristics limits the incremental value that more of the exact same resource type can add to the system.
- For a given DR capacity on the system, ELCC in 2030 is lower than that in 2019 owing to saturation of energy-limited resources on the system in 2030, particularly storage.
The CPUC has been a leader in North America through the incorporation of intermittent and energy-limited resources into RA frameworks

- One of the first to adopt and implement ELCC framework to value wind and solar
- Currently the only jurisdiction that recognizes and accounts for interactive effects of resources through allocation of a “diversity benefit” to wind and solar

The CPUC has recognized that the concept of “interactive effects” applies not only to renewables but to storage and other resources, but has not yet established an approach for allocation that incorporates them all

Establishing a more generalized, durable framework for ELCC (capable of accounting for renewables, storage, and DR) will require a reexamination of the methods used to allocate ELCC and the “diversity benefit”

This section examines alternative options for allocating ELCC among resources that could improve upon existing methods currently in use
Allocating ELCC

+ Allocating Portfolio ELCC is necessary with a centralized or bilateral capacity market framework where individual resources must be assigned a capacity contribution for compensation purposes
  
  • Directly impacts billions of dollars of market clearing transactions within California and other organized capacity markets

+ Allocating Portfolio ELCC can impact planning and procurement in California to the extent that entities procure based on the economic signal they receive in the RA program
  
  • An allocation exercise is not necessary in vertically integrated jurisdictions or in systems with a centralized procurement process

+ There are an infinite number of methods to allocate Portfolio ELCC to individual resources and no single correct or scientific method, similar to rate design

Sample ELCC Allocation Method Options

1. Allocate proportionally to First-In ELCC
2. Allocate proportionally to Last-In ELCC
3. Allocate adjustment to First-In ELCC proportionally to differences between First-in and Last-In ELCC
4. Vintaging approach where each resource permanently receives Last-In ELCC at the time it was constructed
5. More
This section presents a framework as one option for attributing capacity value to DR within the current resource adequacy framework administered by the CPUC.

This framework relies on several key principles:

1) **Reliability**: The ELCC allocated to each project/program should sum to the portfolio ELCC for all resources.

2) **Fairness**: ELCC calculations should be technology neutral, properly reward resources for the capacity characteristics they provide, and not unduly differentiate among similar resources.

3) **Efficiency**: ELCC values should send accurate signals to encourage an economically efficient outcome to maximize societal resources.

4) **Customer Acceptability**: ELCC calculations should be transparent, tractable understandable, and implementable.
Overview of Framework

1. Calculate portfolio ELCC

2. Calculate “first-in” and “last-in” ELCC for each resource category

3. Allocate portfolio ELCC to each resource category

4. Allocate resource category ELCC to each project/program using tractable heuristic
1) Calculate Portfolio ELCC

The first step should calculate the portfolio ELCC of all variable and energy-limited resources

- Wind
- Solar
- Storage
- Demand Response
The second step calculates the “first-in” and “last-in” ELCC for each resource category as a necessary input for allocation of the portfolio ELCC.
3) Allocate Portfolio ELCC to Each Resource Category

Calculate **diversity impact** as the difference between portfolio ELCC and sum of first-in ELCCs

1. **Calculate diversity impact for each resource category**

   - **Wind**
   - **Solar**
   - **Storage**

2. **Allocate diversity impact** in proportion to the difference between first-in and last-in ELCC for each resource category

3. **Scale individual resource category diversity impacts** to match portfolio diversity impact

   - **Wind diversity impact**
   - **Solar diversity impact**
   - **Storage diversity impact**

   **Portfolio Diversity Impact**

   **Scaled impact**
Benefits of this Approach

There are several options to allocate Portfolio ELCC to each technology category, two examples of which are shown below:

**First-In ELCC Allocation Option**

- **Wind**
- **Solar**
- **Storage**
- **DR**

Scale up to match Portfolio ELCC

**Portfolio ELCC**

**Last-In ELCC Allocation Option**

- **Wind**
- **Solar**
- **Storage**
- **DR**

Scale down to match Portfolio ELCC

**Portfolio ELCC**

Both of these options can lead to final ELCC allocations that fall outside the bounds of the first-in or last-in ELCC:

- For example, in the case of a “perfect” resource (e.g. ultra-long duration storage, always available DR, baseload renewables, etc.), this should be counted at 100% ELCC and should not be unduly scaled up or down based on the synergistic or antagonistic impacts of other resource interactions.
- Scaling the first-in or last-in ELCC in any way would result in an ELCC of either >100% or <100% for this perfect resource.

The method presented in this deck scales resources based on the difference of their first-in and last-in ELCC in order to reflect their synergistic or antagonistic contributions to Portfolio ELCC.

- **First-In ELCC**: Negative diversity impact leads to first-in ELCC being scaled up to match Portfolio ELCC.
- **Last-In ELCC**: Positive diversity impact leads to first-in ELCC being scaled down to match Portfolio ELCC.
- No diversity impact leads to no scaling of first-in ELCC to match Portfolio ELCC.
4) Allocate Resource Category ELCC to Individual Resource/Programs Using Heuristics

+ Each DR program submits the following information:
  - Expected output during peak period hours
  - Maximum number of calls per year
  - Maximum duration of call

+ Step 1) Calculate average MW availability during peak period hours (gross and net load)

+ Step 2) Multiple MW availability from step (1) by lookup table de-rating factor to account for call and duration limitations:
  - DR category ELCC to individual program ELCC using first-in and last-in ELCC would work similarly to the allocation process of portfolio ELCC to resource category ELCC
Questions
Thank You

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Zach Ming, (zachary.ming@ethree.com)
Vignesh Venugopal (vignesh.venugopal@ethree.com)
The DR ELCC study has been updated to reflect two primary changes

1) SCE BIP Bid Values
   - The original DR bid data submitted to E3 from SCE reflected the actual BIP bid values but not the full capability of these resources
   - Due to discrete dispatch limitations and registration restrictions, SCE had been underbidding the full capability of its DR resources into the CAISO market
   - SCE has now modified its bidding procedures to reflect the full capability of these resources and has retroactively modified 2019 bid values to reflect its new bidding strategy

2) T&D Loss and PRM Gross Up
   - DR ELCC values are now compared to the DR NQC values net of T&D loss factors and PRM
   - Originally, both SCE and PG&E indicated to E3 that the demand response bid data was grossed up for T&D losses but after the May release of the study indicated it was not

### Average Increase in SCE Hourly DR Bid Data

<table>
<thead>
<tr>
<th>Avg Difference (MW)</th>
<th>Month/Hour (PST)</th>
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Updated November 2020 Results

Original May 2020 Results

Updated November 2020 Results

Updated NQC values remove PRM and T&D gross up in order to ensure apples-to-apples comparison with DR bids

Updated SCE bid values have increased DR ELCC by approximately 100 MW

Nov – May Difference in Results

Key Finding

+ DR ELCC is approximately 20 to 30% less than apples-to-apples NQC comparison
The gap between NQC* and ELCC is driven by two primary factors:

1. Maximum aggregate bids are lower than NQC* in all hours

2. ELCC is lower than maximum aggregate bid because resources do not produce at this level in all loss of load hours

- As more storage is added to the system, it flattens the peak which elongates the period of loss of load hours beyond 4-9pm which further decreases the “Last-In ELCC” of DR

- This issue is expected to grow in the future as evidenced by declining Last-In ELCC in 2030

**Updated November 2020 Results**

- Maximum aggregate bids are lower than NQC* in all hours
- ELCC is lower than maximum aggregate bid because resources do not produce at this level in all loss of load hours
- As more storage is added to the system, it flattens the peak which elongates the period of loss of load hours beyond 4-9pm which further decreases the “Last-In ELCC” of DR
- This issue is expected to grow in the future as evidenced by declining Last-In ELCC in 2030
SCE-Specific Updated Results

+ The update in the overall DR ELCC results are driven by updated bid data from the SCE BIP program
+ SCE BIP ELCC has increased by approximately 100 MW across all cases
+ First-in ELCC for BIP program in each LCA has increased

First-In ELCC for SCE BIP Programs by LCA

Compare to values on slide 15
Comparing SCE BIP NQC to Nominations

- The primary reason SCE BIP ELCC values are lower than NQC values (adjusted for T&D and PRM factors) is due to nomination values that are lower than the NQC values.
- September SCE BIP NQC (net of T&D and PRM) is 624 MW.

### Maximum Nomination MW (2019 SCE BIP)

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- **High LOLP hours**
  - Maximum SCE BIP nomination during high LOLP hours is 517 MW

### Average Nomination MW (2019 SCE BIP)

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- **High LOLP hours**
  - Average SCE BIP nomination during high LOLP hours is 471 MW
Assessment of 2020 DR Bids

CAISO
June 2021

Zach Ming, Director
Vignesh Venugopal, Consultant
E3 analyzed the value of DR to the CAISO system in 2020 and 2030 based on the IRP portfolio for the 2021-2022 Transmission Planning Process. 

**2020 and 2030 CAISO Resource Portfolio**

- **5,000+ MW retirement of thermal resources**
- **26,000+ MW increase in solar**
- **11,000+ MW increase in storage**
- **Small increase in DR**

[1] IRP Inputs to 2021-22 TPP
+ Month/hour (12x24) loss of load probability heat maps provide a quick overview of “high risk” hours

+ Key findings from this project are showing elongation of the peak period by 2030

LOLP in 2020

Historical LOLP hours driven by gross peak load during summer afternoons, but an abundance of solar energy has now reduced the LOLP in these hours

Current LOLP hours have been shifted later into the evening and later in summer due to solar

LOLP in 2030

LOLP hours will continue to shift and extend later into the evening as solar and storage increase
LIP Filing and NQC Calculation Timeline

NQC Calculated For Future Years. Based on (1) DR Performance in Year Prior to PY and (2) DR Enrollment Projections

The NQC\(^1\) that ELCC has been compared to in this report

The timeline shows:

- **2020 DR Program Totals**
- **2021 DR Program Totals**
- **2022 DR Program Totals**
- **2023 DR Program Totals**

*What happens if DR enrollment projection for 2020 is inaccurate?*

Load Impact Filed in April of Program Year (PY)

---

[1] 2020 DR Program Totals
Change in NQC Leading Up to Real-Time SCE BIP In August For Example

While bids are most in line with this NQC, updates to NQC do NOT feed into the RA process.

DR bids are placed in the DAM or RTM. Thus, based on most recent NQC.

DR availability is represented using DR bids. ELCC in MW does not change based on NQC it is being compared to.

Legend
- RECAP ELCC
- NQC Net of PRM and T&D
- Max DR Bid

NQC calculated for Aug 2020 changes over time, with updates to both expected load impact per participant (LIPP) and total number of participants.

While bids are most in line with this NQC, updates to NQC do NOT feed into the RA process.

DR availability is represented using DR bids. ELCC in MW does not change based on NQC it is being compared to.

Legend
- RECAP ELCC
- NQC Net of PRM and T&D
- Max DR Bid
Aggregate ELCC Results

While we remove PRM and T&D gross-up from the NQC to ensure a fair comparison with DR bids submitted, the NQC attributed to DR in the Resource Adequacy process is grossed up for both.

**Legend**
- **RECAP ELCC**
- NQC Net of PRM and T&D (Aug)
- NQC Net of PRM and T&D (Jul)
- NQC Net of PRM and T&D (Sep)
- Max DR Bid (Aug)
- Max DR Bid (Jul)
- Max DR Bid (Sep)

<table>
<thead>
<tr>
<th>2019-PG&amp;E and SCE</th>
<th>2020-PG&amp;E and SCE</th>
<th>2020-With Additional SCE Programs and SDG&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-in 2019</td>
<td>First-in 2020</td>
<td>First-in 2020</td>
</tr>
<tr>
<td>Last-in 2019</td>
<td>Last-in 2020</td>
<td>Last-in 2020</td>
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<tr>
<td>First-in 2020</td>
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<tr>
<td>Last-in 2020</td>
<td>Last-in 2020</td>
<td>Last-in 2020</td>
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<tr>
<td>First-in 2030</td>
<td>First-in 2030</td>
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<tr>
<td>Last-in 2030</td>
<td>Last-in 2030</td>
<td>Last-in 2030</td>
</tr>
</tbody>
</table>

- **DR bids in the summer increased by ~60 MW on avg**
- **ELCCs increase by 4-90 MW**
- **NQCs reduced by ~50 MW**
- **Inclusion of SCE's SEP and LCR and SDG&E’s CBP, BIP and AC programs**
- **First-in ELCC increases by ~90 MW, Last-in by ~45 MW**
### Difference In NQC and Bids from 2019 to 2020

<table>
<thead>
<tr>
<th>IoU</th>
<th>Program</th>
<th>LCA</th>
<th>NQC before T&amp;D and PRM</th>
<th>Max Bid</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Jul</td>
<td>Aug</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>BIP</td>
<td>All LCAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CBP</td>
<td>Bay Area</td>
<td></td>
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</tr>
<tr>
<td></td>
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<td>CAISO System</td>
<td></td>
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<tr>
<td></td>
<td>CBP</td>
<td>Greater Fresno</td>
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<tr>
<td></td>
<td>CBP</td>
<td>Humboldt</td>
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<tr>
<td></td>
<td>CBP</td>
<td>Kern</td>
<td></td>
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<tr>
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<td>North Coast</td>
<td></td>
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<tr>
<td></td>
<td>CBP</td>
<td>Sierra</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>CBP</td>
<td>Stockton</td>
<td></td>
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<tr>
<td>SAC</td>
<td>Bay Area</td>
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<td>CAISO System</td>
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<tr>
<td>SCE</td>
<td>API</td>
<td>Big Creek</td>
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<td>LA Basin</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>BIP</td>
<td>Big Creek</td>
<td></td>
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<td>CBP</td>
<td>Big Creek</td>
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<tr>
<td></td>
<td>CBP</td>
<td>LA Basin</td>
<td></td>
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<td></td>
<td>SDP</td>
<td>Big Creek</td>
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<td>CAISO System</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>SDP</td>
<td>LA Basin</td>
<td></td>
<td></td>
</tr>
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</table>
First-in ELCC Based on 2020 DR Bids

Legend
- RECAP ELCC
- NQC Net of PRM and T&D (Aug)
- NQC Net of PRM and T&D (Jul)
- NQC Net of PRM and T&D (Sep)
- Max DR Bid (Aug)
- Max DR Bid (Jul)
- Max DR Bid (Sep)

<table>
<thead>
<tr>
<th></th>
<th>PG&amp;E</th>
<th>SCE</th>
<th>SDG&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>80%</td>
<td>84%</td>
<td>63%</td>
</tr>
<tr>
<td>Aug</td>
<td>82%</td>
<td>79%</td>
<td>54%</td>
</tr>
<tr>
<td>Sep</td>
<td>86%</td>
<td>83%</td>
<td>49%</td>
</tr>
</tbody>
</table>

ELCC as a % of NQC Net of PRM and T&D

Axis change

PG&E: 1,200 MW
SCE: 1,000 MW
SDG&E: 18 MW
First-in ELCC Based on 2020 DR Bids
PG&E Programs

ELCC as a % of Aug NQC

NQCs for some program-LCAs were not disclosed due to small number of participants

Legend
- RECAP ELCC
- NQC Net of PRM and T&D (Aug)
-NQC Net of PRM and T&D (Jul)
-NQC Net of PRM and T&D (Sep)
- Max DR Bid (Aug)
- Max DR Bid (Jul)
- Max DR Bid (Sep)
First-in ELCC Based on 2020 DR Bids
SCE Programs

ELCC as a % of Aug NQC

Legend
- RECAP ELCC
- NQC Net of PRM and T&D (Aug)
- NQC Net of PRM and T&D (Jul)
- NQC Net of PRM and T&D (Sep)
- Max DR Bid (Aug)
- Max DR Bid (Jul)
- Max DR Bid (Sep)
First-in ELCC Based on 2020 DR Bids
SDG&E Programs

ELCC as a % of Aug NQC

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Res + Com AC Saver DA</td>
<td>49%</td>
</tr>
<tr>
<td>Res + Com AC Saver DO</td>
<td>42%</td>
</tr>
<tr>
<td>BIP</td>
<td>67%</td>
</tr>
<tr>
<td>CBP DA (11AM-7PM + 1PM-9PM)</td>
<td>215%</td>
</tr>
<tr>
<td>CBP DO (11AM-7PM + 1PM-9PM)</td>
<td>78%</td>
</tr>
</tbody>
</table>

Legend:
- RECAP ELCC
- NQC Net of PRM and T&D (Aug)
- NQC Net of PRM and T&D (Jul)
- NQC Net of PRM and T&D (Sep)
- Max DR Bid (Aug)
- Max DR Bid (Jul)
- Max DR Bid (Sep)
Appendix
NQCs as a Basis for Comparison with ELCCs

+ NQCs are calculated using load impacts (LI), i.e. load reductions expected during peak conditions, calculated in line with the Load Impact Protocols.

+ Load impacts are grossed up for transmission and distribution losses, as also the 15% PRM, owing to demand response being a demand reduction measure.

\[
NQC = LI \times 1.15 \times (PRM) \times T&D \ loss \ factor^{[1]}
\]

+ Load impacts for the year 2019 are referenced from the CPUC’s RA Compliance documents\(^2\)

+ Load impacts were defined on an LCA level from 1 pm to 6 pm, Apr to Oct, and from 4 pm to 9 pm in the rest of the year, both with and without line losses

+ The timing has since been revised to 4 pm to 9 pm year-round\(^3\)

---

\(^1\) CPUC 2019 RA Guide
\(^2\) CPUC 2019 IoU DR Program Totals
\(^3\) CPUC 2020 IOU LIP Workshop
Key Question: What Call and Duration Characteristics are Needed to Maximize DR ELCC?

E3 tested how two primary constraints impact the ELCC of demand response resources

- Max # of calls per year
  - How many times can a system operator dispatch a demand response resource?

- Max duration of each call
  - How long does the demand response resource respond when called by the system operator?

Key Assumptions:

- DR portfolio is divided into 100 MW units, each of which can be dispatched independently of the other
  - In other words, 2-hour-100 MW units can be dispatched in sequence to avoid an unserved energy event 100 MW deep and 4 hours long

- Each 100 MW unit is available 24/7, at full capacity of 100 MW, subject to call constraints defined above to establish a clear baseline for ELCC %’s

- Pure Shed DR; No shifting of load; No snap-backs
### Average ELCC as a function of DR Capacity on the System

#### First-in ELCC

<table>
<thead>
<tr>
<th>DR capacity (MW)</th>
<th>ELCC (% of DR capacity)</th>
<th>Call constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour/call 1 call/year</td>
<td>4 hours/call 10 calls/year</td>
</tr>
<tr>
<td>2,195</td>
<td>46% 51% 70%</td>
<td>94% 95% 95%</td>
</tr>
<tr>
<td>3,000</td>
<td>40% 47% 61%</td>
<td>92% 94% 96%</td>
</tr>
<tr>
<td>4,000</td>
<td>36% 42% 52%</td>
<td>78% 80% 86%</td>
</tr>
<tr>
<td>5,000</td>
<td>32% 39% 46%</td>
<td>73% 75% 83%</td>
</tr>
<tr>
<td>10,000</td>
<td>21% 30% 31%</td>
<td>51% 60% 65%</td>
</tr>
<tr>
<td>20,000</td>
<td>14% 21% 20%</td>
<td>33% 46% 44%</td>
</tr>
</tbody>
</table>

#### Last-in ELCC

<table>
<thead>
<tr>
<th>DR capacity (MW)</th>
<th>ELCC (% of DR capacity)</th>
<th>Call constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour/call 1 call/year</td>
<td>4 hours/call 10 calls/year</td>
</tr>
<tr>
<td>2,195</td>
<td>59% 73% 77%</td>
<td>100% 100% 100%</td>
</tr>
<tr>
<td>3,000</td>
<td>52% 65% 67%</td>
<td>99% 100% 100%</td>
</tr>
<tr>
<td>4,000</td>
<td>44% 57% 63%</td>
<td>93% 98% 98%</td>
</tr>
<tr>
<td>5,000</td>
<td>39% 52% 59%</td>
<td>87% 94% 94%</td>
</tr>
<tr>
<td>10,000</td>
<td>27% 39% 38%</td>
<td>61% 75% 75%</td>
</tr>
<tr>
<td>20,000</td>
<td>19% 28% 25%</td>
<td>39% 53% 50%</td>
</tr>
</tbody>
</table>

### Energy + Environmental Economics

58
Incremental ELCC as a function of DR Capacity on the System

<table>
<thead>
<tr>
<th>DR capacity (MW)</th>
<th>Call constraints</th>
<th>ELCC (% of DR capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour/call 1 call/year</td>
<td>1 hour/call 4 calls/year</td>
</tr>
<tr>
<td>2,195</td>
<td>46%</td>
<td>51%</td>
</tr>
<tr>
<td>3,000</td>
<td>25%</td>
<td>36%</td>
</tr>
<tr>
<td>4,000</td>
<td>22%</td>
<td>29%</td>
</tr>
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<td>5,000</td>
<td>15%</td>
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<tr>
<td>10,000</td>
<td>11%</td>
<td>22%</td>
</tr>
<tr>
<td>20,000</td>
<td>7%</td>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DR capacity (MW)</th>
<th>Call constraints</th>
<th>ELCC (% of DR capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour/call 1 call/year</td>
<td>1 hour/call 4 calls/year</td>
</tr>
<tr>
<td>2,195</td>
<td>35%</td>
<td>37%</td>
</tr>
<tr>
<td>3,000</td>
<td>9%</td>
<td>16%</td>
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<tr>
<td>4,000</td>
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<td>12%</td>
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<tr>
<td>5,000</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>10,000</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>20,000</td>
<td>9%</td>
<td>11%</td>
</tr>
</tbody>
</table>
2019 vs 2030 Loss of Load Events

**Frequency of Event Occurrence**

- No significant change in frequency of events

**Distribution of Event Duration**

- Events become longer as energy-limited resources increase

**Distribution of Event Magnitude**

- Events become larger as availability of energy becomes more variable
The 2019 PG&E and SCE DR ELCC results focus on “event-based” DR programs, as opposed to passive measures like dynamic pricing applicable throughout a season/year.

- Does not consider SDG&E or Demand Response Auction Mechanism (DRAM) resources which are a significant portion of the data DR portfolio, due to data limitations.

Data sources for RECAP ELCC calculations

1. Hourly PG&E DR bid data for 2019
   - BIP, CBP, and SAC
   - PSPS outage logs were provided by PG&E and used by E3 to identify and then fill gaps in DR bid data

2. Hourly SCE DR bid data for 2019
   - API, BIP, CBP, and SDP
E3 used utility data directly from PG&E and SCE for two reasons

- CAISO does not have data by utility program
- Wanted to ensure results were not predicated on CAISO data

E3 benchmarked utility data to CAISO data to ensure the veracity of the data

- Data generally benchmarked well
- A few inconsistencies were spotted in the RDRR data:
  - In ~1.3% of hours in the year, DR bids present in PG&E’s data are missing in CAISO’s data. Technical glitches in transmitting/recording systems may explain this.
  - DR bids in SCE data were slightly lower than bids recorded in CAISO data across significant portions of the year. Underlying reason is currently not known.
Benchmarking of 2019 Bid Data from PG&E and CAISO

+ PDR data from the two sources are identical
+ There are a few hours (114 out of 8760) where RDRR data is inconsistent:
  - Several instances across each of the 24 hours of the day
  - These are hours where data is missing in the CAISO dataset
  - Unclear if a bid was not placed, or if it was placed but not recorded due to technical glitches

Example comparison for one of the subLAPs over the entire year and a couple of days in specific
Benchmarking of 2019 Bid Data from SCE and CAISO data

+ PDR data from the two sources are identical
+ Inconsistencies exist in RDRR data – unclear if the difference is systematic and attributable to a single factor, like treatment of line-losses

Example comparisons for 2 subLAPs - across the entire year and across a couple of days in specific
In order to calculate the ELCC of a DR program or portfolio, RECAP must predict how these programs will perform over many different conditions and weather years.

Therefore, E3 must extend actual 2019 data over the entire historical temperature record as a data requirement for the E3 RECAP model.

In response to stakeholder feedback from the May 3 CAISO ESDER meeting, E3 modified the backcasting approach to include temperature for temperature-dependent air conditioner DR programs.

More details on this process and methodology can be found in the appendix.
Process of Extrapolating Actual DR Bid Data to Entire Weather Record

1. Get daily max, min and average temperature data (1950-2019) from NOAA for every climate zone that DR program bids come from.

2. Use weather-informed day-matching to match every day from Jan 1, 1950 - Dec 31, 2018 to the “most similar” day from Jan 1, 2019 – Dec 31, 2019.

3. Use day-matching results to extrapolate hourly DR bids from just 2019 to 1950-2019.

4. Aggregate extrapolated DR bids by program-LCA to allow for comparison with respective NQCs.

5. Each aggregated shape dictates the hourly availability of the corresponding DR program-LCA combination in RECAP.
As in the previous phase of this project, E3 used a simple day-matching approach for CBP, BIP and API programs.

DR bid forecasts for these programs were not as strong a function of the temperature as Smart AC.

For an individual DR program and a particular day, ‘d’ in a simulated year, pick one day out of +/- 3 calendar days, ‘d+3’ to ‘d-3’ of the same type (workday/holiday) from the actual 2019 data at random.
Weather-informed Day-Matching Algorithm for AC cycling DR Programs

+ Inclusion of weather for air conditioner DR is in direct feedback to stakeholder comments from the May 3, 2020 CAISO ESDER meeting

+ For an individual DR program and a particular day in a simulated year, pick one day out of +/- 10 calendar days of the same type (workday/holiday) from actual 2019 data with the closest $T_{\text{max}}$, $T_{\text{min}}$ and $T_{\text{avg}}$

+ Applied to PG&E’s Smart AC program and SCE’s Summer Discount Plan program data to account for influence of temperature on DR availability

Example weekday in simulated year

Candidate (2019) days for matching

[Graph showing temperature ranges for candidate days]
The Mean Absolute Percentage Error (MAPE) is defined as:

$$\text{MAPE} = \frac{|\text{Day-matched value} - \text{Actual Value}| \times 100}{\text{Actual Value}}$$

MAPE is calculated and shown below for July-September, 4 pm to 10 pm.
Why Day Matching and not Regression?

Regression based on temperature, month and day-type couldn’t explain movement in DR bids. Potential reasons could be:

- Mismatch in temperature data used by E3 and IoUs.
- Not accounting for other explanatory variables that IoUs use in their forecasts.

Absence of reliable hourly temperature records going back to 1950 meant only regression for daily DR bids was doable.
## Assumptions on DR Program Characteristics

<table>
<thead>
<tr>
<th>Utility</th>
<th>DR Program</th>
<th>Event Duration (hours/call)</th>
<th>Max. Events per Month</th>
<th>Max. Events per Year</th>
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<tbody>
<tr>
<td>PG&amp;E</td>
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<td>CBP</td>
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<td>17</td>
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<td>SCE</td>
<td>API</td>
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<td>AC Saver</td>
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<td>6</td>
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<tr>
<td></td>
<td>BIP</td>
<td>4</td>
<td>10</td>
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</table>
Climate zones and sub-LAPs for reference
<table>
<thead>
<tr>
<th>Sub-LAP</th>
<th>Sub-LAP (long form)</th>
<th>Local Capacity Area</th>
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<tbody>
<tr>
<td>PGCC</td>
<td>PG&amp;E Central Coast</td>
<td>Bay Area</td>
</tr>
<tr>
<td>PGEB</td>
<td>PG&amp;E East Bay</td>
<td>Bay Area</td>
</tr>
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<td>PGF1</td>
<td>PG&amp;E Fresno</td>
<td>Greater Fresno</td>
</tr>
<tr>
<td>PGFG</td>
<td>PG&amp;E Fulton-Geyser</td>
<td>North Coast/North Bay</td>
</tr>
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<td>PG&amp;E Humboldt</td>
<td>Humboldt</td>
</tr>
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<td>PGKN</td>
<td>PG&amp;E Kern</td>
<td>Kern</td>
</tr>
<tr>
<td>PGNB</td>
<td>PG&amp;E North Bay</td>
<td>North Coast/North Bay</td>
</tr>
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<td>PGNC</td>
<td>PG&amp;E North Coast</td>
<td>North Coast/North Bay</td>
</tr>
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<td>PG&amp;E North of Path 15 - non local</td>
<td>CAISO System</td>
</tr>
<tr>
<td>PGP2</td>
<td>PG&amp;E Peninsula</td>
<td>Bay Area</td>
</tr>
<tr>
<td>PGSB</td>
<td>PG&amp;E South Bay</td>
<td>Bay Area</td>
</tr>
<tr>
<td>PGSF</td>
<td>PG&amp;E San Francisco</td>
<td>Bay Area</td>
</tr>
<tr>
<td>PGSI</td>
<td>PG&amp;E Sierra</td>
<td>Sierra</td>
</tr>
<tr>
<td>PGST</td>
<td>PG&amp;E Stockton</td>
<td>Stockton</td>
</tr>
<tr>
<td>PGZP</td>
<td>PG&amp;E ZP26 (between Path 15 and 26) - non local</td>
<td>CAISO System</td>
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<td>Big Creek/Ventura</td>
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<td>SCE West</td>
<td>LA Basin</td>
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<td>VEA</td>
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